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 7

	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
DIRECTORATE GENERAL CIPTA KARYA
DEPARTMENT OF PUBLIC WORKS
GOVERNMENT OF INDONESIA

DIRECTORATE GENERAL
FOR INTERNATIONAL COOPERATION
MINISTRY OF FOREIGN AFFAIRS
GOVERNMENT OF THE NETHERLANDS

MDP PRODUCTION TEAM

TRAINING MATERIALS FOR WATER ENTERPRISES

VOLUME 7
TRAINING MODULES
TECHNICAL (Distribution + Consumption)

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

JAKARTA
APRIL 1985

PREFACE

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	

TABLE OF CONTENTS

TRAINING MODULES

Module : **PRINCIPLES OF WATER TRANSMISSION, STORAGE AND DISTRIBUTION**	Code : TDG 001
	Edition : 19-03-1985
Section 1 : INFORMATION SHEET	Page : 01 of 01/13

Duration :	45 minutes.
Training objectives :	After the session the trainees will be able to: - list the basic principles of water transmission, storage and distribution; - list the methods of water transmission; - list the reasons for and methods of water storage - state the routine maintenance procedure of distribution.
Trainee selection :	- Director PDAM/Head BPAM; - Head of Technical Department; - Head of Section Production; - Head of Section Distribution; - Head of Section Planning & Supervision; - Head of Section Maintenance.
Training aids :	- Viewfoils : TDG 001/V 1-6; - Handout : TDG 001/H 1.
Special features :	-
Keywords :	Transmission/storage/distribution.

1. Introduction	
- The system between the water source and the consumer consists of 3 main parts: . transmission; . storage; . distribution.	Show V 1
2. Transmission	
- Transmission mains transmit water from the source to the area of distribution - Water flows in two basic ways: a. by gravity; b. by pumping. - The size of the transmission main relies on the quantity of water to be transmitted.	Show V 2 (a-b)
3. Gravity	
- If the source of the water supply is above the level of the distribution area the water flow will flow by gravity. - Quantity of water should be metered.	
4. Pumping	
- Pumps are used when the distribution area is above the level of the water source.	
5. Storage	
- Water demand fluctuates throughout the day - To minimize costs, transmission mains are designed for average flows - Reservoirs level out the differences between supply and demand - There are two types of reservoirs: . ground reservoirs (at elevated locations) . water towers	Show V 3

- Reservoirs are located as close as possible to, or even inside, the distribution area.	Show V 5
6. Distribution System	
- The basic prinsiple is to provide a network of pipes from which connections can be made to supply consumers.	Show V 6
- There are 3 types of distribution pipes: . primary; . secondary; . tertiary.	
- <u>Primary mains</u> distribute water throughout the system to large areas.	
- <u>Secondary mains</u> supply water from the primary pipes to smaller areas.	
- <u>Tertiary pipes</u> take the distributed water to the individual roads and streets.	
- Size of pipe depends on the quantity of water distributed.	
7. House connections and Public taps	
- House connections and public taps are normally connected to the tertiary pipes	
- Tappings are made on water pipe.	
- Small diameter service pipe from tertiary pipe to house.	
8. Maintenance	
- Water mains, if laid correctly, should require very little real maintenance.	
- Problems arise primarily with bad mainlaying causing leakages over a period of time	

- Monitoring of water consumption of the distribution system, be means of meters is important.
- Monitoring gives a rapid indication of losses due to leakage.
- Pressure recordings are also useful.
- Valves, hydrants and all special working fittings should be checked on a regular basis.

9. Operation

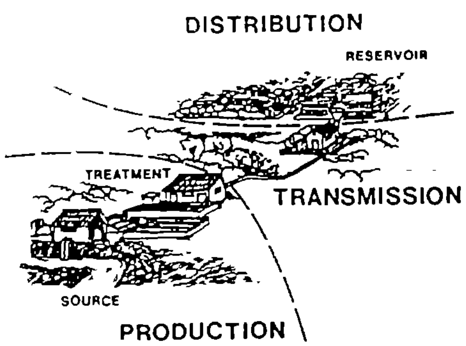
- Normally the only operations on a distribution system concern sluice valves.
- Good distribution systems always have ALL SLUICE VALVES OPEN
- Sluice valves are normally closed to control leakage or increased pressure.

10. Summary

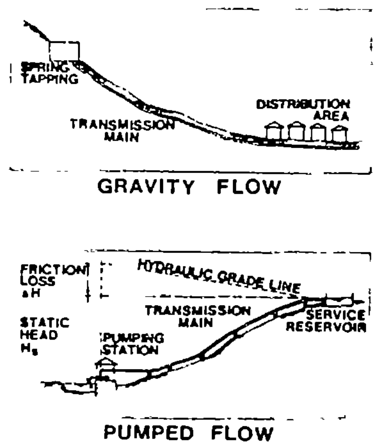
Give H 1.

Module :	**PRINCIPLES OF WATER TRANSMISSION, STORAGE AND DISTRIBUTION**	Code :	TDG 001
		Edition :	21-09-1984
Section 3 :	T R A I N I N G A I D S	Page :	01 of 02

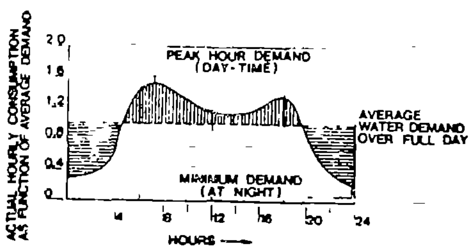
Water supply system TDG 001/V 1



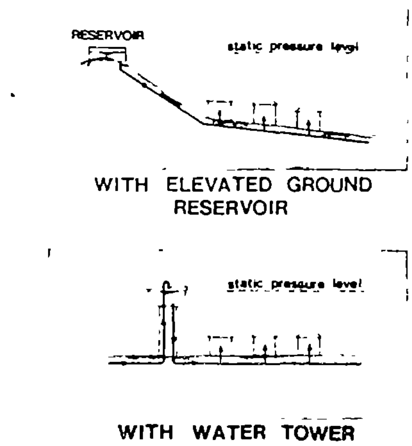
Basic water flows TDG 001/V 2 (a-b)



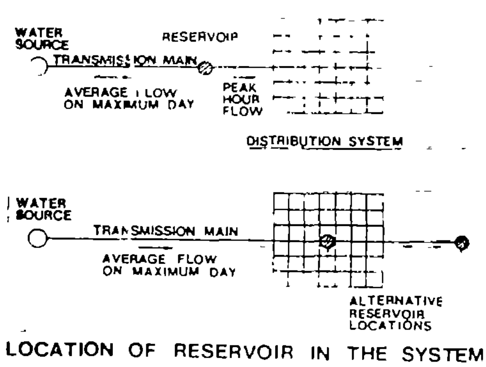
Daily consumption fluctuation TDG 001/V 3



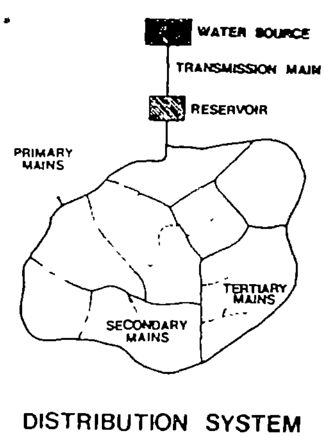
Storage TDG 001/V 4 (a-b)



Location of reservoir TDG 001/V 5



Distribution system TDG 001/V 6



Principles of water transmission, storage and distribution

TDG 001/H 1

1. INTRODUCTION

The system that links the water source with the consumers, generally comprises the following:
- transmission;
- storage;
- distribution.

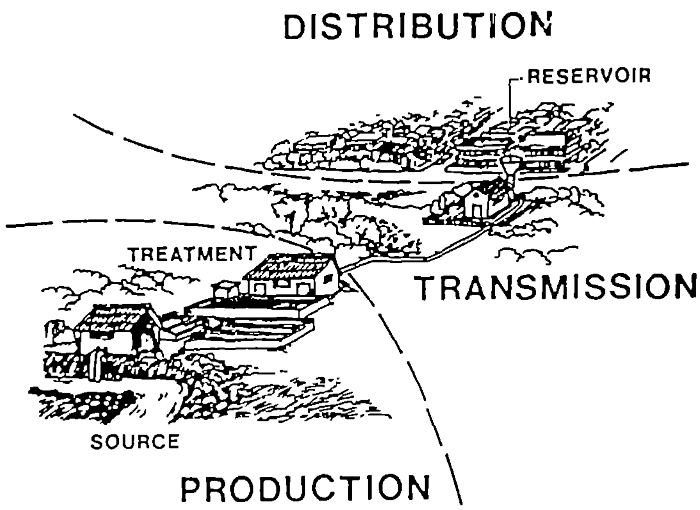


Fig. 1. Simplified system lay-out.

2. TRANSMISSION

After being disinfected, either at the source or at the treatment plant, the water is transported to the distribution area (i.e. the area where the consumers live) by means of transmission mains. These pipelines serve only one purpose, viz. to transport water, and no water is taken directly from them.

The transmission main may be a single pipeline, but especially when the supply water is of critical importance, a twin main may be used, which is interconnected at regular distances. In this way the supply of water can be guaranteed even in case of a pipe burst: the section with the burst is than repaired after being valved off at both sides, while the supply of water is continued through the second pipe.

If the source is above the distribution area the water flows by gravity.
If the source is below the distribution area it is pumped.

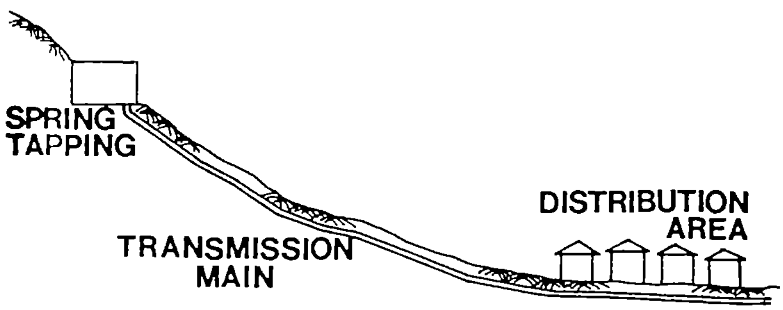


Fig. 2. Gravity flow system.

Care should be taken with transmission mains to ensure that all the necessary air-valves and wash-outs are installed on the main. The quantity of water passing through the main should be measured by means of a meter, in order to check for losses.

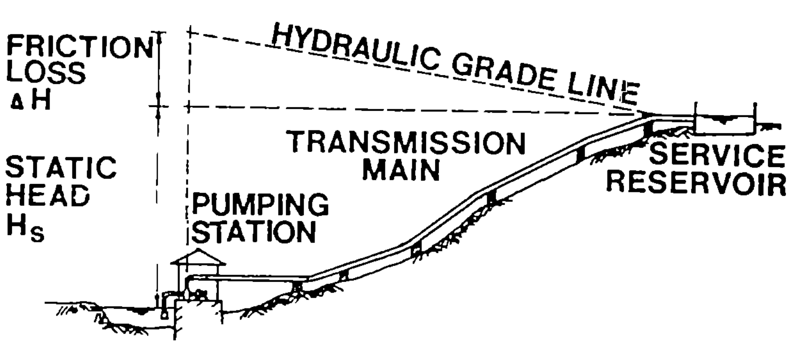


Fig. 3. Pumped system.

3. STORAGE

Water is not used at a constant rate throughout the day, but at fluctuating rates, with mostly two periods of higher use during the day, and relatively low use of water at night.

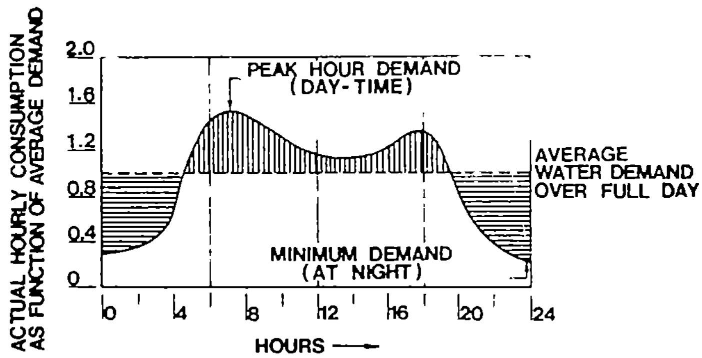


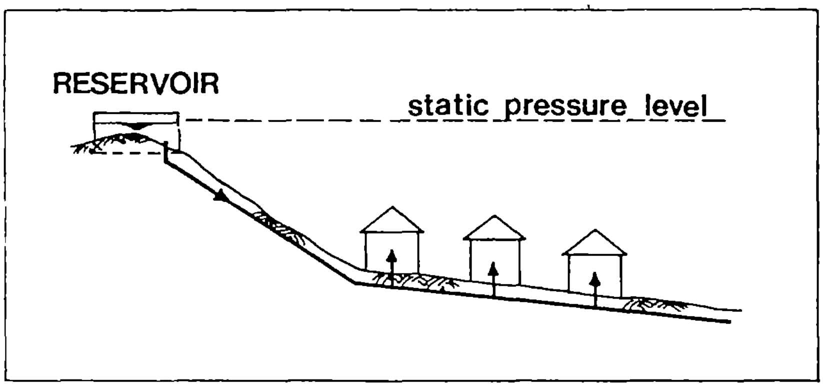
Fig. 4. Daily fluctuation of water consumption.

In order to minimize the size (and thus : the cost) of the transmission mains, these are usually designed to transport the average daily flows only. At periods of high water demand more water is used than supplied by transmission main(s), and during periods of low water demand less.

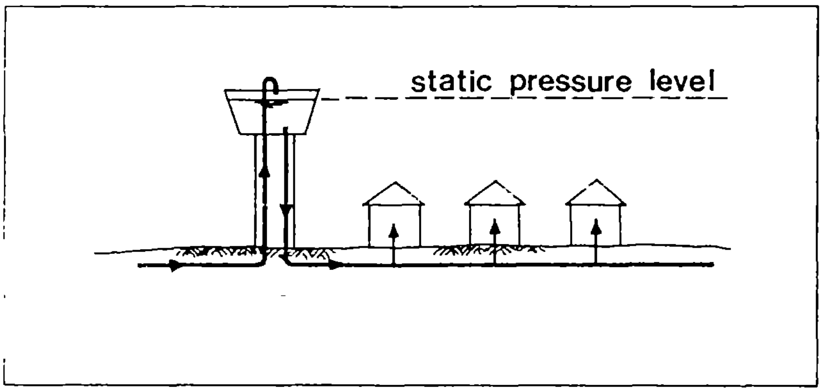
The supply and demand of water thus have to be balanced by reservoirs.
There are 2 main types of reservoirs:

a. ground reservoirs, preferably located on a hillock, so that they can supply the water by gravity, without pumping;

b. water towers.



WITH ELEVATED GROUND RESERVOIR



WITH WATER TOWER

Fig. 5. Storage.

As water towers are much more expensive than elevated ground reservoirs, preference must be given to the latter.

Storage reservoirs are located as close as possible to the distribution area or even in the area itself.

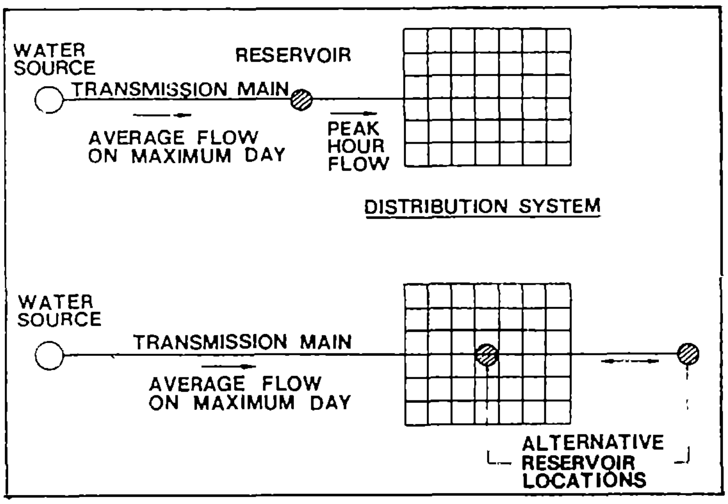


Fig. 6. Location of storage within system.

4. DISTRIBUTION

The distribution system is that part of the water supply system that actually distributes the water to the consumers.
Since the income of the water enterprise is directly related to the sale of water, for which the uninterrupted operation of the distribution system is of prime importance, the operation of the distribution system is one of the major tasks of the enterprise.

The distribution system is built up of 3 types of mains :
- primary;
- secondary;
- tertiary.

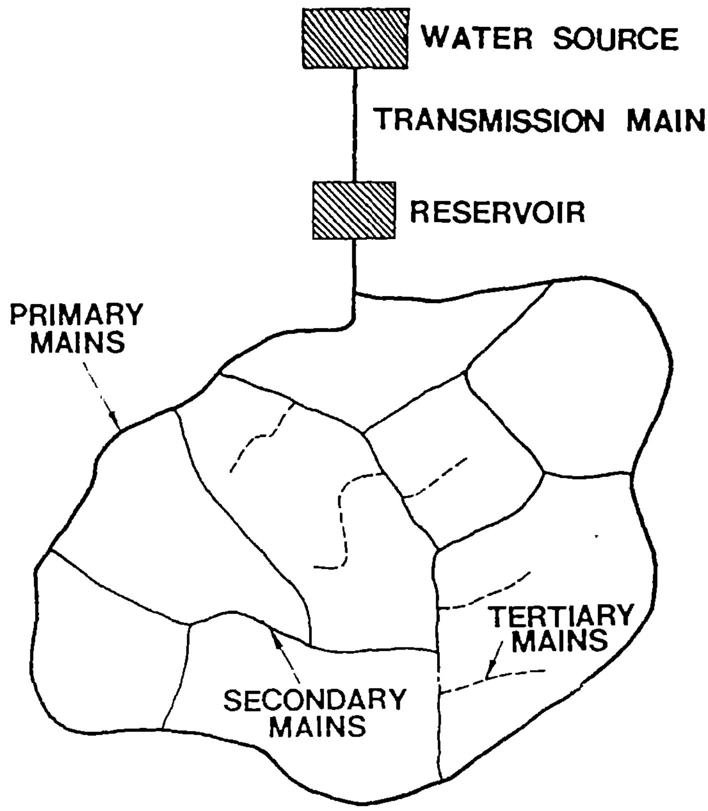


Fig. 7. Schematical lay-out of distribution system.

Primary pipes or water mains take the water from the transmission main to the major parts of the supply area, while secondary pipes distribute the water to smaller areas. Tertiary pipes and those mains laid in individual roads and streets are where the connections are made for supplying water to the consumers' premises.

The size of the water mains depends entirely on the quantities of water required in any part of the distribution area.

Water mains need very little maintenance except when damaged and when leakages occur. However, most leakages are caused by bad mainlaying and corrosion problems, either because of the quality of the water itself or because of soil conditions. To maintain a constant check on losses through leakage on the system it is necessary to monitor the distribution process by means of water meters and pressure gauges.

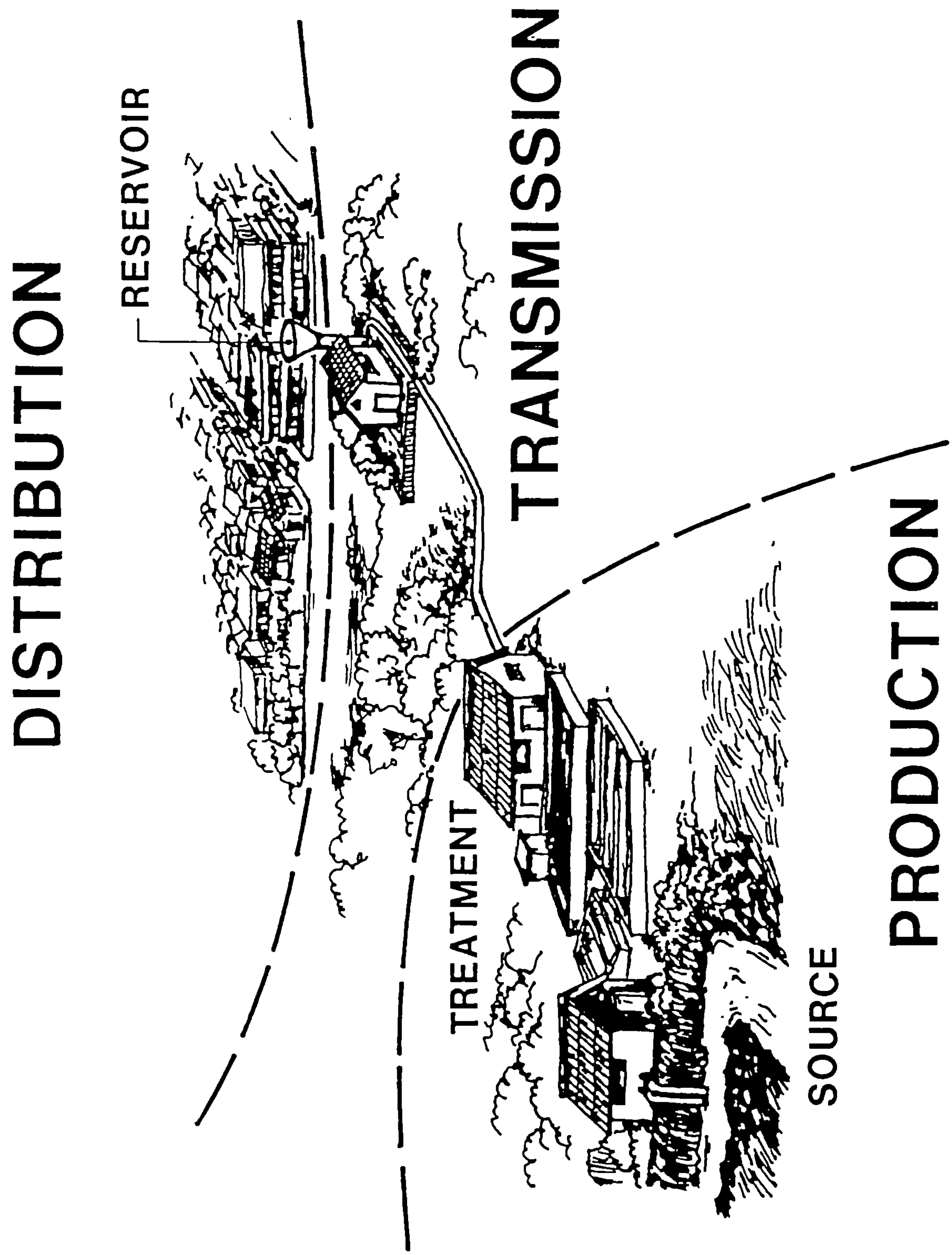
Routine inspection should be made of all gate valves, fire hydrants and any other special fittings.

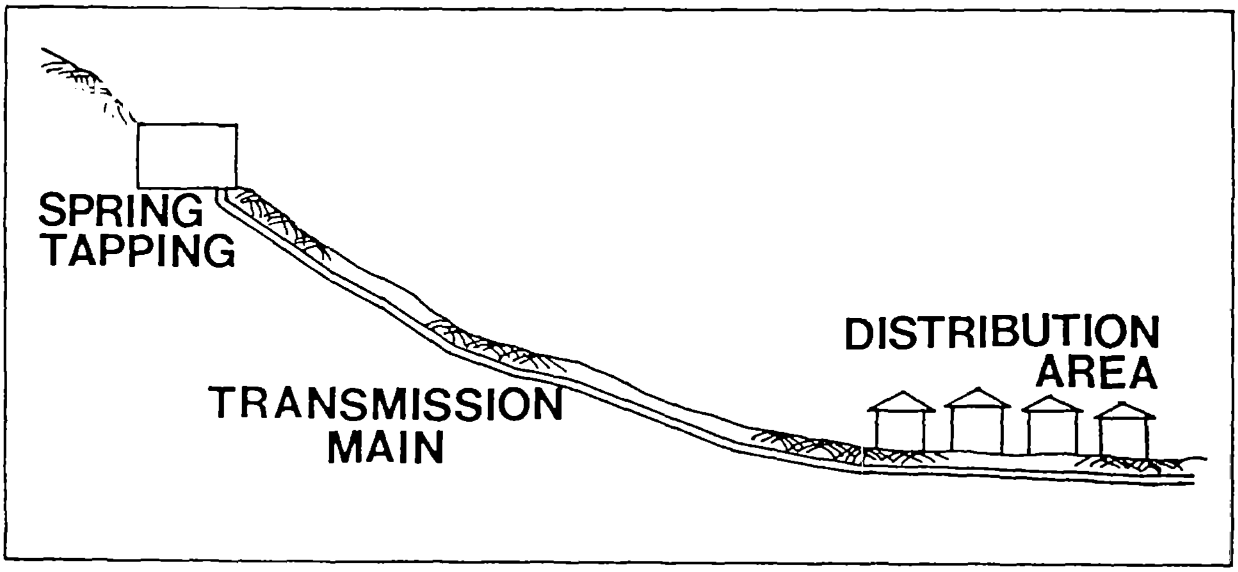
The operation of the distribution system is normally simple.
A good distribution system operates with ALL GATE VALVES OPEN.
They are closed only during emergencies of for special purposes e.g. leakage surveys.

5. SUMMARY

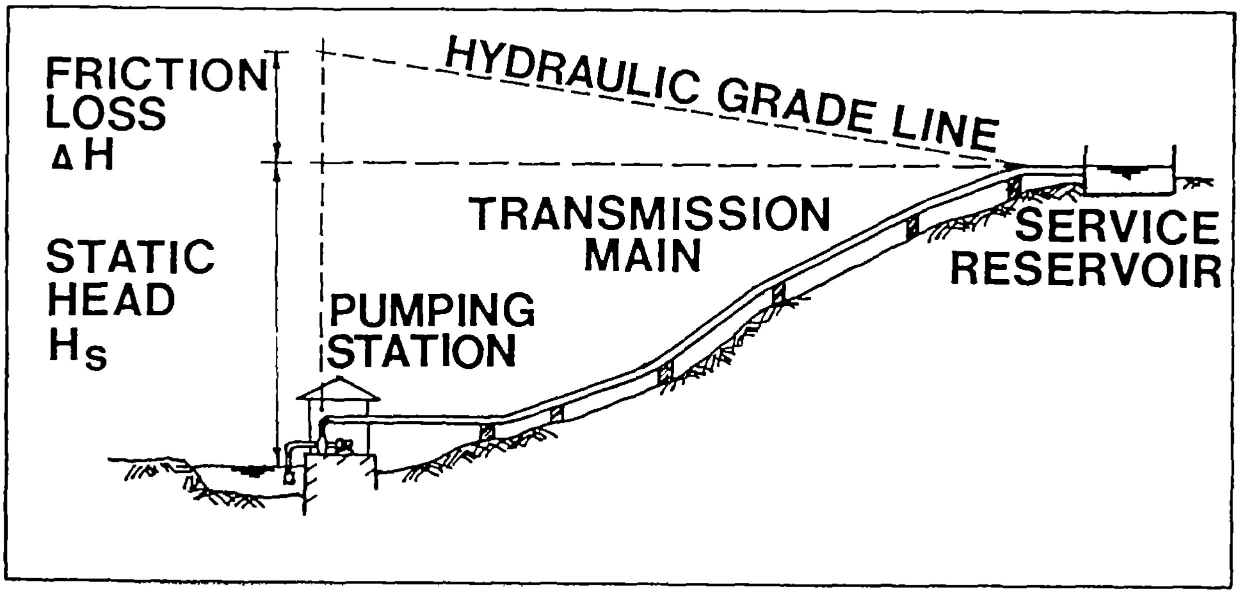
- The system that links the water source with the consumers comprises:
  - . transmission;
  - . storage;
  - . distribution.
- Water can be transmitted by:
  - . gravity, or
  - . pumps.
- Supply and demand of water are balanced by reservoirs. There are 2 types of reservoirs:
  - . ground reservoirs;
  - . water towers.
- The distribution system is built up of 3 types of mains:
  - . primary;
  - . secondary;
  - . tertiary.

* * *

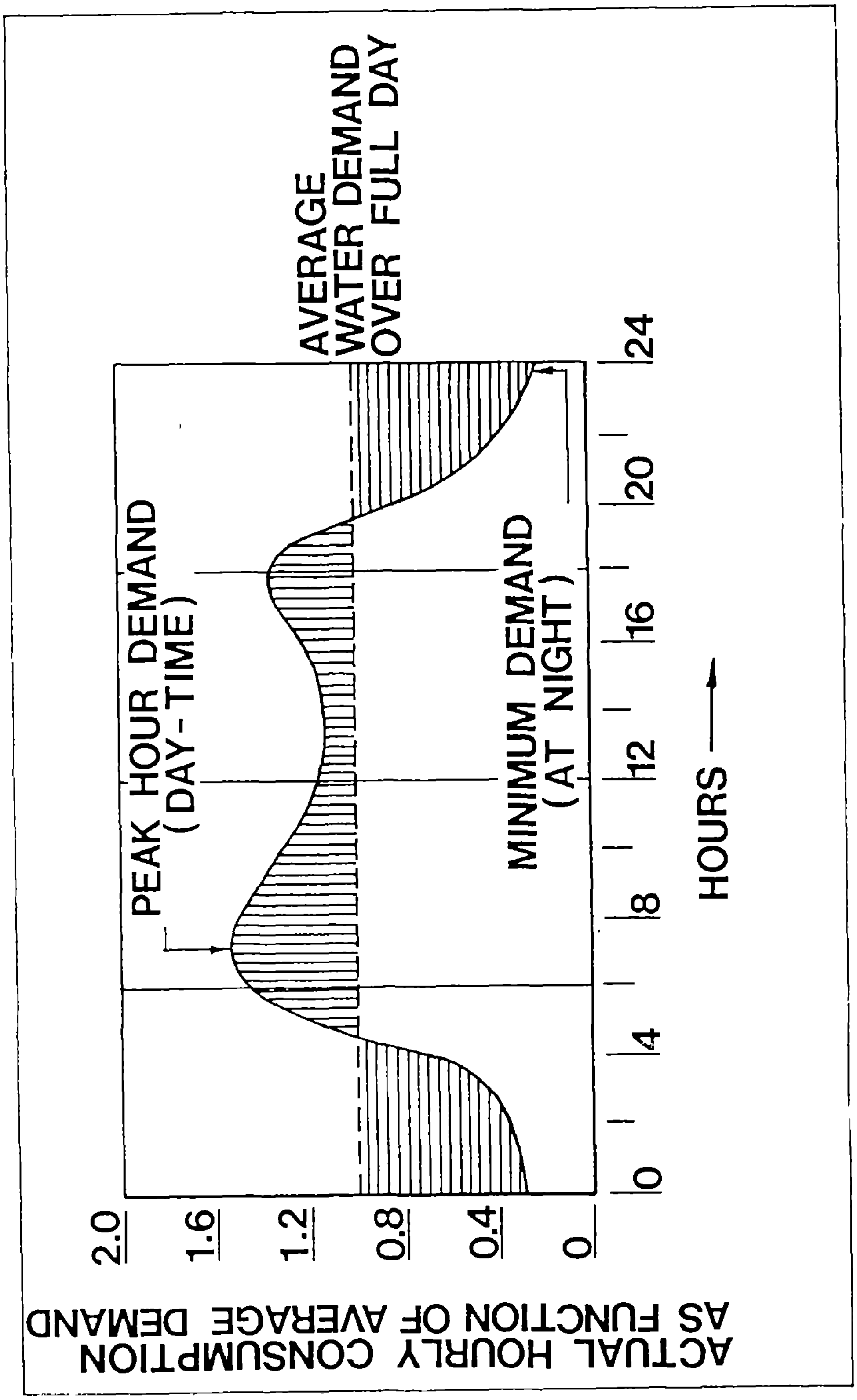

DISTRIBUTION
RESERVOIR
TRANSMISSION
TREATMENT
PRODUCTION
SOURCE



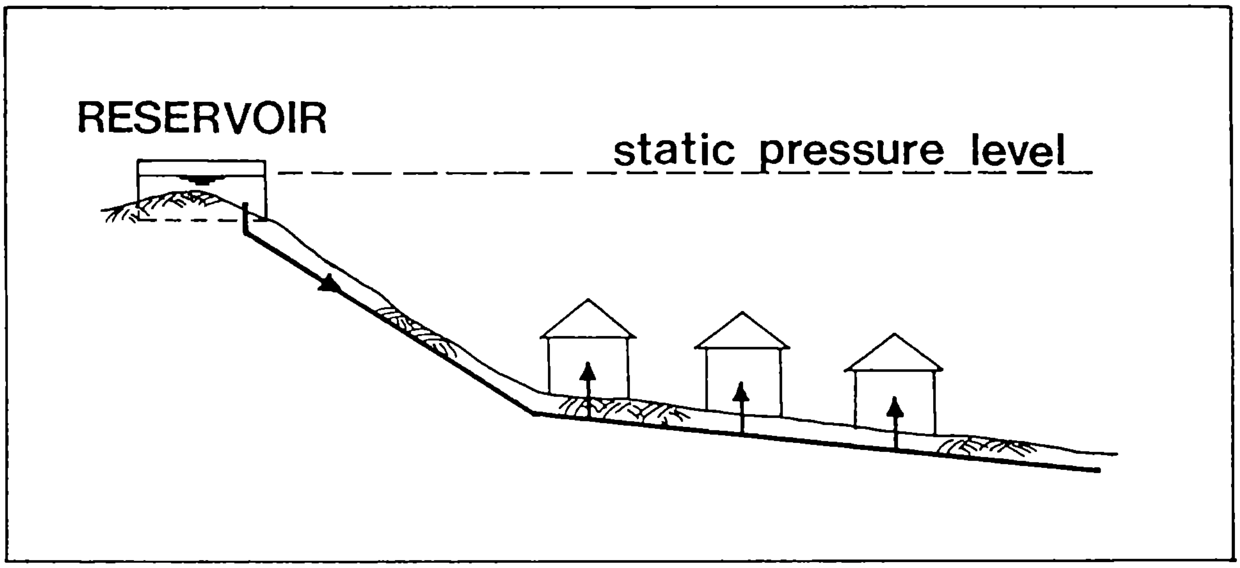
GRAVITY FLOW



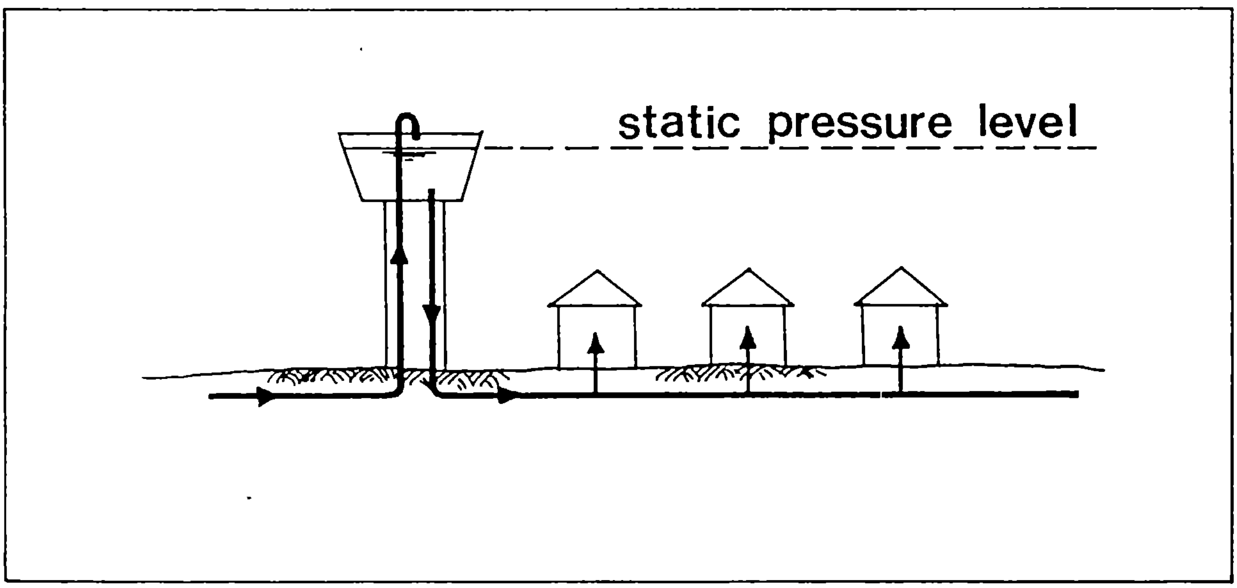
PUMPED FLOW



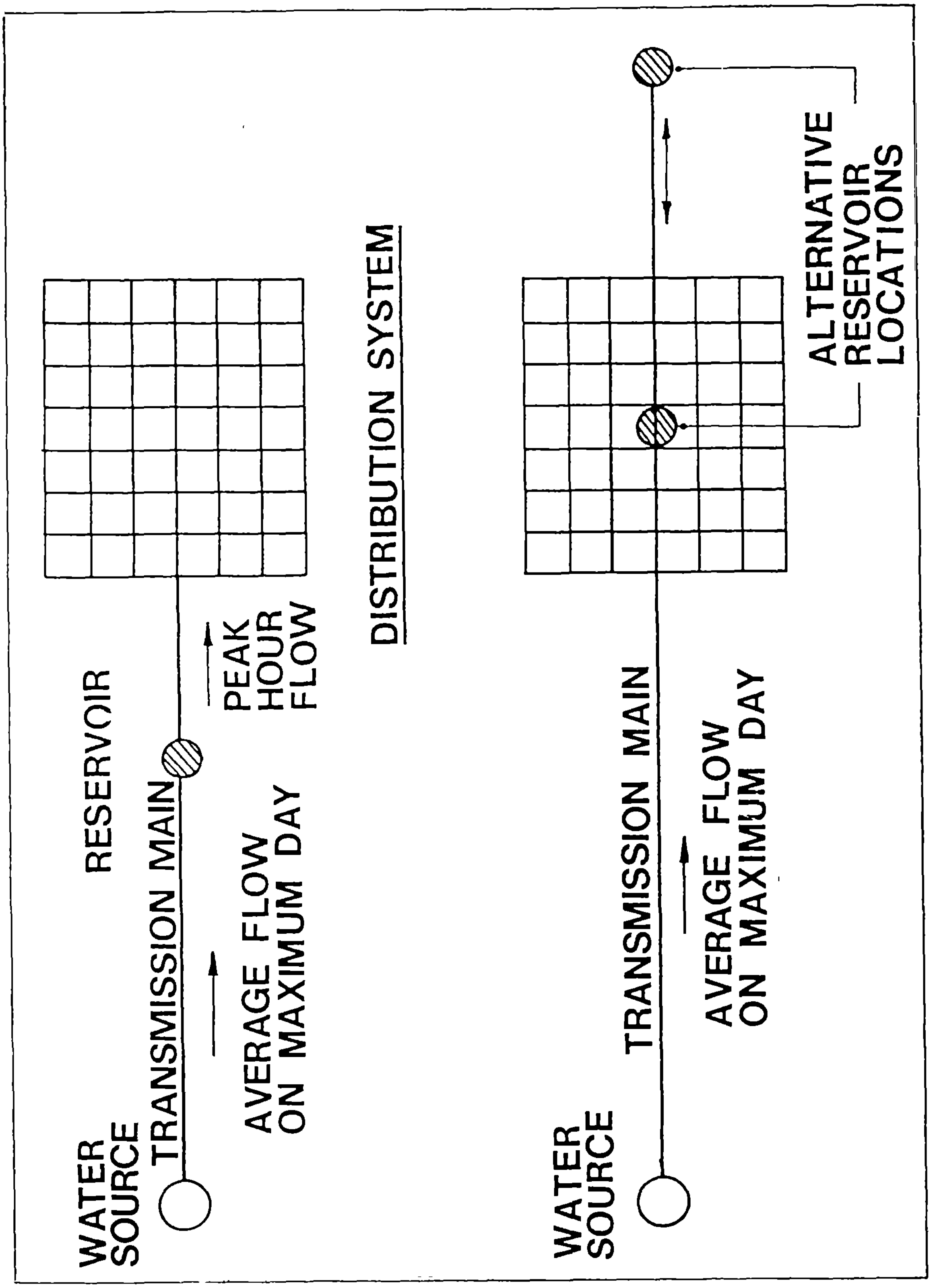
DAILY WATER CONSUMPTION FLUCTUATION



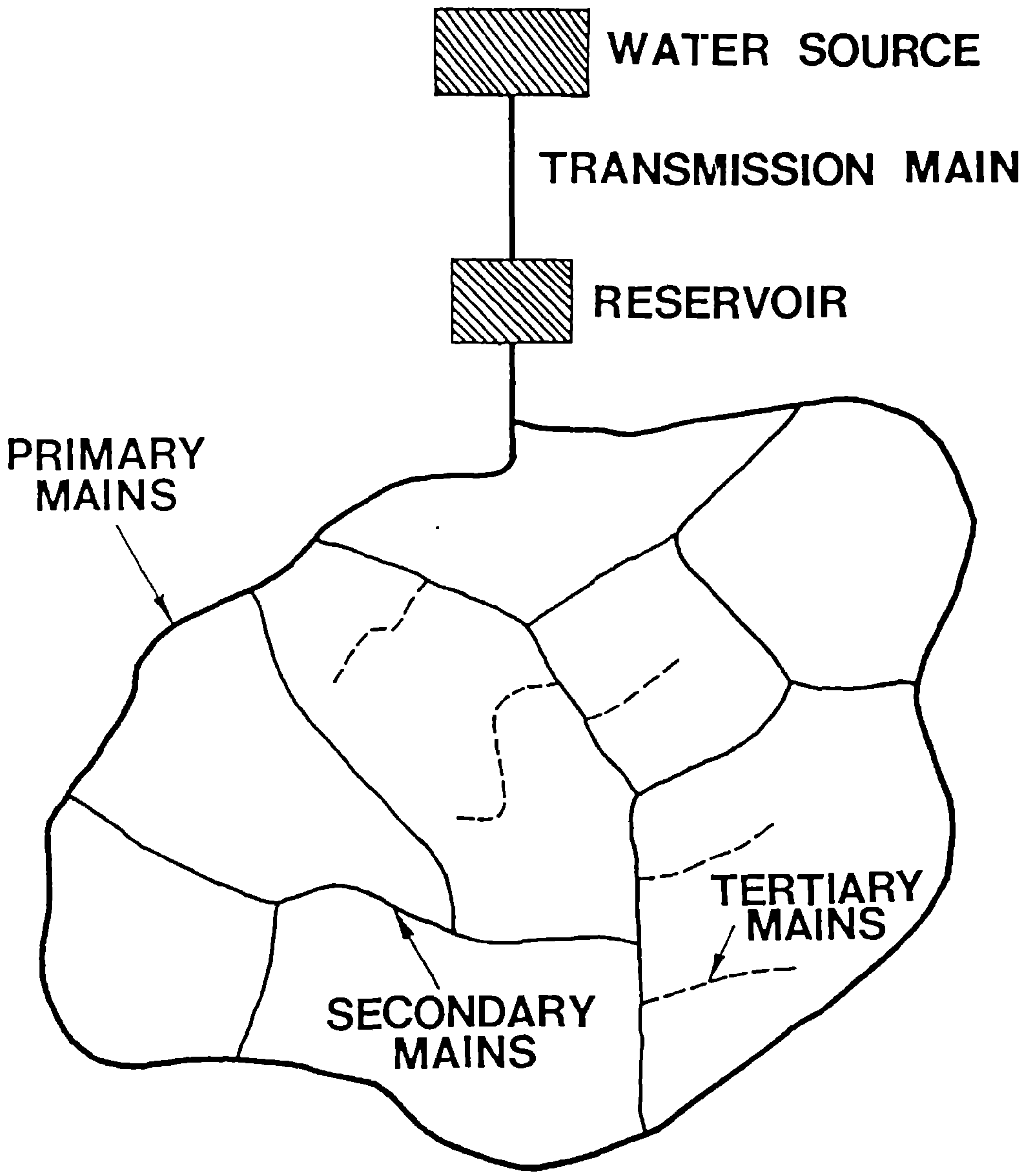
WITH ELEVATED GROUND RESERVOIR



WITH WATER TOWER



LOCATION OF RESERVOIR IN THE SYSTEM



DISTRIBUTION SYSTEM

Module : ANCHOR BLOCKS	Code : TDD 260
	Edition : 21-09-1984
Section 1 : INFORMATION SHEET	Page : 01 of 01/10

Duration :	45 minutes.
Training objectives :	After the session the trainees will be able to: - identify where anchor blocks are needed on a pipeline; - determine the size of anchor blocks.
Trainee selection :	- Head of Technical Department; - Head of Section Distribution; - Head of Sub-section Distribution & Connection; - Pipeline Inspector; - Head of Section Planning & Supervision; - Head of Sub-section Planning; - Technical Planning Assistant; - Head of Sub-section Supervision; - Construction Supervisor.
Training aids :	- Viewfoils : TDD 260/V 1-5; - Handout : TDD 260/H 1.
Special features :	-
Keywords :	Anchor block/thrust block.

1. Introduction

- Pressure within any pipeline produces thrust.
- Normally the thrust is contained by pipe walls.
- Bends and tees etc. produce the effect of thrust continuing to act in a straight line.

2. **Thrust at end of pipe**

Show V 1 (a-b)

- Thrust at end of pipe

$$T = \left(\frac{\pi D^2}{4} \times \frac{1}{100}\right) \times P$$

T = Total thrust (kg)
D = Diameter of pipe (cm)
P = Pressure (kg/cm^2)

3. **Thrust at bends**

Show V 2 (a-b)

- Thrust at bends:

$$T = A \times P \times 2 \sin\left(\frac{\alpha}{2}\right)$$

T = Total thrust (kg)
A = Area of Pipe (cm^2)
P = Pressure (kg/cm^2)
= Angle of bend

4. **Siting of thrust blocks**

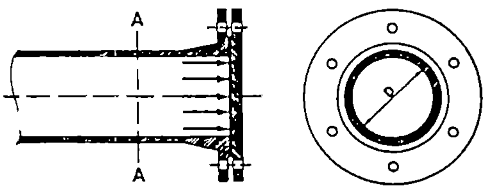
Show V 3

- Thrust block is normally:
  - . constructed of concrete;
  - . set at outside of bend;
  - . set behind Tee;
  - . set at end of pipeline;
- Bearing strength of ground behind trust block must be considered e.g. rock or clay.

5. **Size of thrust block**	Show V 4, V 5
- Approximate sizes given by manufacturer's tables.	
6. **Exercise**	
- Draw simple distribution network.	Use whiteboard
- Invite trainees to indicate where thrust blocks are required (10 minutes).	Use drawing on white-board.
7. **Summary**	Give H 1

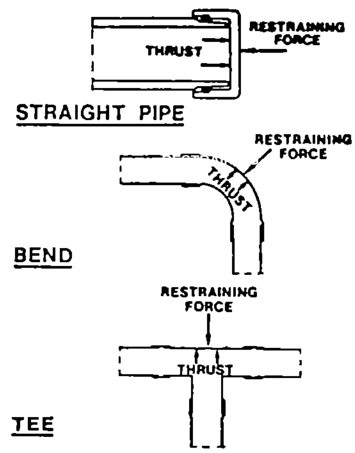
Module : ANCHOR BLOCKS	Code : TDD 260
	Edition : 21-09-1984
Section 3 : T R A I N I N G A I D S	Page : 01 of 01

Thrust at end of pipe — TDD 260/V1

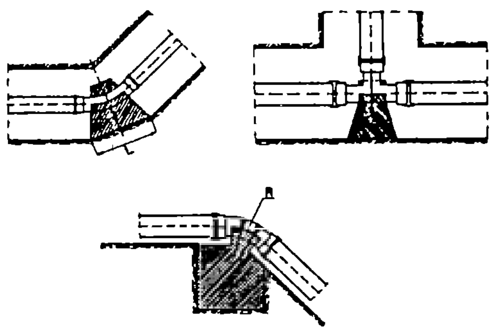


CROSS SECTION A-A

Thrust at bends and junctions — TDD 260/V 2



Examples of anchor blocks — TDD 260/V3



EXAMPLES OF ANCHOR BLOCKS

Tables size of anchor blocks (1) — TDD 260/V 4

PRESSURE IN PIPE (m.head)	H
15	1
30	7
45	11
60	13
75	15
90	17
105	18
120	19
135	20
150	21
165	22
180	23

TYPE OF FITTING	F
11¼° Bend	1
22½° Bend	7
45° Bend	13
90° Bend	18
End cap or valve	20
Tee (use outlet dia for D)	15

TYPE OF SOIL	S
Gravel	1
Sand	4
Sandy Loam	7
Loam	12
Clay Loam	13
Clay	16

DIA (mm)	D
50	1
75	8
100	13
150	20
200	25
250	29
300	32
350	35
400	37
450	39
500	41
600	44
700	47
800	48
900	51
1000	53

Tables size of anchor blocks (2) — TDD 260/V 5

TOTAL	WIDTH OF ANCHOR BLOCK (metres)	HEIGHT OF ANCHOR BLOCK (metres)
57	0.3	0.3
60	0.5	0.3
63	0.6	0.3
56	0.7	0.4
69	0.8	0.5
72	0.8	0.6
75	0.9	0.8
78	1.1	0.9
81	1.4	1.1
84	1.5	1.4
87	1.8	1.6
90	2.1	2.0

Anchor blocks — TDD 260/H 1

1. INTRODUCTION

Pressure within a pipeline produces thrust. This thrust is normally contained by the walls of the pipe but where there occurs any change of direction, or abrupt stop, the thrust continues to act in a straight line.

2. THRUST AT END OF PIPE

The most simple example of this can be seen by considering the thrust on a blank flange at the end of a pipeline :

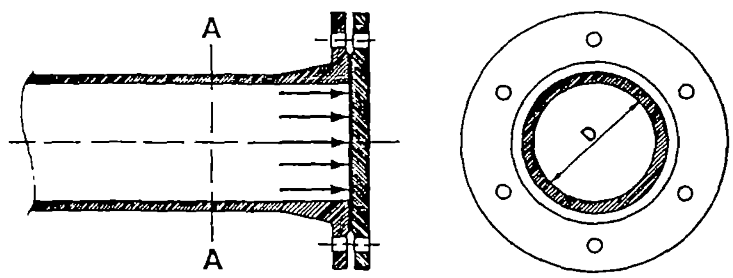


Fig. 1. Thrust at end of pipe.

On every square centimetre of the blank flange there is a thrust of P kilogrammes.

Total thrust on flange = (area on flange [cm^2]) x P

$$= \left(\frac{\pi D^2}{4} \times \frac{1}{100}\right) \times P$$

If, for example, the water pressure (P) is 10 kg/cm^2 and the diameter of the pipe (D) is 100 mm, then:

Thrust on flange $= \left(\frac{\pi 100^2}{4} \times \frac{1}{100}\right) \times 10$

$= 786$ kg.

In this example the thrust would be carried by the bolts holding the blank flange in position. However, if we had been considering an end cap fitted with only a spigot and socked connection, the thrust would tend to force the cap off the pipe unless it was restained from the outside:

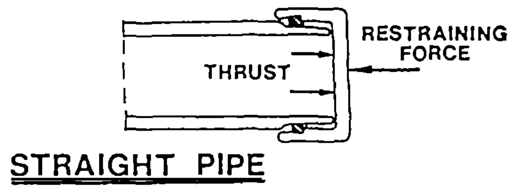


Fig. 2. Forces acting on end of pipe.

3. **THRUST AT BENDS**

A similar situation arises at bends and junctions, where an external restraining force is usually required to balance the thrust within the pipe.

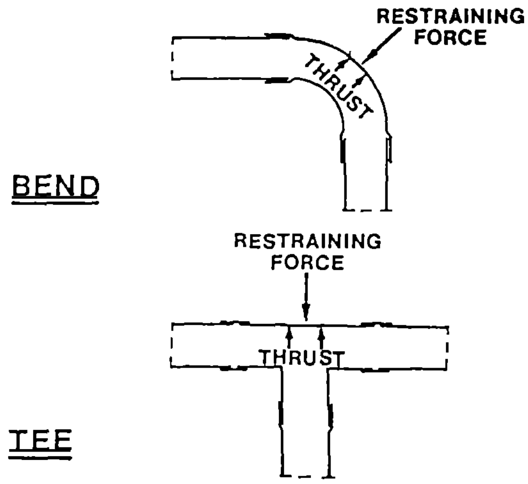


Fig. 3. Thrust at bends/tees.

The thrust is given by the formula

$$T = A \times P \times 2 \text{ Sin } \frac{\alpha}{2}$$

In which α is the angle between the 2 pipe axes.

4. SITING OF THE THRUST BLOCK

In pipe-laying practice the restraining force is usually provided by a block of concrete cast in-situ against the pipe and in contact with the walls of the trench. This is called an ANCHOR BLOCK or THRUST BLOCK.

The concrete transmits the thrust from the pipe onto the sides of the trench, and the area of concrete in contact with the trench wall determines the pressure the wall is subjected to. Thus the required size of anchor block is determined by considering:
a. the water pressure in the pipe;
b. the safe bearing pressure of the trench wall.

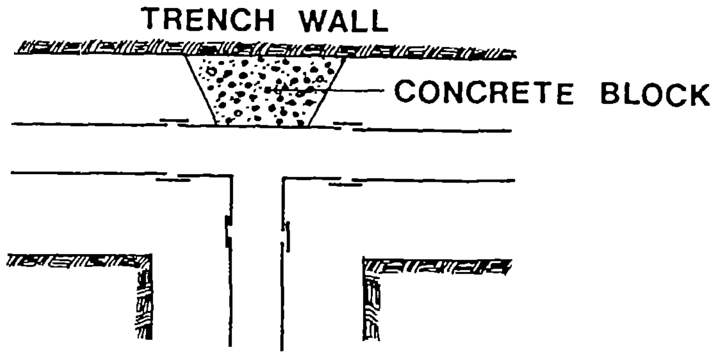


Fig. 4. Thrust block at T-junction.

5. SIZE OF THRUST BLOCK

The safe bearing pressure of the trench wall will depend on the material it is composed of. Some typical values are given below.

Soil type	Safe bearing pressure kg/cm² (Assuming 0.6 m cover on pipe)
Soft clay	0.25
Sand	0.5
Sand & gravel	0.75
Sand & gravel bonded with clay	1.0
Shale	2.5

In the previous example it was found that the thrust on the end cap of a 100 mm diameter pipe, caused by a water pressure of 10 kg/cm^2, was 786 kg. If the ground in which the pipe was laid was sand and gravel then it can be seen from the table that 1 cm^2 of this can withstand a thrust of 0.75 kg.

The required area of the concrete block is then 786/0.75 cm^2 = 1048 cm^2 say 1050 cm^2.

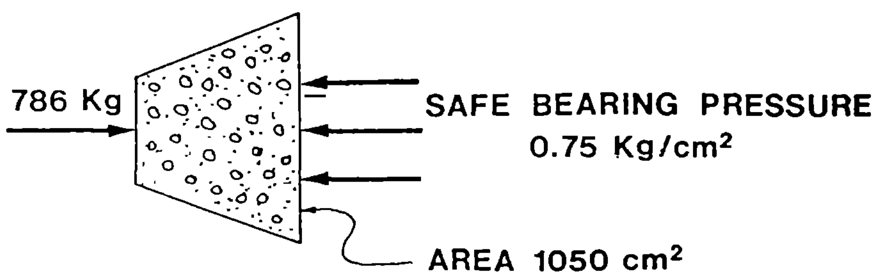


Fig. 5. Forces acting on thrust block.

Various manufacturer's tables are available which enable the calculation of the size of the anchor block to be made quickly and simply. Overleaf is an example of such a table.

D = Diameter of pipe (mm)
F = Type of fitting
H = Pressure in pipe (metres head of water)
S = Type of soil

total T = D + F + H + S

From the table, when T has been calculated, the size of the anchor block against the wall of the trench can be found.

DIA (mm)	D
50	1
75	8
100	13
150	20
200	25
250	29
300	32
350	35
400	37
450	39
500	41
600	44
700	47
800	49
900	51
1000	53

TYPE OF FITTING	F
11.25° bend	1
22.5° bend	7
45° bend	13
90° bend	18
End cap or valve	20
Tee (use outlet dia for D)	15

TYPE OF SOIL	S
Gravel	1
Sand	4
Sandy Loam	7
Loam	12
Clayey Loam	13
Clay	16

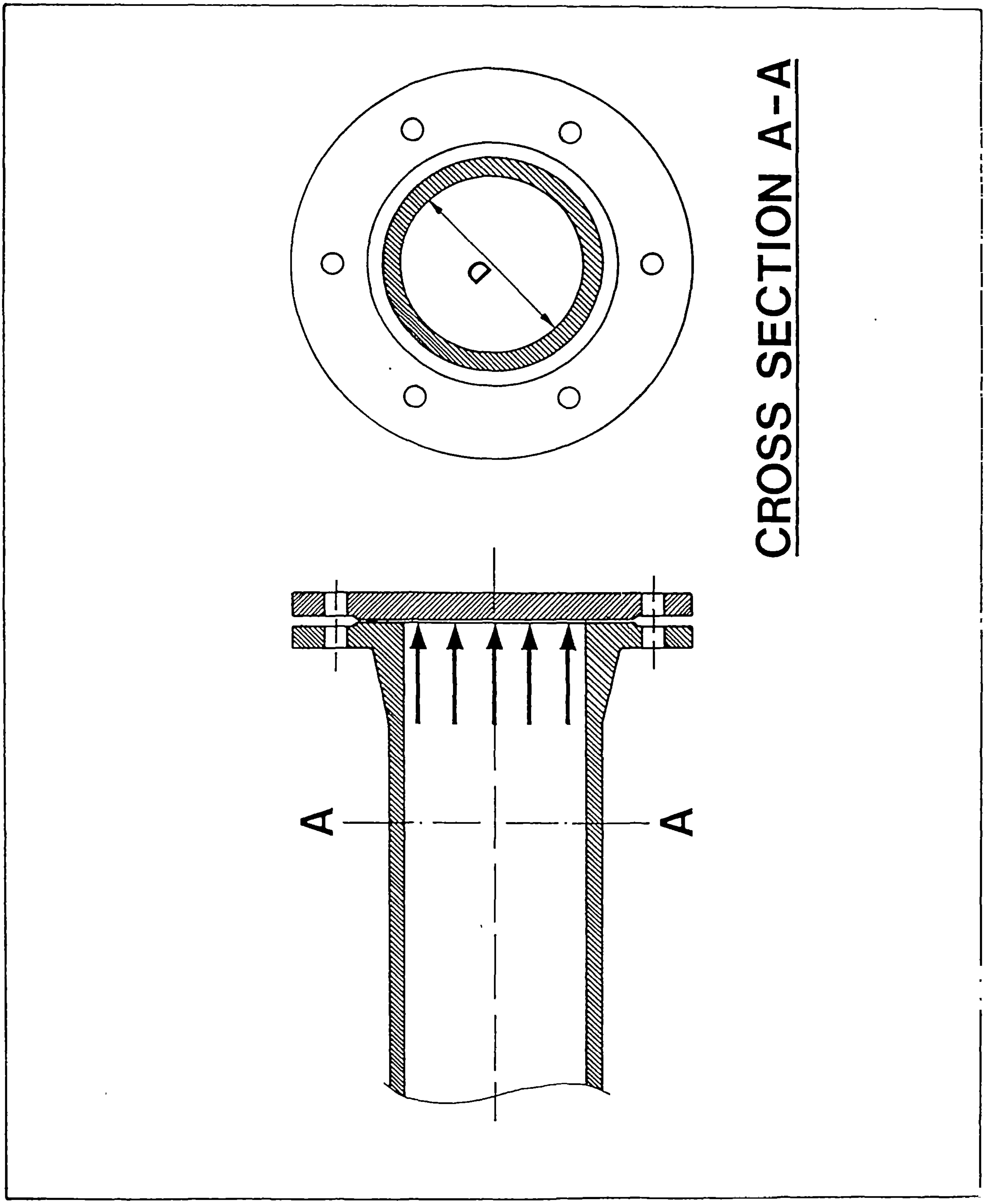
PRESSURE IN PIPE (M HEAD)	H
15	1
30	7
45	11
60	13
75	16
90	17
105	18
120	19
135	20
150	21
165	22
180	23

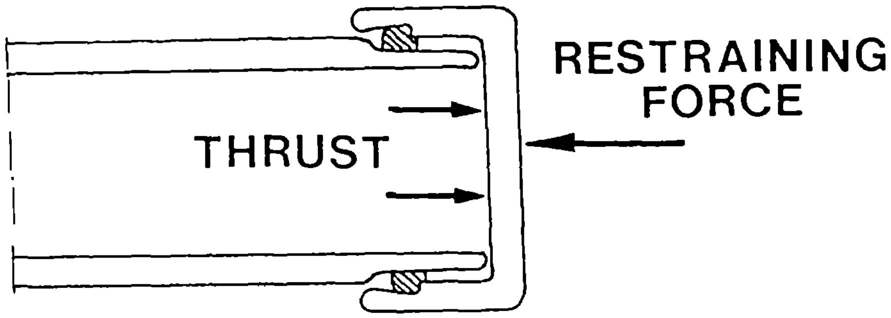
TOTAL T	Width of anchor block (metres)	Height of anchor block (metres)
57	0.3	0.3
60	0.5	0.3
63	0.6	0.3
66	0.7	0.4
69	0.8	0.5
72	0.8	0.6
75	0.9	0.8
78	1.1	0.9
81	1.4	1.1
84	1.5	1.4
87	1.8	1.6
90	2.1	2.0

6. SUMMARY

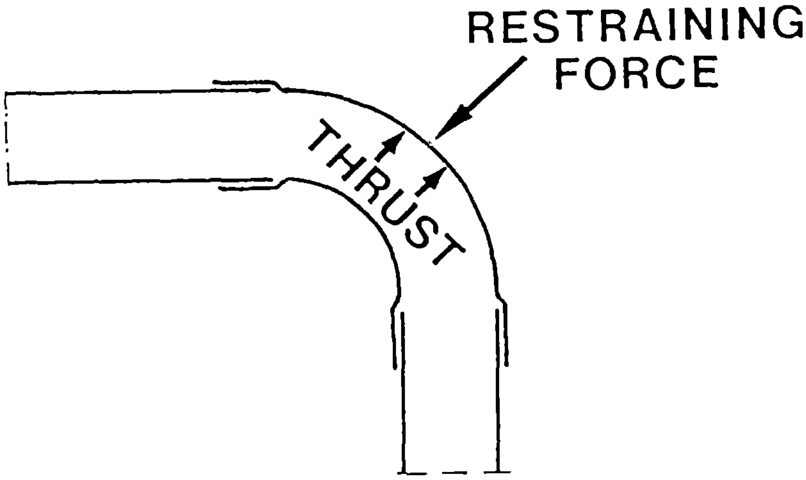
- Pressure within a pipeline produces thrust.
- Where there is any change of direction or abrupt stop, the thrust continues to act in a straight line.
- Pipe end caps with only a spigot and socket connection and pipe bends and junctions require external support.
- Tables can be used to determine the size of thrust blocks.

* * *

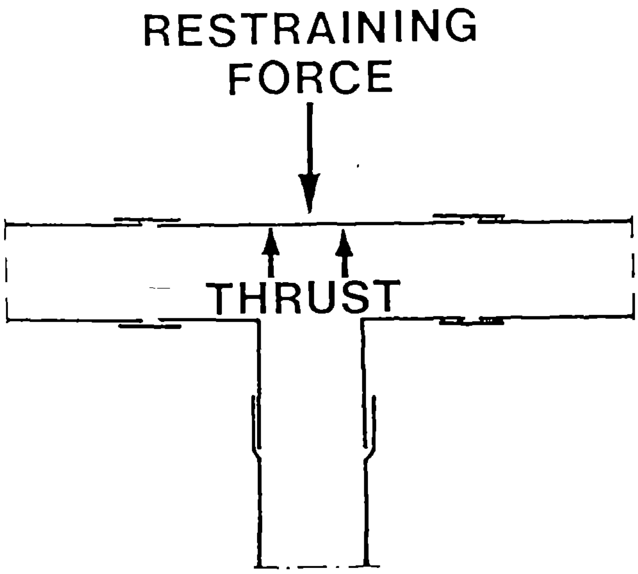

CROSS SECTION A-A
D
A
A



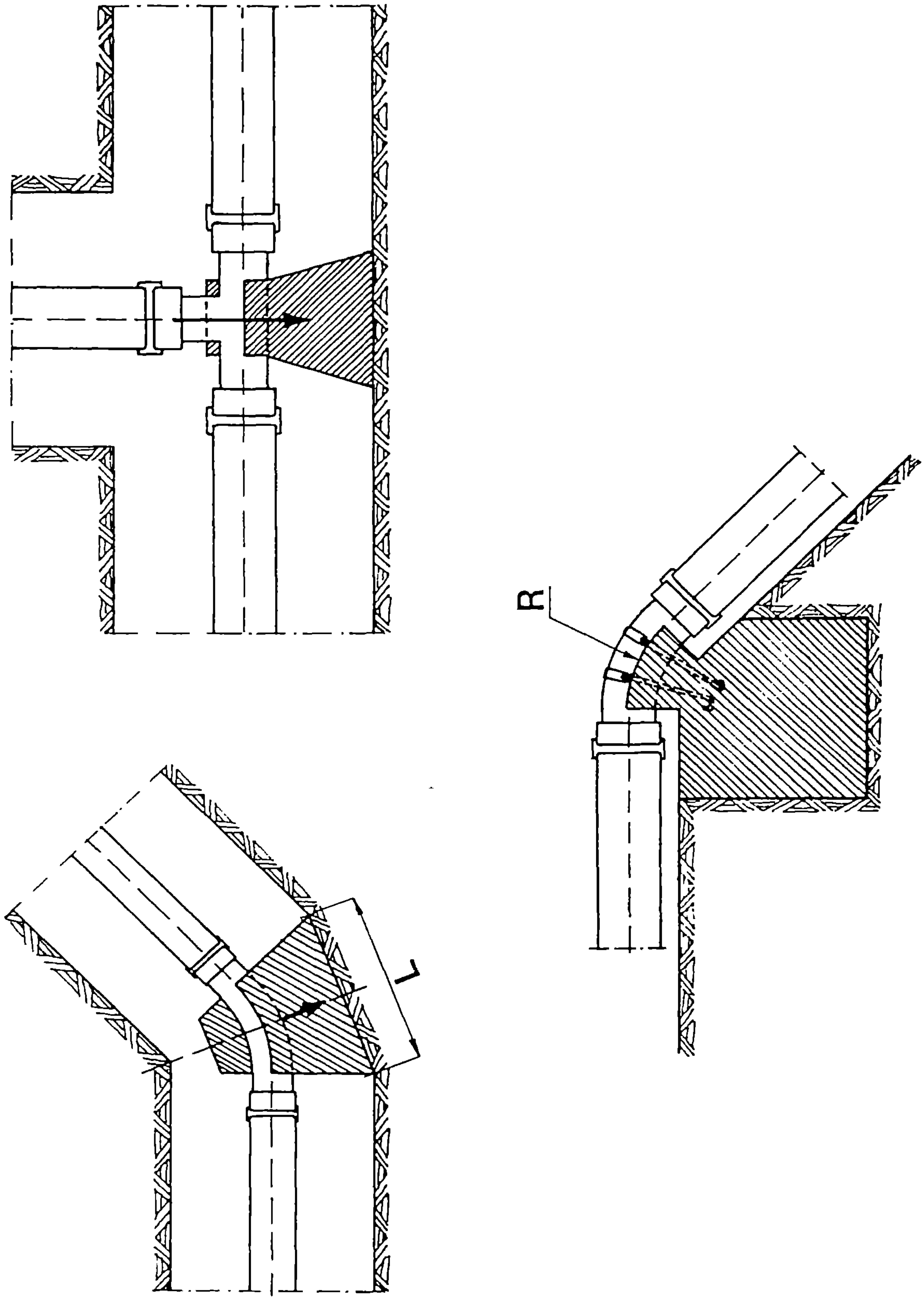
STRAIGHT PIPE



BEND



TEE



EXAMPLES OF ANCHOR BLOCKS

PRESSURE IN PIPE (m.head)	H
15	1
30	7
45	11
60	13
75	15
90	17
105	18
120	19
135	20
150	21
165	22
180	23

TYPE OF FITTING	F
11 1/4° Bend	1
22 1/2° Bend	7
45° Bend	13
90° Bend	18
End cap or valve	20
Tee (use outlet dia for D)	15

TYPE OF SOIL	S
Gravel	1
Sand	4
Sandy Loam	7
Loam	12
Clay Loam	13
Clay	16

DIA (mm)	D
50	1
75	8
100	13
150	20
200	25
250	29
300	32
350	35
400	37
450	39
500	41
600	44
700	47
800	49
900	51
1000	53

TOTAL	WIDTH OF ANCHOR BLOCK (metres)	HEIGHT OF ANCHOR BLOCK (metres)
57	0.3	0.3
60	0.5	0.3
63	0.6	0.3
66	0.7	0.4
69	0.8	0.5
72	0.8	0.6
75	0.9	0.8
78	1.1	0.9
81	1.4	1.1
84	1.5	1.4
87	1.8	1.6
90	2.1	2.0

Module : FLUSHING WATER MAINS	Code : TDO 170
	Edition : 29-09-1984
Section 1 : INFORMATION SHEET	Page : 01 of 01/05

Duration :	45 minutes.
Training objectives :	After the session the trainees will be able to: - state the reasons for flushing mains; - demonstrate their ability to flush water mains; - state the flow rates required to effectively flush water mains.
Trainee selection :	- Head of Technical Department; - Head of Section Distribution; - Head of Sub-section Distribution & Connections; - Pipelayer; - Pipeline Inspector
Training aids :	- Demonstration area (water main with valves); - Viewfoils : TDO 170/V 1-3; - Handout : TDO 170/H 1.
Special features :	-
Keywords :	Flushing mains/water mains.

1. Introduction	
- Residue will always occur in water mains, whether: a. newly laid mains; b. existing mains.	Show V 1
- Creates problems: a. unhygienic; b. dirty water problems; c. damaging valves and fittings; d. restricting flow rates.	
2. Dirty water	
- Caused by abnormal flows in the water main that are: a. higher than normal; b. lower than normal.	
- Flushing is imposing an abnormally high flow on water main to eliminate residue by controlled means.	
- To remove residue from the main flush section at flow rate of: . 75 mm main - 7 l/sec; . 100 mm main - 15 l/sec; . 150 mm main - 40 l/sec.	Show V 2
- At least twice the volume of water normally in the main should be flushed.	
- Flushing may be enhanced by using water and air together.	Show V 3
3. Summary	Give H 1

Module : FLUSHING WATER MAINS	Code : TDO 170
	Edition : 29-09-1984
Section 3 : T R A I N I N G A I D S	Page : 01 of 01

Flusing water mains (1) TDO 170/V 1

FLUSHING WATER MAINS (1)

Residues . Newly laid mains
- Existing mains

Problems : - Unhygienic
- Dirty water
- Damage (valves/fittings)
- Flow rates restricted

Flushing water mains (2) TDO 170/V 2

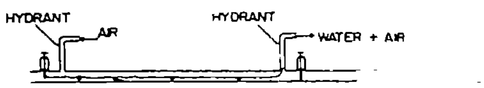
FLUSHING WATER MAINS (2)

Pipe dia.	Flow rate
ø 75mm	7 l/s
ø 100mm	15 l/s
ø 150mm	40 l/s

2X Main volume

Flushing with water and air TDO 170/V 3

AIR/WATER FLUSHING



Flushing water mains TDO 170/H 1

1. INTRODUCTION

Residue will always remain in water mains even when they are in constant use, whether the mains are newly laid or old existing ones.

Additional residue is found in more quantity, generally, in newly laid mains as it is almost inevitable that some deposits enter the main during mainlaying.

This residue creates probles:
a. unhygienic conditions;
b. dirty water;
c. damaged valves and fittings;
d. restricted flow rates;
and should be avoided as much as possible. Most residue can be removed by flushing.

2. DIRTY WATER

This is normally caused by abnormal flows in the water main, whether high or low, as the residue normally forms a series of ridges at the bottom of the pipe. Due to the way in which water flows in the pipe these ridges remain static at normal or constant flow rates.
However, with large changes in flow rates the ridges of sediment are disturbed and reshaped according to the new flow.

This disturbance of the residue allows particles to be held in suspension in the water, thus causing dirty water.
To remove this dirty water the mains should be flushed, but at a predetermined rate for the size of pipe:

75 mm pipe	-	7 l/sec.
100 mm pipe	-	15 l/sec.
150 mm pipe	-	40 l/sec.

At least twice the volume of the water main to be flushed should be used for flushing.

In some cases the effect of flushing can be enhanced by allowing air to enter the pipe and flushing with air and water together (see Fig. 1)

AIR/WATER FLUSHING

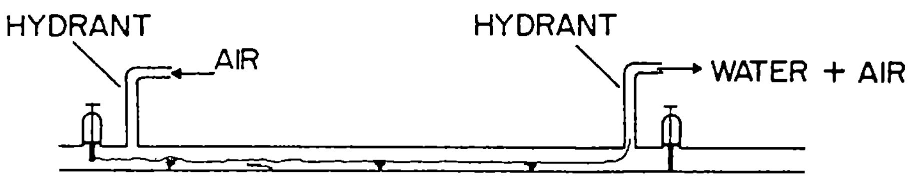


Fig. 1. Air/water flushing.

Normally the water is flushed from a fire hydrant or a wash-out.

3. SUMMARY

Flushing is important to preserve water mains and minimize maintenance.

* * *

TITLE :	CODE :
1. Flushing water mains (1)	TDO 170/V 1
2. Flushing water mains (2)	TDO 170/V 2
3. Air water flushing	TDO 170/V 3

FLUSHING WATER MAINS (1)

Residues : Newly laid mains
- Existing mains

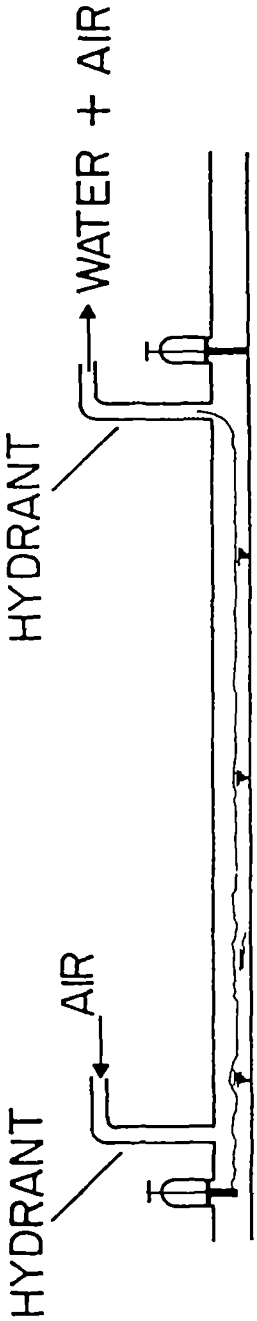
Problems :
- Unhygienic
- Dirty water
- Damage (valves/fittings)
- Flow rates restricted

FLUSHING WATER MAINS (2)

Pipe dia.	Flow rate
ø 75mm	7 l/s
ø100mm	15 l/s
ø150mm	40 l/s

2X Main volume

AIR/WATER FLUSHING



Module : **CAUSES OF LEAKAGE**	Code : TDO 610
	Edition : 19-03-1985
Section 1 : INFORMATION SHEET	Page : 01 of 01/07

Duration :	45 minutes.
Training objectives :	After the session the trainees will be able to: - specify the 6 most common causes of leakage from water mains.
Trainee selection :	- Head of Technical Department; - Head of Section Distribution; - Head of Sub-section Distribution & Connections; - Pipeline Inspector; - Leakage Officer.
Training aids :	- Viewfoils : TDO 610/V 1; - Handout : TDO 610/H 1.
Special features :	-
Keywords :	Leakages.

1. Introduction	
- There are 6 main categories of problems which cause water leaks from mains: . corrosive soil conditions; . poor quality of materials and workmanship; . ground movement; . water hammer; . corrosive water; . age of mains and services.	Show V 1
2. Corrosive soil conditions	
- Many soils contain corrosive elements either within the soil itself or in the water content.	Show samples of externally corroded pipe
- Mains should either be selected of the correct material or protected.	
3. Poor quality materials and workmanship	
- Materials from manufacturers sometimes contain faults.	Show samples of faulty materials
- These faults may cause leakage when the material comes under pressure.	
- The workmanship, particularly in jointing, can cause leakage if not done correctly.	
4. Ground movement	
- The ground in which water mains are laid moves regularly because of: a. moisture content (expansion or shrinkage); b. subsidence; c. traffic; d. slippage.	

5. Water hammer	
- Caused by turning off too quickly: . valves; . taps; . hydrants; . etc.	
- Also caused by insufficient fixings of pipes to walls etc.	
6. Corrosive water	
- Water from treatment works sometimes has a corrosive effect on the pipes.	Show samples of internally corroded pipes
- Raw water sometimes causes corrosion of pipes.	
7. Age of mains and service connections	
- Pipes and service connections deteriorate with age.	
- Life of pipes depends on many factors including corrosive effects.	
- Age of pipes and fittings should always be noted.	
8. Summary	Give H 1

Module : **CAUSES OF LEAKAGE**	Code : TDO 610
	Edition : 29-09-1984
Section 3 : T R A I N I N G A I D S	Page : 01 of 01

Causes of leakage TDO 610/V 1

CAUSES OF LEAKAGE
- Corrosive soils
- Corrosive water
- Poor quality
  - Materials
  - Workmanship
- Ground movement
- Water hammer
- Age

Causes of leakage TDO 610/H 1

1. INTRODUCTION

Leakage on water mains has causes which can be grouped into 6 main categories :
- corrosive soil conditions;
- poor quality of materials and workmanship;
- ground movement;
- water hammer;
- corrosive water;
- age of mains and service connections.

One or a combination of these factors causes leakage.

2. CORROSIVE SOIL CONDITIONS

Many soils contain corrosive elements or compounds within their structure or the moisture content of the soil is corrosive.
Examples of this are certain clays or "made-up" (man-made) soils containing ash.

If a metal water main is laid in these soils then corrosion may take place, not only of the main, but also of the rubber jointing gaskets (if used).

Therefore care should be taken to select the correct material for the main.

3. POOR QUALITY MATERIALS AND WORKMANSHIP

No matter how good the quality control checks made by manufacturers, inevitably one or two defective items are delivered to water enterprises. Simple tests such as the "ring test" on pipes should be made before laying the pipes. (A ring test is merely striking the pipe with a hammer and listening for the noise. Defective pipes have a distorted "ring").

Equally, when pipes and fittings are laid and installed, careful attention should be given to the quality of workmanship and supervision, to avoid building in leaks from the beginning.

4. GROUND MOVEMENT

Ground movement is caused in many ways and if a water main moves with it, this causes leakage.

The most common cause is moisture content variation, causing expansion during wet conditions and contraction during dry conditions. Subsidence occurs due to underground workings e.g. mining, or due to erosion e.g. erosion of caves.

Traffic continually moving over roads not properly reinforced, or trenches of water mains not properly backfilled, causes movement and damage to the main.

Slippages of ground on slopes, usually caused by rainfall, can damage water mains and cause leakage.

5. WATER HAMMER

Water hammer is a common cause of leakage and occurs when valves, hydrants, taps etc. are turned off too quickly. The energy in the pipeline sets up pressure waves which can easily cause fractures. Additionally, unsupported or badly supported pipe work contributes to this cause of leakage problem.

6. CORROSIVE WATERS

Raw water from intakes to treatment works and sometimes also treated water can have a corrosive effect on the internal lining or face of a pipe. A careful selection must be made of pipe linings (e.g. cement lining) and pipe materials.

7. AGE OF MAINS AND SERVICE CONNECTIONS

Pipes for water mains, service connections and internal plumbing deteriorate with time. Corrosion always occurs but very often it is extremely slow, becoming apparent only after many years.

Note should be made of the date of laying for all water mains.

8. **SUMMARY**

Leakage of water mains is caused primarily in 6 ways:

a. corrosive soils;
b. poor quality materials and workmanship;
c. ground movement;
d. water hammer;
e. corrosive waters;
f. age of mains and service connections.

* * *

TITLE :	CODE :
1. Causes of leakage	TDO 610/V 1

CAUSES OF LEAKAGE

- Corrosive soils
- Corrosive water
- Poor quality
  · Materials
  · Workmanship
- Ground movement
- Water hammer
- Age

Module : **REASONS FOR LEAKAGE CONTROL**	Code : TDO 620
	Edition : 29-09-1984
Section 1 : I N F O R M A T I O N S H E E T	Page : 01 of 01/06

Duration :	45 minutes.
Training objectives :	After the session the trainees will be able to: - state the fundamental reasons for control of leakage on water mains.
Trainee selection :	- Head of Technical Department; - Head of Section Distribution; - Head of Sub-section Distribution & Connections; - Pipeline Inspector; - Leakage Officer.
Training aids :	- Viewfoils : TDO 620/V 1; - Handout : TDO 620/H 1.
Special features :	-
Keywords :	Leakage control.

1. Introduction

- There are many reasons for leakage control:
  . costs;
  . bad management to waste water;
  . water conservation;
  . health (contamination through back syphonage);
  . danger to life and property.

Show V 1

2. Costs

- Water production costs money;
- Revenues are obtained from water sales;
- Usually only source of income;
- Repair materials are expensive.

3. Bad management to waste water

- Water enterprise like factory;
- Waste of raw material;
- Management control should be exercised.

4. Water conservation

- Limited supply of water;
- Expensive treatment process;
- Expensive to distribute.

5. Health

- Leakage;
- Low pressure;
- Back syphonage;
- Distribution system contaminated;
- Health hazards;
- Waterborne diseases.

6. **Danger to life and property** - Water can damage buildings; - Water can drown people; - Water is a potential flood hazard; - Water can destroys crops.	
7. **Summary**	Give H 1

Module : **REASONS FOR LEAKAGE CONTROL**	Code : TDO 620
	Edition : 29-09-1984
Section 3 : T R A I N I N G A I D S	Page : 01 of 01

Reasons for leakage control — TDO 620/V 1

LEAKAGE CONTROL
BECAUSE OF

- COSTS
- MANAGEMENT
- CONSERVATION
- HEALTH
- DANGER

Reasons for leakage control — TDO 620/H 1

1. INTRODUCTION

The primary reasons for leakage control are to minimize expenditure within a Water Enterprise, and to increase the efficiency of the entire distribution system.

Reasons for leakage control can be summarized as follows:
. costs;
. bad management to waste water;
. water conservation;
. health;
. danger to life and property.

2. COSTS

The only source of revenue normally open to a Water Enterprise is the sale of water to its consumers. In order to provide clean water it must be treated at treatment plants and safely distributed to the consumer. This costs money. If water is lost through leakage then this directly affects the running costs of the Water Enterprise and also reduces the amount of potential revenue which the Water Enterprise might receive.

3. BAD MANAGEMENT TO WASTE MATER

In any form of production, whether it be in a factory or in a Water Enterprise, it should be realized that the raw material must be utilized in the best available way. In a Water Enterprise the raw material is water and it is obviously good managerial practice to make sure that every litre of water which has been produced at the treatment plant is actually sold to the consumer. If it is not, then it is ineffective management of the situation. Consequently, it should be a managerial function to ensure that leakage control is undertaken in an efficient manner.

4. WATER CONSERVATION

The quantity of water produced at the treatment plant is regulated by the design criteria of the distribution system and the number of potential consumers.
Consequently, the water production is usually sufficient to cater for existing outlets and thus for a few years hence.

If excessive water is lost by leakage then this will possibly disrupt the distribution system and limit the number of consumers served but, more important, it will waste available raw material in the form of treated water.

5. HEALTH

A particular problem encountered in the case of leakage is the possibility of back syphonage through leaks. If the water pressure drops in a system and there is a leak in the affected part of the system then there could be a tendency to suck air or contaminated groundwater and sewage back into the water main by virtue of back syphonage.
This has the effect of mixing contaminated liquids, whether it be bad water or sewage, with treated water and may produce a series of waterborne diseases when the water is accidentaly drunk by consumers. There are many reported cases of typhoid due to the back syphonage problem.

6. DANGER

When water discharges from a broken water pipe in sufficient quantities it is possible that serious damage can be done to property by way of flooding or constructional damage with all the attendant compensation problems.
Alternatively, people may be swept away by water from burst water mains and drown or possibly underground erosion can occur, resulting in craters into which people could easily fall.

7. SUMMARY

There are many reasons for leakage control:
a. costs;
b. bad management;
c. water conservation;
d. health;
e. danger.

* * *

LEAKAGE CONTROL BECAUSE OF :

- COSTS
- MANAGEMENT
- CONSERVATION
- HEALTH
- DANGER

Module : **METHODS OF LEAKAGE CONTROL**	Code : TDO 630
	Edition : 29-09-1984
Section 1 : I N F O R M A T I O N S H E E T	Page : 01 of 01/07

Duration :	45 minutes.
Training objectives :	After the session the trainees will be able to: - identify the methods of leakage control; - list the advantages and disadvantages of each method.
Trainee selection :	- Head of Technical Department; - Head of Section Distribution; - Head of Sub-section Distribution & Connections; - Pipeline Inspector; - Leakage Officer.
Training aids :	- Viewfoils : TDO 630/V 1-5 (a-b); - Handout : TDO 630/V 1;
Special features :	-
Keywords :	Leakage control methods / district metering / bulk metering / leakage meters / waste meters.

Module : METHODS OF LEAKAGE CONTROL	Code : TDO 630
	Edition : 29-09-1984
Section 2 : S E S S I O N N O T E S	Page : 01 of 01

1. Introduction	
- There are essentially 3 methods of leakage control: a. bulk (or district) metering; b. leakage (waste) metering; c. routine sounding.	Show V 1
- Leakage control should be systematic.	
2. Bulk (or district) metering	
- Readings are taken regularly (daily, weekly, monthly) to establish a norm for the district. - Any high quantities are investigated. It is important to know exactly which area is being supplied. - Bulk meters may be used for step-tests.	Show V 2
3. Leakage (or waste) meters	
- Leakage meters are installed either temporarily or permanently in a district. - It is important that the district is defined with no unknown inlets or outlets. - Leakage meters are used mainly for step-tests.	Show 3-4
4. Sounding	
- Routine sounding is executed on an area-by-area basis. - Listening has to be done on valves, hydrants, stop taps etc. - Leaks emit noise. - Sounding either by: a. acoustic stick; b. electronic listening device.	Show V 5
5. Summary	Give H 1

Module : METHODS OF LEAKAGE CONTROL	Code : TDO 630
	Edition : 29-09-1984
Section 3 : T R A I N I N G A I D S	Page : 01 of 01

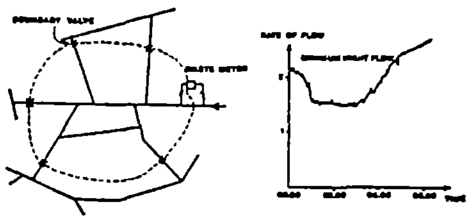
Leakage control — TDO 630/V 1

LEAKAGE CONTROL

- Bulk (District) metering
- Leakage (Waste) metering
- Routine sounding

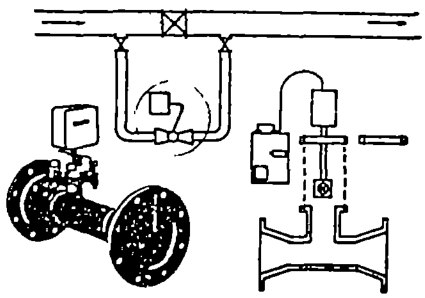
District metering — TDO 630/V 2 (a-b)

DISTRICT METERING



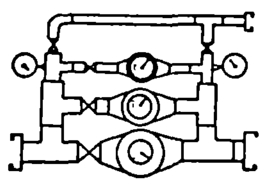
Waste metering I — TDO 630/V 3

WASTE METERING I



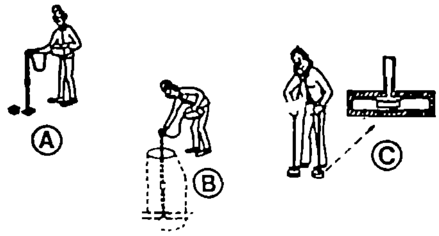
Waste metering II — TDO 630/V 4

WASTE METERING II



Leak sounding — TDO 630/V 5

LEAK SOUNDING



Methods of leakage control — TDO 630/H 1

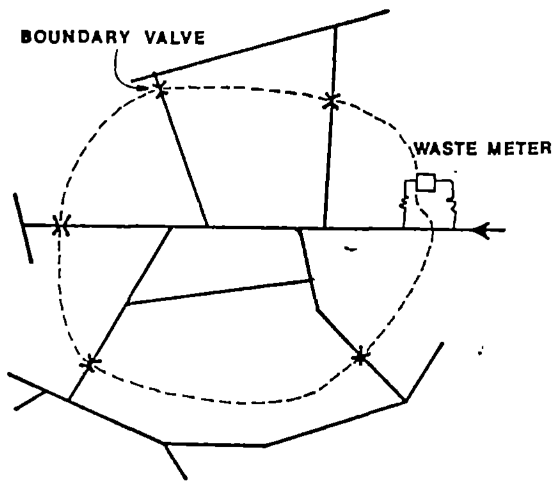
1. INTRODUCTION

Leakage control is a systematic approach to the location of leakage and is a routine part of the distribution function.
Essentially there are 3 ways of exercising the control, i.e. using:

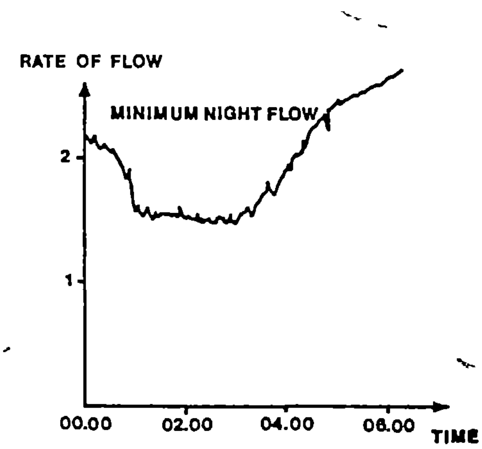
a. bulk meters
b. leakage meters
c. sounding.

2. BULK METERS

Bulk meters (large-capacity water meters) are normally installed on every distribution system and should be read at regular intervals (See Fig. 1).



District in waste meter network



Typical night flow chart

Fig. 1. District metering

By comparing these readings a comparison of consumption may be made between each period.

Should high consumption occur this can be investigated. Very often high consumption can be genuine e.g. new consumers etc., but if no good reasons can be found then either a step-test or sounding survey may be undertaken.

3. LEAKAGE (OR WASTE) METERS

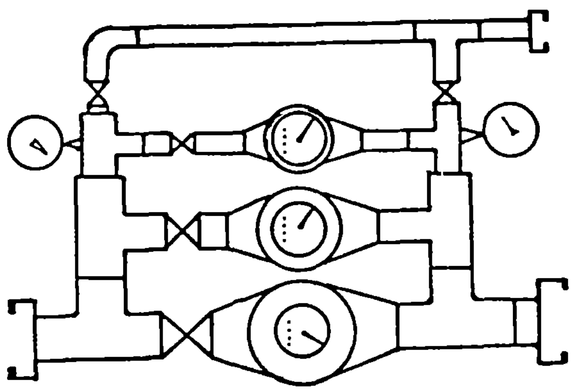


Fig. 2. Portable waste meter

These meters are installed either temporarily (See Fig. 2) or permanently (See Fig. 3) within the distribution area and are used primarily for step-testing which should be done at regular intervals.

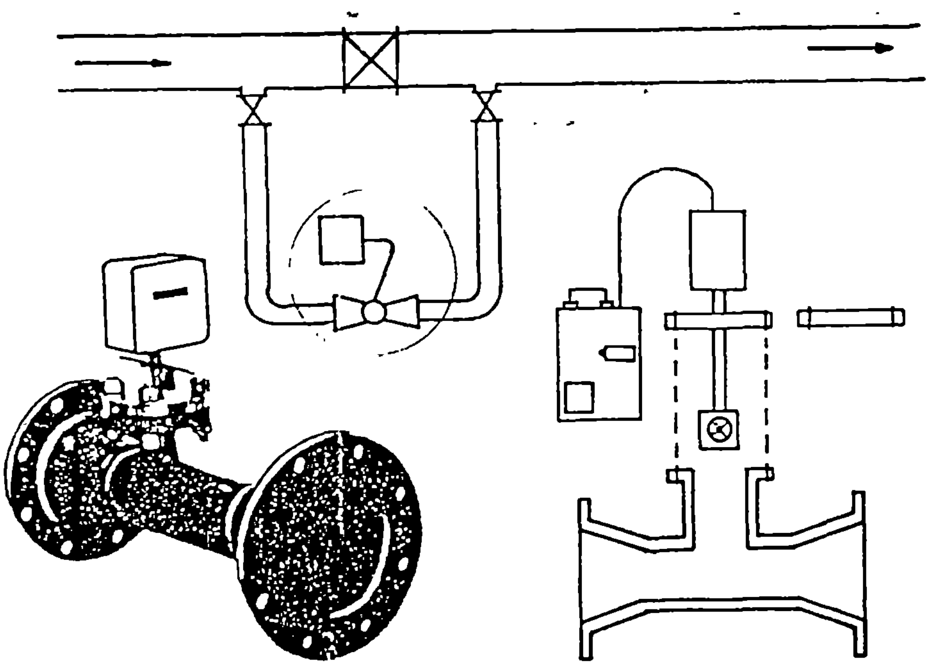


Fig. 3. Permanent waste meter

4. **SOUNDING**

Routine sounding surveys are carried out normally when no meters are available.
As leaks emit noise, each valve, hydrant, stop tap, etc. is located and listened to in order to detect the noise of any leak which is transmitted along the pipeline.
Listening is undertaken with either an acoustic stick or an electronic listening device (See below, Fig. 4).

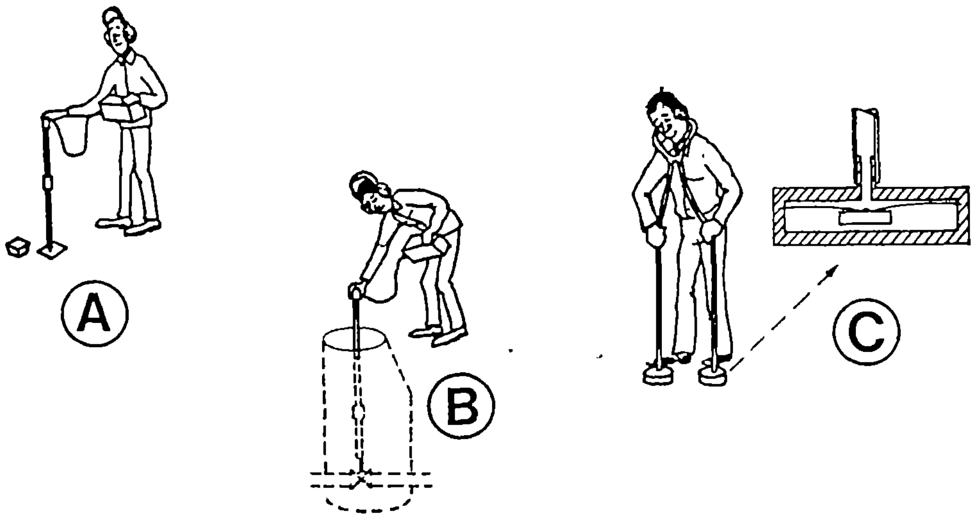


Fig. 4. Leak sounding methods

5. **SUMMARY**

There are basically 3 methods of routine leakage control:
a. bulk metering
b. leakage metering
c. routine sounding.

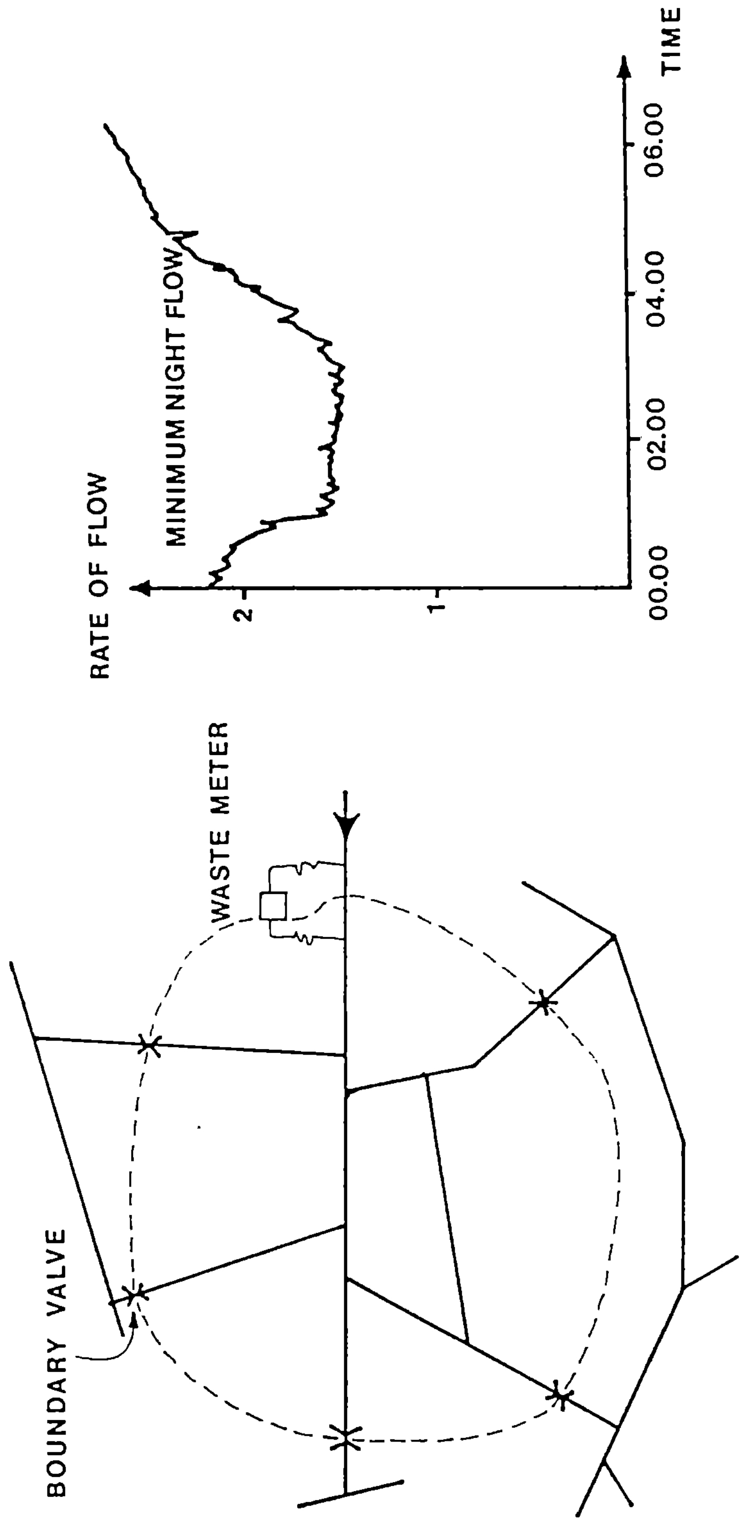
* * *

TITLE :	CODE :
1. Leakage control	TDO 630/V 1
2. District metering	TDO 630/V 2
3. Waste metering (I)	TDO 630/V 3
4. Waste metering (II)	TDO 630/V 4
5. Leak sounding	TDO 630/V 5 (a-c)

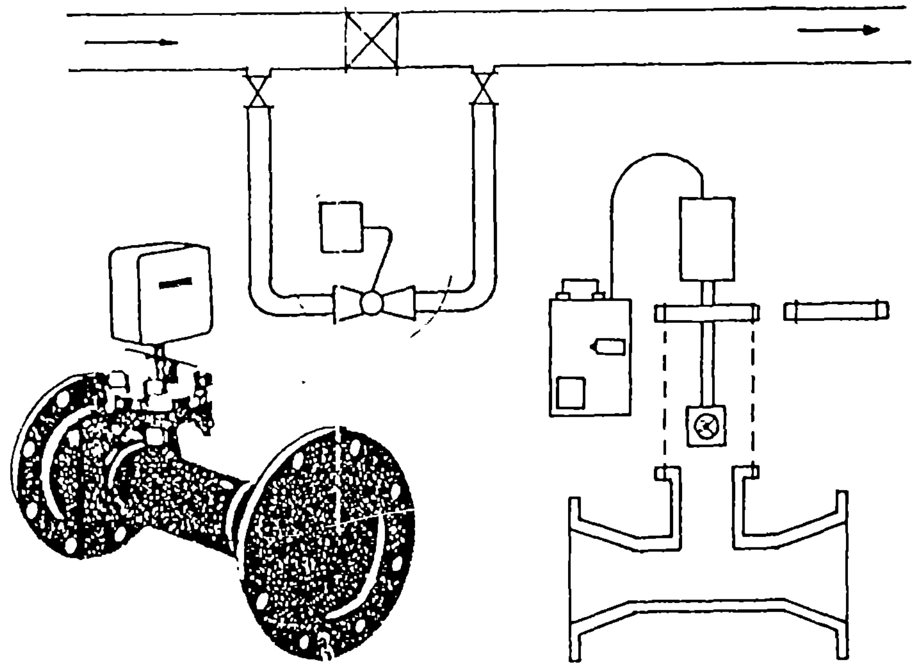
LEAKAGE CONTROL

- Bulk (District) metering
- Leakage (Waste) metering
- Routine sounding

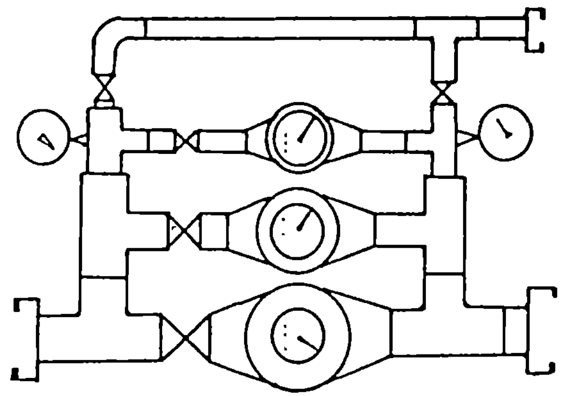
DISTRICT METERING

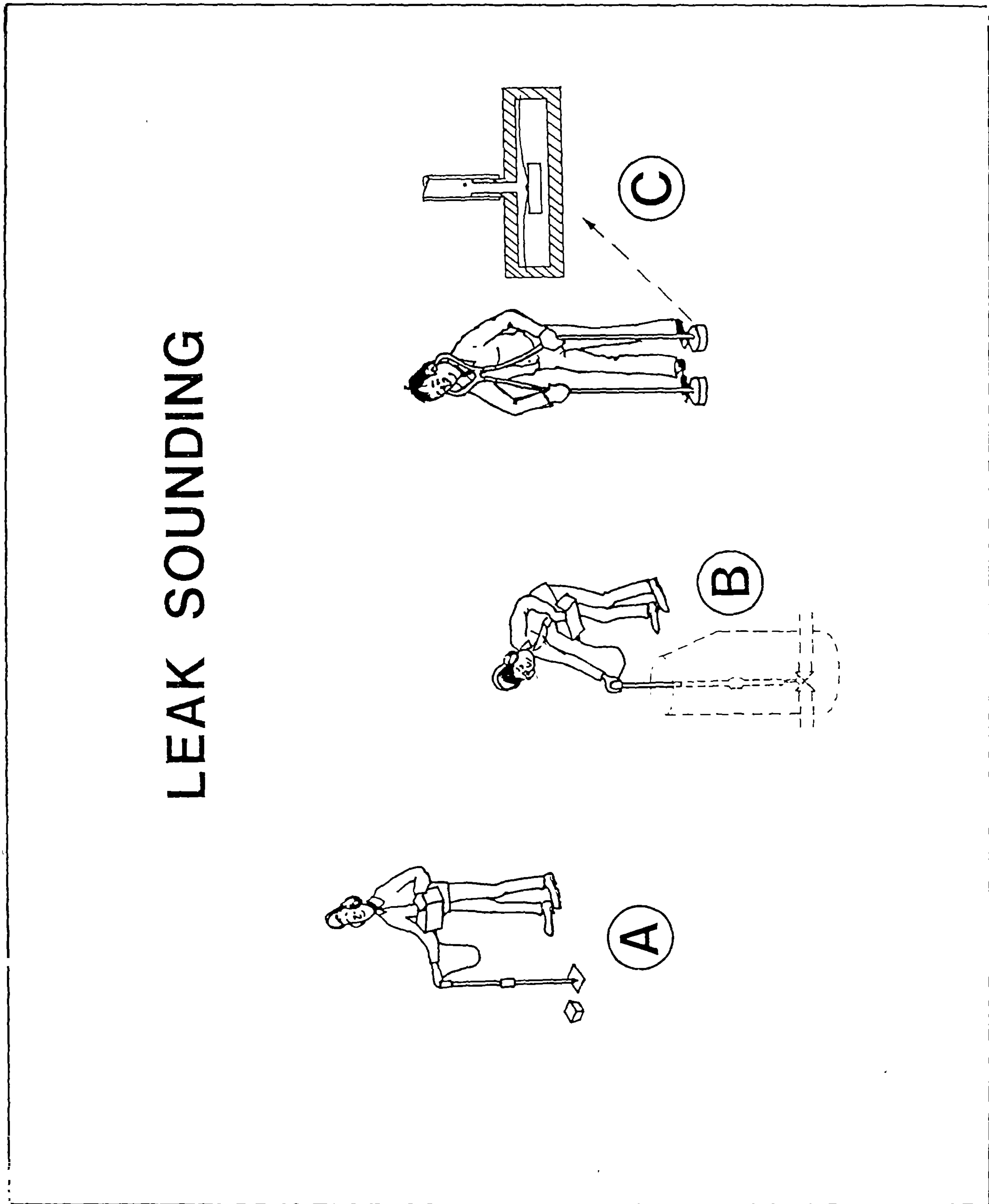


WASTE METERING I



WASTE METERING II




LEAK SOUNDING
A
B
C

Module : DETERMINATION OF THE LEAKAGE FACTOR	Code : TDO 631
	Edition : 19-09-1984
Section 1 : INFORMATION SHEET	Page : 01 of 01/08

Duration :	45 minutes.
Training objectives :	After the session the trainees will be able to : - state the 3 main methods of determining the leakage factor; - calculate the leakage factor for any distribution district according to each of these methods; - decide on the best method of expressing the leakage factor for any district.
Trainee selection :	- Head of Technical Department; - Head of Section Distribution; - Head of Sub-section Distribution & Connections; - Pipeline Inspector; - Leakage Officer.
Training aids :	- Viewfoils : TDO 631/V 1-4; - Handout : TDO 631/H 1.
Special features :	-
Keywords :	Leakage factors.

1. Introduction

- Three ways of determining leakage factors in distribution systems: — Show V 1
  a. night flow factor;
  b. relationship with number of consumers;
  c. relationship with lengths of mains.

2. Hypothetical flow percentage factor

- This is a hypothetical calculation: — Show V 2
  . leakage cannot be measured, only assumed;
  . percentage ratio between minimum night flow (mnf) and average day flow (adf);
  . calculation :
  mnf/adf x 100% = % leakage;
  . used infrequently nowadays;
  . gives only an approximation of leakage;
  . used as comparison with the previous results.

3. Relationship with number of consumers

- The direct ratio between minimum night flow and number of consumers: — Show V 3
  . calculation :
  (mnf [l/s])/(no.cons) = leakage factor;
  . used only if there is a high density of consumers throughout the distribution system;
  . effective if used as comparison with previous results.

4. Relationship with length of mains

- There is a direct relation between length of mains and minimum night flow: — Show V 3
  . calculation:

$$\frac{\text{mnf [l/s]}}{\text{length of main [km]}} = \text{leakage factor;}$$

  . advisable to use this method for most water enterprises in Indonesia;
  . dependent on accurate knowledge of total length of water mains laid.

5. **Exercises**	
- Calculate the leakage factor for a dis-district using all formulae:	Allow trainees to undertake exercises given the following basic information: **
- Basic information: ** . minimum night 4 l/s, . 3 water sources for water enterprise: a. 260 m^3 per day; b. 170 m^3 per day; c. 450 m^3 per day; . number of consumers: a. private 1,752; b. commercial 7; c. religious 78; . length of mains: 150 mm - 2.3 km; 100 mm - 2.7 km; 80 mm - 3.6 km; 50 mm - 1.7 km.	
6. **Summary**	Give H 1

Leakage factors TDO 631/V 1 LEAKAGE FACTORS - night flow factor - consumer-related factor - main length-related factor	**Night flow factor** TDO 631/V 2 NIGHT FLOW FACTOR $\frac{\text{minimum night flow (l/s)}}{\text{average flow (l/s)}}$
Consumer related factor TDO 631/V 3 CONSUMER-RELATED FACTOR $\frac{\text{minimum night flow (l/s)}}{\text{number of consumers}}$	**Main length related factor** TDO 631/V 4 MAIN LENGTH-RELATED FACTOR $\frac{\text{minimum night flow (l/s)}}{\text{total length of mains (l/s)}}$
	Determination of the leakage factor TDO 631/H 1

1. INTRODUCTION

Quantifying the amount of water that is escaping from a distribution system in the form of leakage is virtually impossible. Consequently, characteristic water consumption ratios are often established, and recalculated at regular intervals, to check whether or not ratios remain constant or show a relative growth of water consumption, which might indicate (growing) leakage. Once one form of calculation is used it should be maintained in order that comparisons can be made with previous calculations. In this way it can readily be seen whether the leakage is increasing or decreasing.

There are essentially three methods used to calculate this so-called leakage factor, and selection is made as to the best one to affect the conditions or the water enterprise :

a. night flow factor;
b. relationship with number of consumers;
c. relationship with length of mains.

2. NIGHT FLOW FACTOR

This ratio has been used for many years in areas where individual water consumption is normally negligible and there is a high density of domestic connections. It is based on the assumption that night flows (for domestic water demand) are normally very small, so that leakages would show relatively large changes. However, because of the use of the "bak mandi" in Indonesia it cannot be used effectively. The calculation is as follows :

$$\frac{\text{minimum night flow [l/s]}}{\text{average flow over 24 hours [l/s]}} = \text{\% of leakage factor}$$

The minimum night flow is normally established during the hours when it is anticipated that very little consumption is taking place. In most water enterprises this would be between 01.00 hours and 03.00 hours. The quantity of water entering a distribution system is measured accurately by way of meters, and any outlets from the distribution system are either shut off or metered. The rate of flow in l/s can then be calculated for this period.
The average flow rate over a 24 hours period can be calculated in the same way.

It must be emphasized that the night flow factor does not quantify the kind of leakage from the water mains but merely gives an indication as to its quantity.

3. RELATIONSHIP WITH THE NUMBER OF CONSUMERS

This ratio is normally used where there is a high density of consumers throughout the distribution system and again, in most cities in Indonesia where Water Enterprises exist, this particular ratio will be less effective. However, some of the larger cities may find it appropriate. The calculation is as follows:

$$\frac{\text{minimum night flow [l/s]}}{\text{total number of consumers}} = \text{LF (cons)}$$

The minimum night flow is obtained as in (2) above, and the total number of consumers from the office records.

4. RELATIONSHIP WITH THE LENGTHS OF MAINS

This is the most appropriate leakage factor for use in most Indonesian Water Enterprises. The calculation is as follows:

$$\frac{\text{minimum night flow [l/s]}}{\text{total length of mains [km]}} = \text{LF (length)}$$

The minimum night flow is determined as in (2) above and the length of the water mains, regardless of diameter, is taken from the office records.

5. EXERCISES

The following information is from a typical Indonesian water enterprise. The leakage factor can be calculated using each of the three methods mentioned above.

<u>D a t a</u>

Minimum Night Flow (MNF) = 4 l/s

Flows from sources into Water Enterprise :

Source 1	260 m^3/day
Source 2	170 m^3/day
Source 3	450 m^3/day

Number of consumers :

Private	1,750
Commercial	7
Religious	78

Length of mains :

150 mm	2.3 km
100 mm	2.7 km
80 mm	3.6 km
50	1.7 km

a. <u>Night Flow Factor</u>

$$L.F. = \frac{\text{Minimum Night Flow (MNF)}}{\text{Average flow over 24 hours}} \times 100\%$$

M.N.F. = 4 l/s

Average flow over 24 hours =

= Source 1 + Source 2 + Source 3

= 260 + 170 + 450 m^3/day

= 880 m^3/day

= 880,000 l/day

= (880,000)/(24 x 60 x 60) = 10.185 l/s

L.F. = (4/10.185) x 100% = 39.27%

b. <u>Relationship with number of consumers</u>

M.N.F. = 4 l/s

Number of consumers

= 1,752 + 7 + 78

= 1,837

Hence: LF (cons) = (4/1,837) x 1000 = 2.18 l/s per consumer

c. <u>Relationship with lengths of mains</u>

M.N.F. = 4 l/s

Length of mains :

150 mm	=	2.3 km
100 mm	=	2.7 km
80 mm	=	3.6 km
50 mm	=	1.7 km
Total	=	10.3 km

LF (length) = 4/103 = 0.388 l/s per km

6. SUMMARY

When analysing leakage problems in a distribution system it is important to have a systematic approach and comparison between tests recently undertaken and those previously undertaken. This will show whether the leakage factor is increasing or decreasing.

* * *

LEAKAGE FACTORS

- night flow factor
- consumer - related factor
- main length - related factor

NIGHT FLOW FACTOR

$$\frac{\text{minimum night flow (l/s)}}{\text{average flow (l/s)}}$$

CONSUMER-RELATED FACTOR

$$\frac{\text{minimum night flow (l/s)}}{\text{number of consumers}}$$

MAIN LENGTH-RELATED FACTOR

$$\frac{\text{minimum night flow (l/s)}}{\text{total length of mains (l/s)}}$$

Module : **STEP TESTING**	Code : TDO 634
	Edition : 19-09-1984
Section 1 : **I N F O R M A T I O N S H E E T**	Page : 01 of 01/08

Duration	45 minutes.
Training objectives	After the session the trainees will be able to: - carry out a step-test; - interpretate the results of a step-test.
Trainee selection :	- Head of Technical Department; - Head of Section Distribution; - Head of Sub-section Distribution & Connections; - Pipeline Inspector; - Leakage Officer.
Training aids :	- Viewfoils : TDO 634/V 1-4 (a-b); - Handout : TDO 634/H 1.
Special features :	-
Keywords :	Step testing/distribution district/valves.

Module : STEP TESTING	Code : TDO 634
	Edition : 19-09-1984
Section 2 : S E S S I O N N O T E S	Page : 01 of 02

1. Introduction

- Step testing is a systematic sequence of closing valves in a distribution district and noting the variation in water flow through a meter.

- The district must be "closed" i.e. one inlet via a meter and no outlets. — Show V 1

- The meters used to measure the flow can be: — Show V 2-3
  - . bulk meters;
  - . leakage (waste) meters.

2. Preparation

- A plan of the district must be prepared to indicate all valves. — Show V 4-a

- All boundary valves must be marked.

- The step-test must be planned so that the valves, when closed, form positive shuts.

- This means some valves have to be closed to stop circulation of water within the district, called CIRCULATION VALVES.

- Step valves can now be numbered in sequence to produce positive shuts.

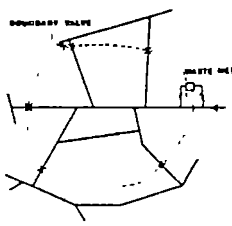
3. Step-test

- Sequence of a step-test are: — Show V 4 (a-b)
  - . consult plan;
  - . set up bulk meter or leakage meter;
  - . close all boundary valves;
  - . close all circulating valves;
  - . at 10-minute intervals, close step valves in sequence;
  - . note readings of flow rate on the leakage meter, or time flows on bulk meter, after each closure;
  - . when all step valves have been closed, leave for 10 minutes;
  - . re-open step valves in reverse order.

4. Interpretation of results	
- Check for any dramatic fall in flow rate after each step valve has been closed.	
- High flows which have been observed usually indicate a leak between two step valves.	
- Suspected leaks can now be located by observation and listening.	
5. Summary	Give H 1

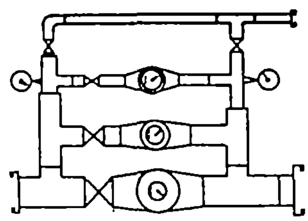
Module : STEP TESTING	Code : TDO 634
	Edition : 19-09-1984
Section 3 : T R A I N I N G A I D S	Page : 01 of 01

District waste meter network — TDO 634/V 1



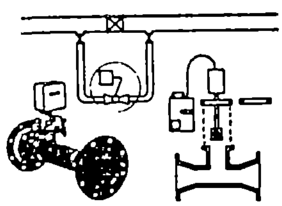
DISTRICT IN WASTE METER NETWORK

Portable waste meter — TDO 634/V 2



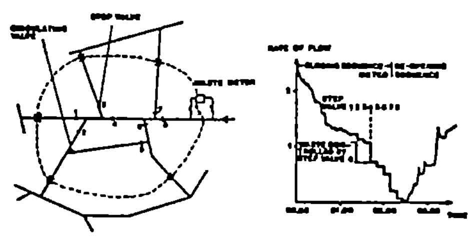
TYPICAL PORTABLE WASTE METER ASSEMBLY

Permanent waste meter — TDO 634/V 3



TYPICAL PERMANENT WASTE METER

Typical step test — TDO 634/V 4 (a-b)



Step testing — TDO 634/H 1

1. INTRODUCTION

Step testing is the systematic sequence of closing valves on a distribution district and noting the variation in water flow through a meter.

The district should be "CLOSED" i.e. there is only one inlet (through the meter) and no outlets.

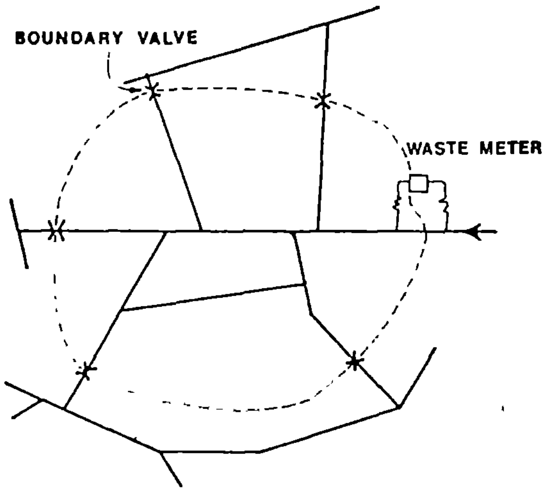


Fig. 1. District in waste meter network

The meters which may be used are either the normal bulk meters or special leakage (waste) meters.

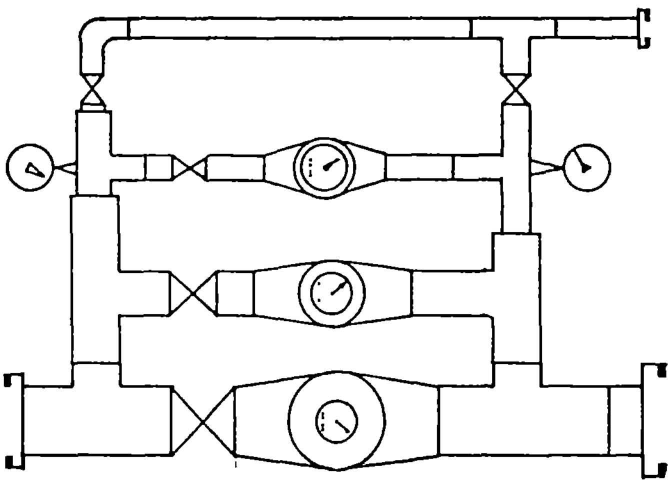


Fig. 2. Portable waste meter assembly

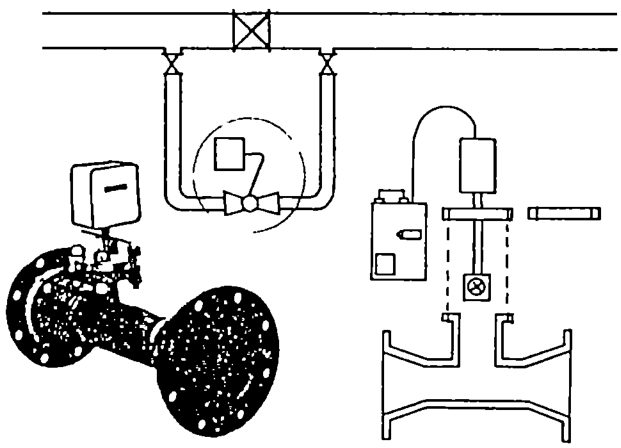


Fig. 3. Typical permanent waste meter

2. PREPARATION

It is essential that a good plan or drawing is available of the district to be tested.
All the outlets from the district must be closed. The valves used are called BOUNDARY VALVES.

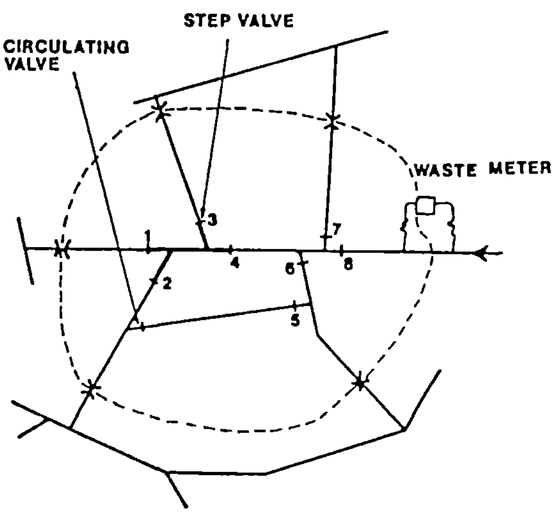


Fig. 4. Valves in waste district

Each valve closure during the test must produce a positive shut, this means part of the system between valves is closed off. In order to do this, and stop circulation, some valves will have to be temporarily closed. These are called CIRCULATION VALVES.

Step valves are now selected and numbered to produce positive shuts from the extremities of the district back to the meter.

3. STEP TEST

If the preparations and data are correct, particularly the plan, then the stop test itself is relatively straight forward.
Set up the bulk meter or leakage meter and check that it is working. Then close all boundary and circulation valves.

At ten-minute intervals, close each step valve in sequence and note the flow rate on the leakage meter or calculate the rate of flow at the bulk meter using a stop watch and the meter readings.

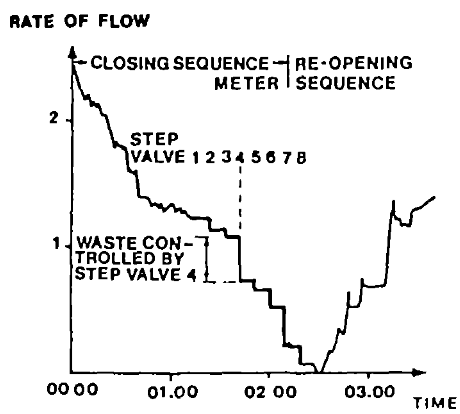


Fig. 5. Flow rate during step test

When all the step valves have been closed, leave them closed for ten minutes and then reopen the step valves in reverse order.

4. INTERPRETATION OF RESULTS

After each step valve closure the reduction in the flow rate, if any, should be noted.

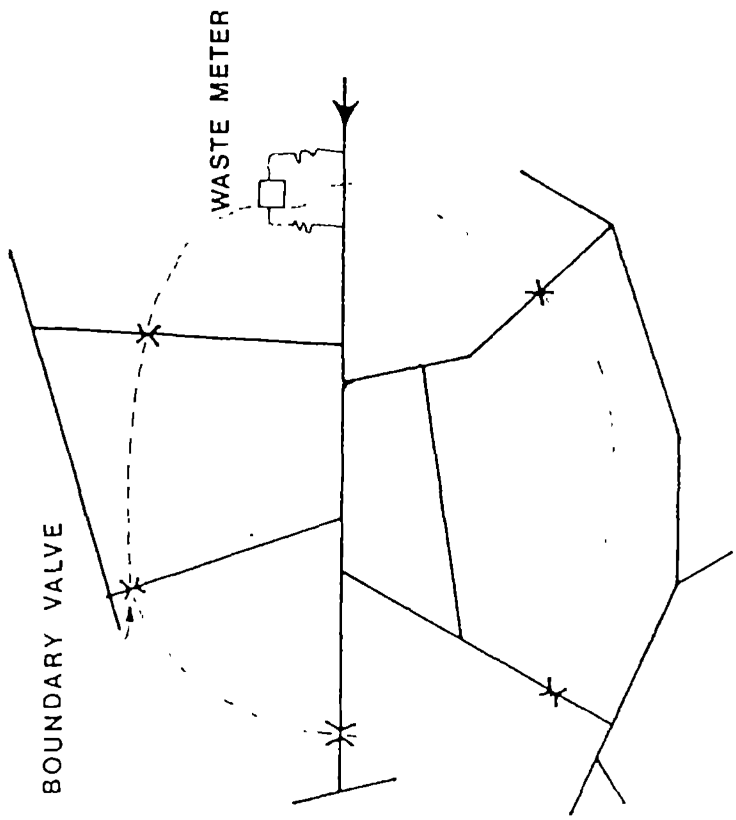
High flow rates if reduced by a step valve closure usually indicate leakage between the two step valves.
Suspected leakage can be isolated by observation and listening.

5. SUMMARY

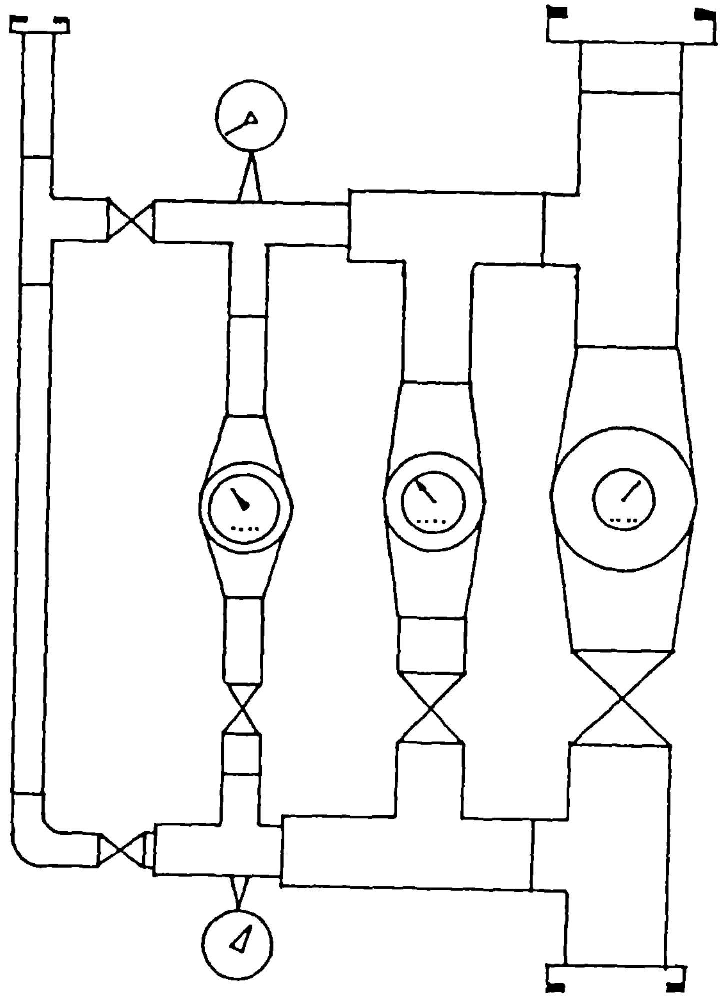
Step testing is a systematic sequence of closing valves on a distribution district and noting the variation of water flow through a meter.

* * *

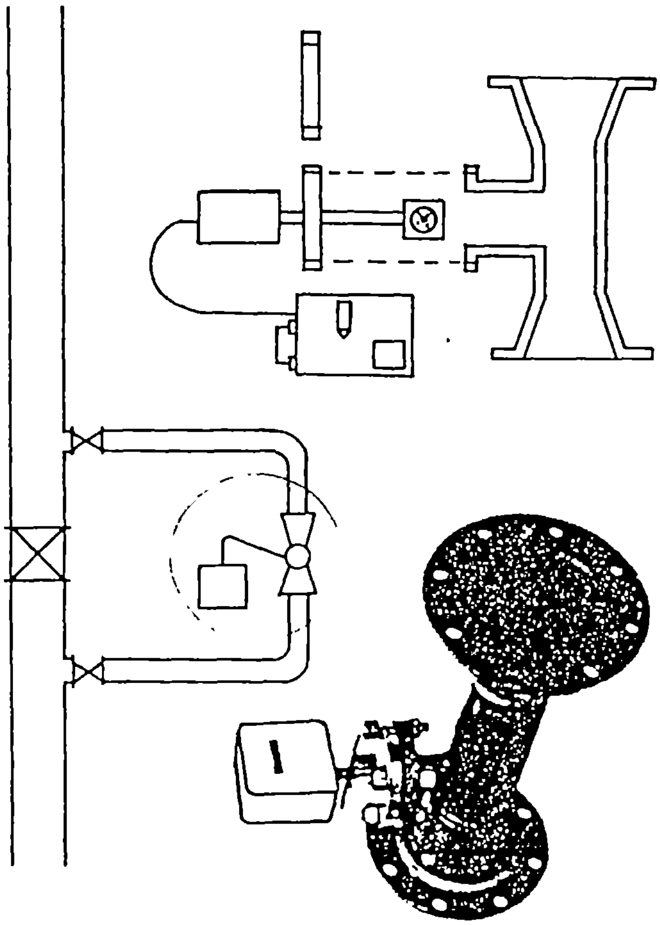
Module : STEP TESTING	Code : TDO 634
	Edition : 19-09-1984
Annex : V I E W F O I L S	Page : 01 of 06



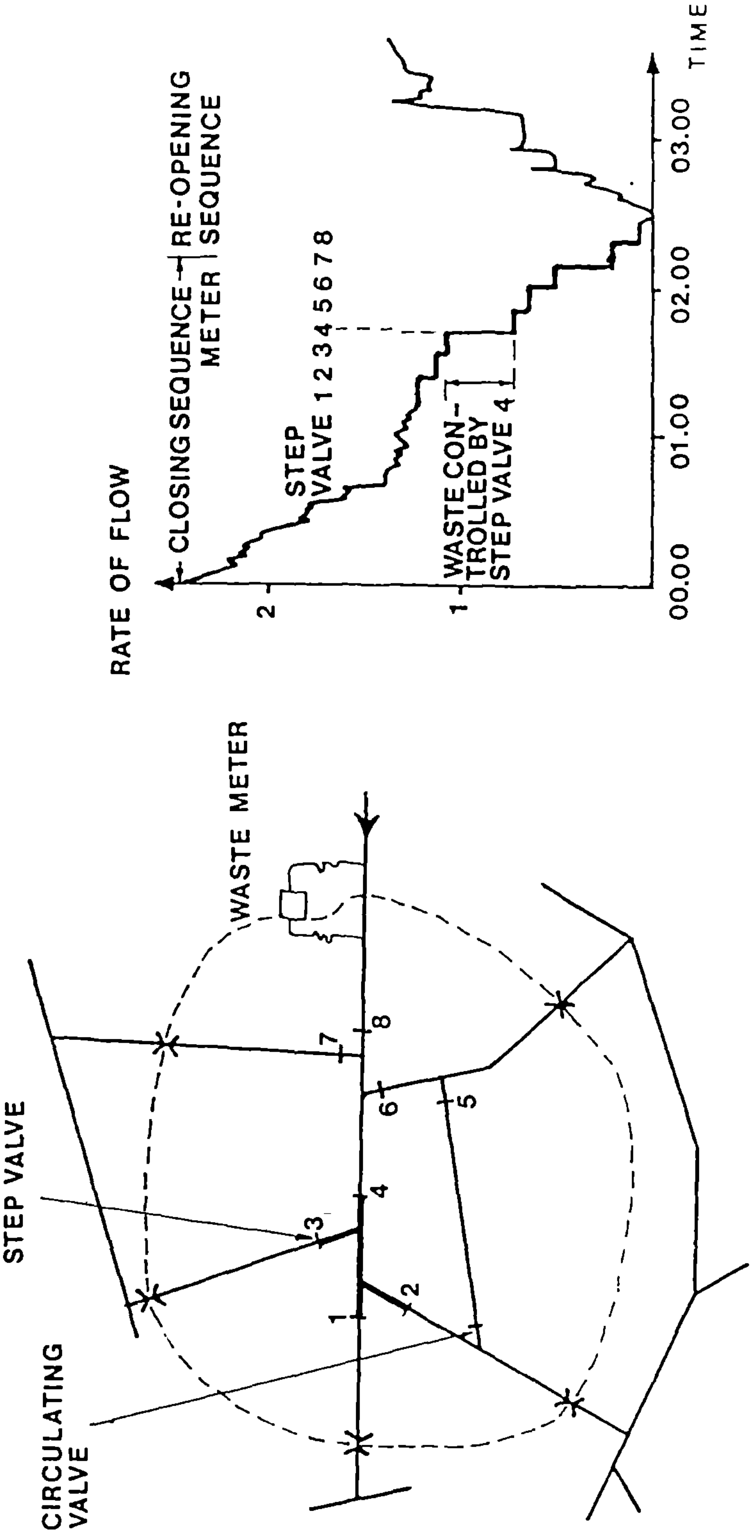
DISTRICT IN WASTE METER NETWORK



TYPICAL PORTABLE WASTE METER ASSEMBLY



TYPICAL PERMANENT WASTE METER


RATE OF FLOW
CLOSING SEQUENCE
RE-OPENING SEQUENCE
METER
STEP VALVE 1 2 3 4 5 6 7 8
WASTE CON-TROLLED BY STEP VALVE 4
2
1
00.00
01.00
02.00
03.00
TIME
WASTE METER
STEP VALVE
CIRCULATING VALVE
1
2
3
4
5
6
7
8

Module : LISTENING SURVEYS	Code : TDO 635
	Edition : 19-03-1985
Section 1 : INFORMATION SHEET	Page : 01 of 01/12

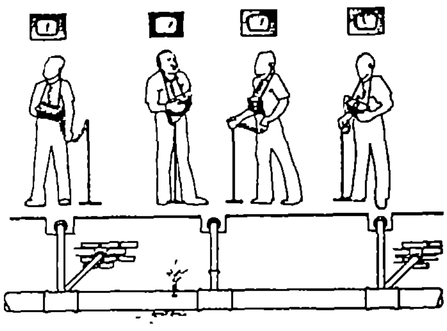
Duration :	45 minutes.
Training objectives :	After the session the trainees will be able to : - list the principles of conducting listening surveys; - locate suspected leakage, using these principles.
Trainee selection :	- Head of Section Distribution; - Head of Sub-section Distribution & Connections; - Pipeline Inspector.
Training aids :	- Listening devices; - Viewfoils : TDO 635/V 1-7; - Handout : TDO 635/H 1.
Special features :	-
Keywords :	Listening surveys/listening devices/Leak noise correlator.

1. Introduction	
- Listening surveys are used to locate leakage when no meters are available;	
- Are used when leakage is suspected in any area.	
2. Surveys	
- The district covered must be pressurized to normal or increased pressure.	
- Each valve, hydrant, stop tap etc. is located and listened to, using an acoustic stick.	Show V 1 Show listening devices
- Noise of escaping water may be heard.	
- The louder the sound the closer the leak.	
- When maximum sound is heard, excavation is necessary to locate the source of the leakage.	
3. Listening devices	
Devices used for listening surveys are :	
- rods	Show V 2
- acoustic devices	
- electronic devices	Show V 3
- leak noise correlators.	Show V 4-5
4. Exercise	
- Explain exercise with listening devices. - Do exercise (20 minutes). - Discuss results.	

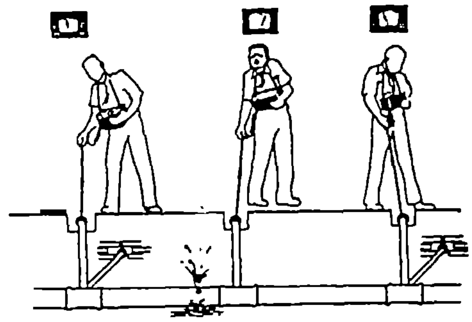
5. **Problems**	
Problems may be caused by : - difference in materials; - difference in ground cover; - direct vs indirect measurements.	Show V 6
6. **Summary**	Give H 1

Module : LISTENING SURVEYS		Code	: TDO 635
		Edition	: 19-03-1985
Section 3 : T R A I N I N G A I D S		Page	: 01 of 02

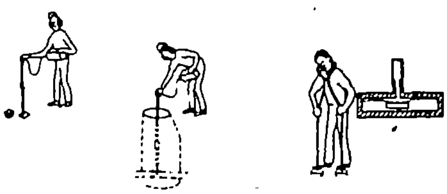
Sounding on the ground — TDO 635/V 1



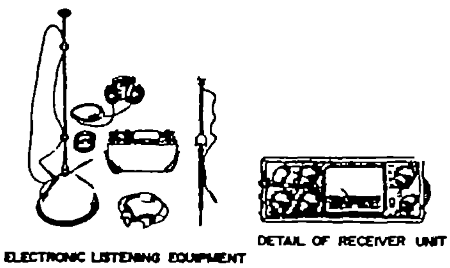
Sounding on fittings — TDO 635/V 2



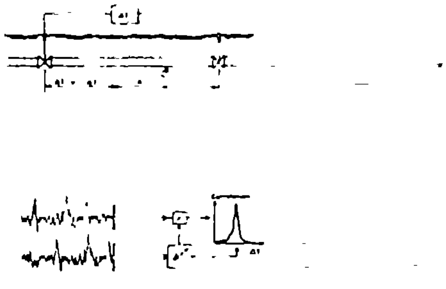
Listening devices I — TDO 635/V 3



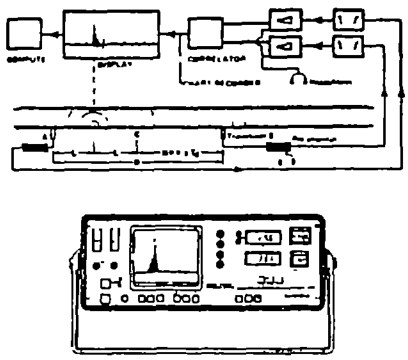
Listening devices II — TDO 635/V 4



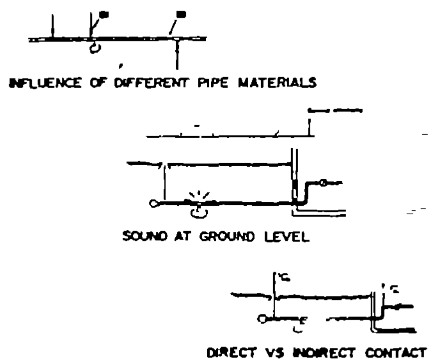
Leak noise correlation — TDO 635/V 5



Leak noise correlator — TDO 635/V 6



Difficulties TDO 635/V 7



Listening Surveys TDO 635/H 1

1. INTRODUCTION

Listening surveys are carried out when leakage is suspected after a step test, or as a routine leakage control activity when no meters are available.

2. SURVEY

The district to be surveyed must be pressurized to normal pressure or to an increased pressure.

Each valve, hydrant, stop tap, etc. must be located and listened to, using an acoustic stick or electronic listening device.

Noise of water escaping from leaks is transmitted along the pipes and may be heard.

The louder the sound, the shorter the distance to the leak. When a maximum sound is heard, excavations should be made in order to locate the source.

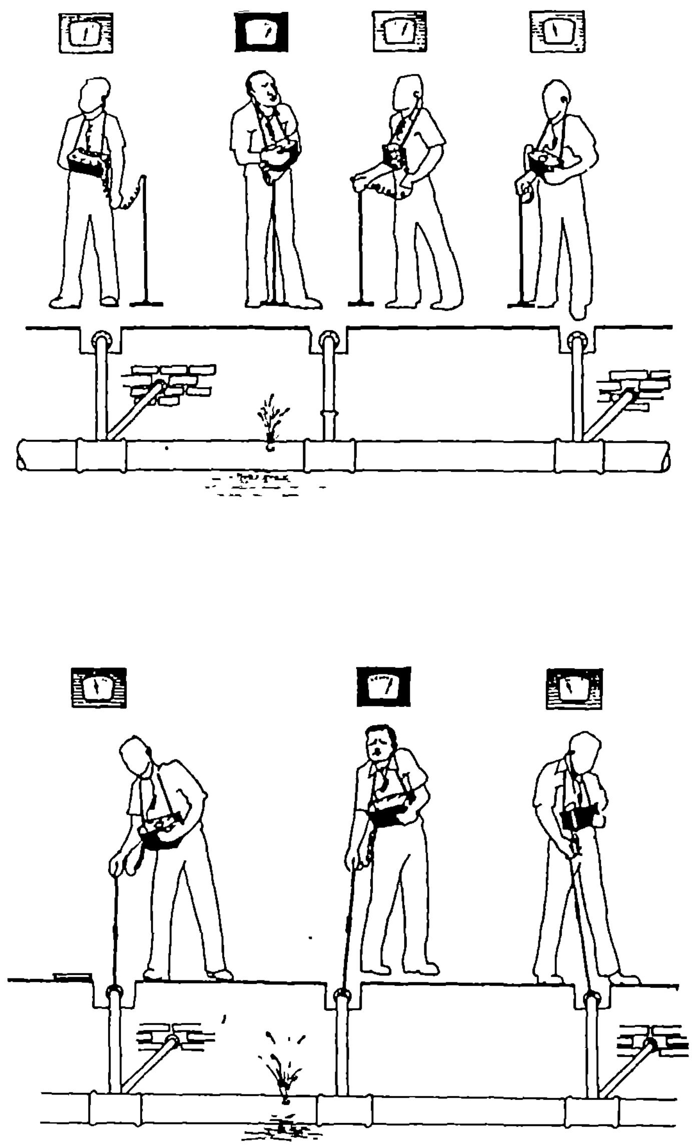


Fig. 1. Listening surveys:
- sounding on ground (above);
- sounding on fittings (below).

3. LISTENING DEVICES

Listening devices used in practice are:

a. simple rods;
b. acoustic devices, e.g. geophones;
c. electronic listening equipment;
d. leak noise correlators.

Items (a) and (b) produce a louder noise when closer to the leak, whereas electronic equipment shows a higher read-out.

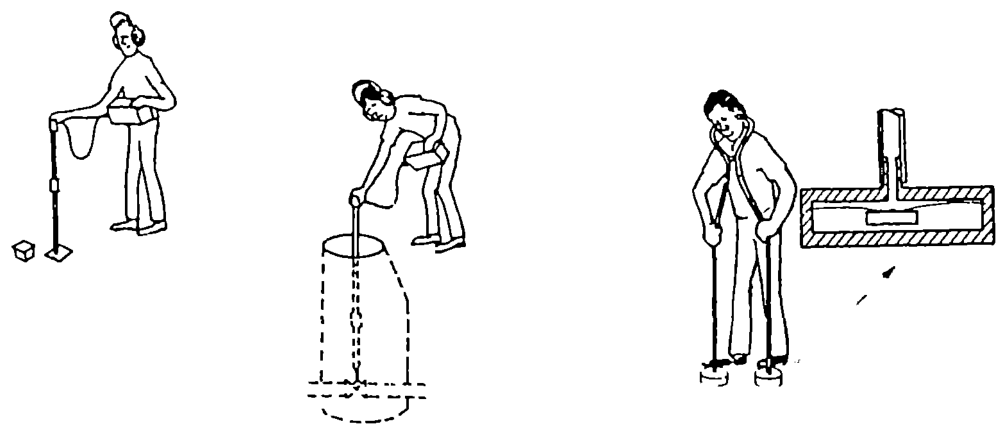
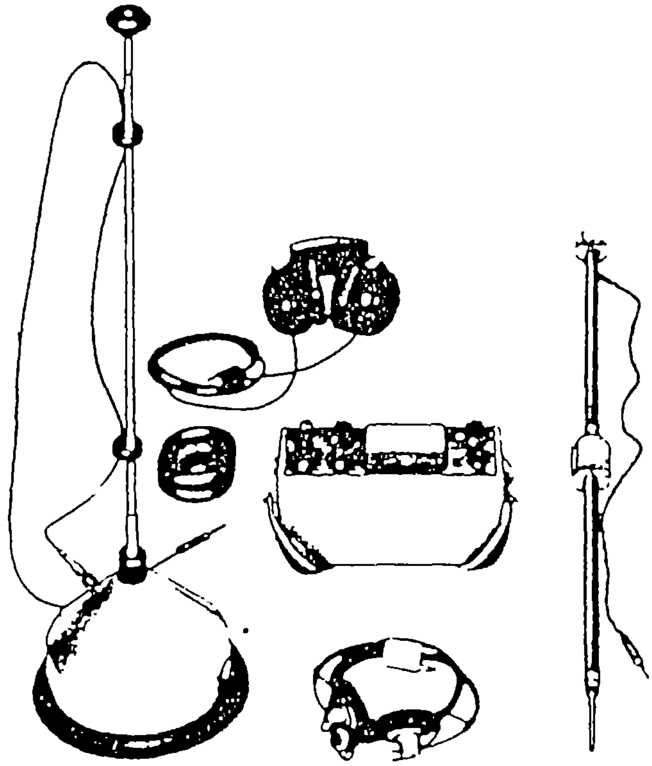


Fig. 2. Sounding for water leaks:
- with electronic sounding equipment (left and middle);
- with acoustic geophone (right).



ELECTRONIC LISTENING EQUIPMENT

Fig. 3. Electronic listening equipment

Leak noise correlators compare the sound intensity measured at 2 different points and thus indicate the actual location of the leak directly.

The sound from the leak reaches the right-hand microphone after travelling the distance A (see sketch below), during which time it has travelled the same distance to the left.
The delay in reaching the left-hand microphone is obtained from the correlator and the distance between the leak and the correlator can be calculated.

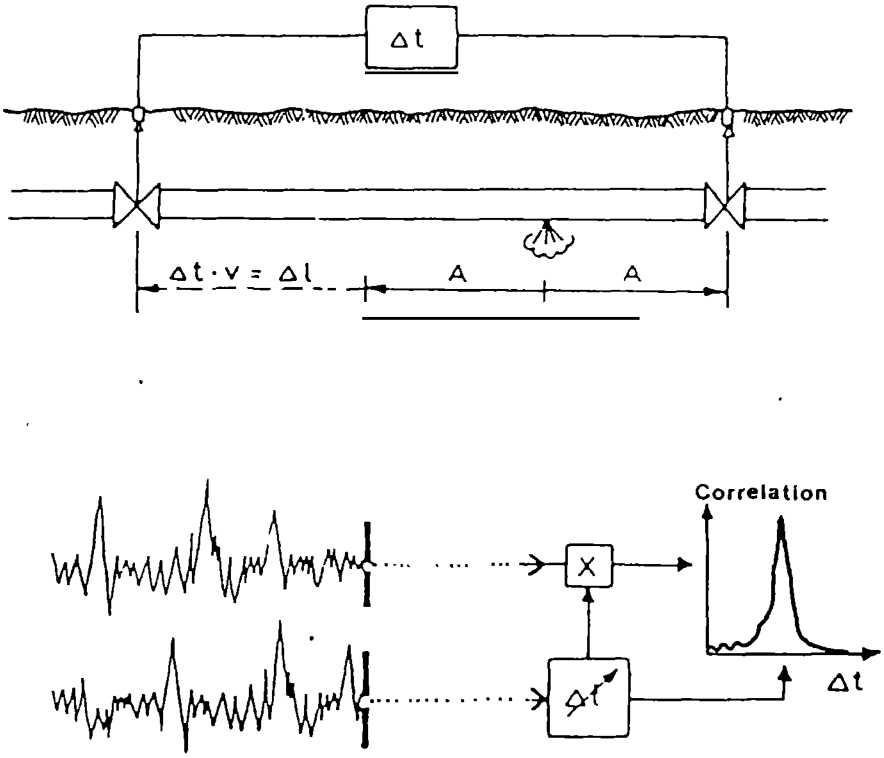
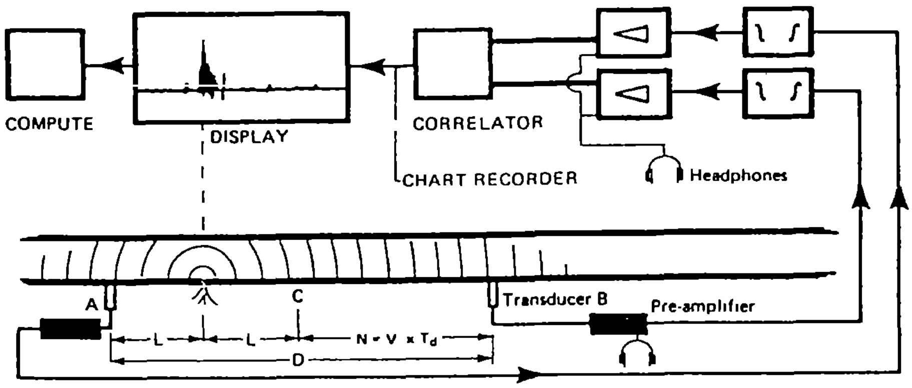


Fig. 4. Principle of the correlation process.



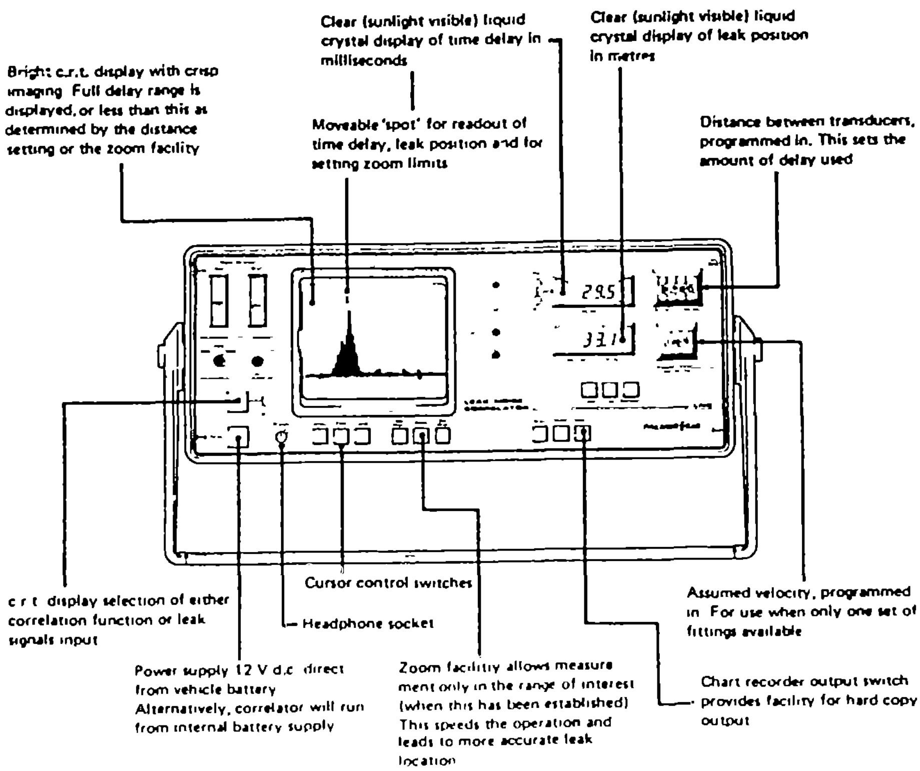
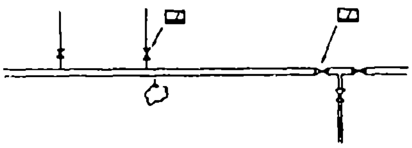


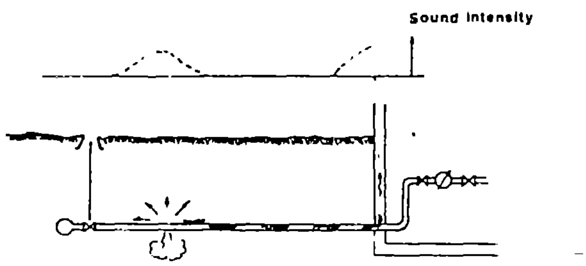
Fig. 5. Leak-noise correlator.

4. PROBLEMS

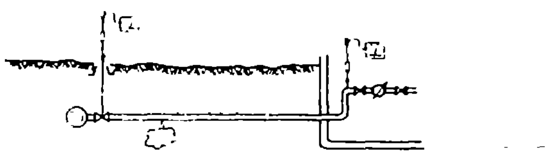
Noise levels are influenced by the type of pipe material, by soil cover, etc. Errors may thus be introduced when different types of noise measurements are compared directly (e.g. measured on uPVC and steel pipes; on fittings and directly on the pipe; on the pipe and on the ground, etc.).



INFLUENCE OF DIFFERENT PIPE MATERIALS



SOUND AT GROUND LEVEL



DIRECT VS INDIRECT CONTACT

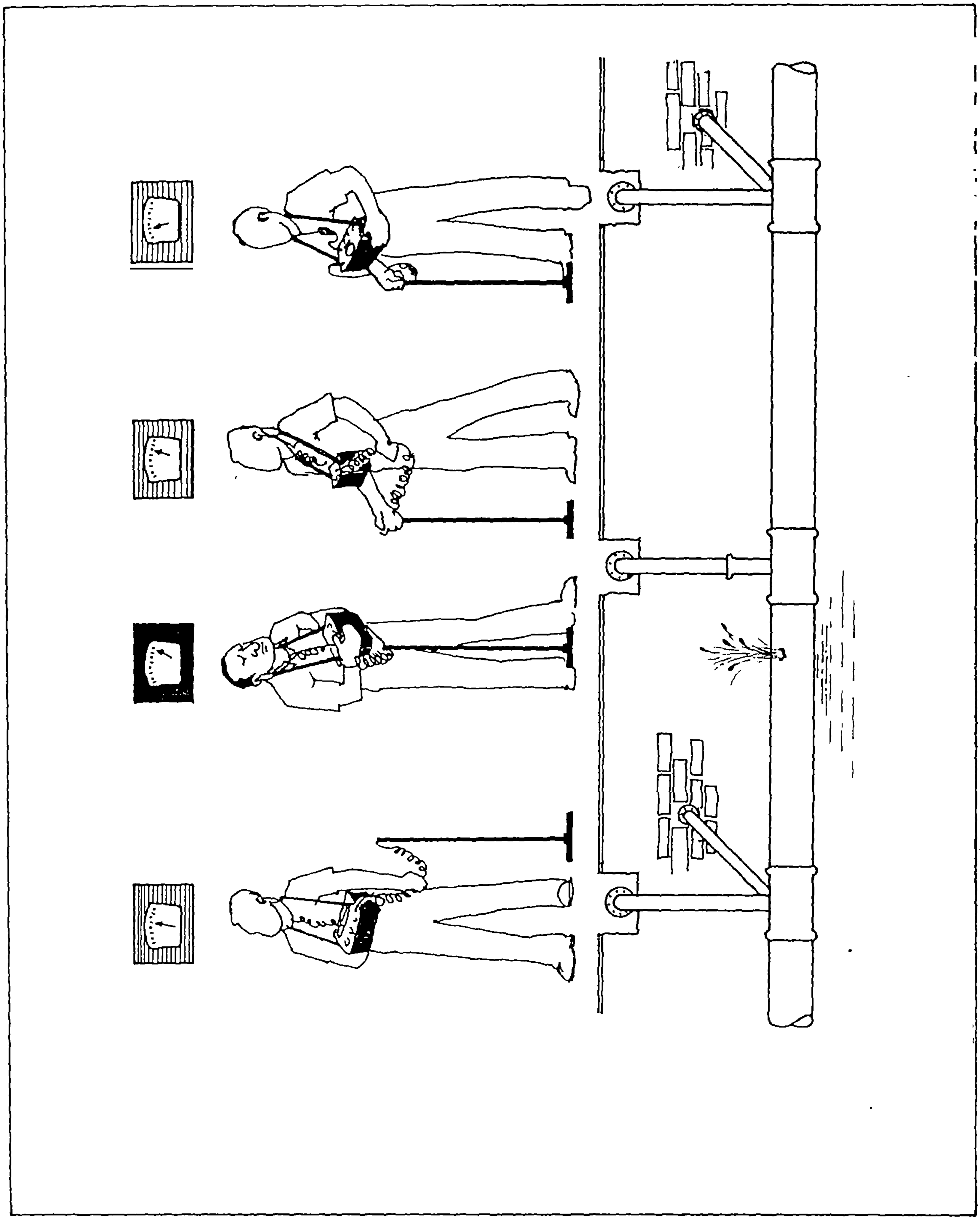
Fig. 6. Difficulties in listening surveys

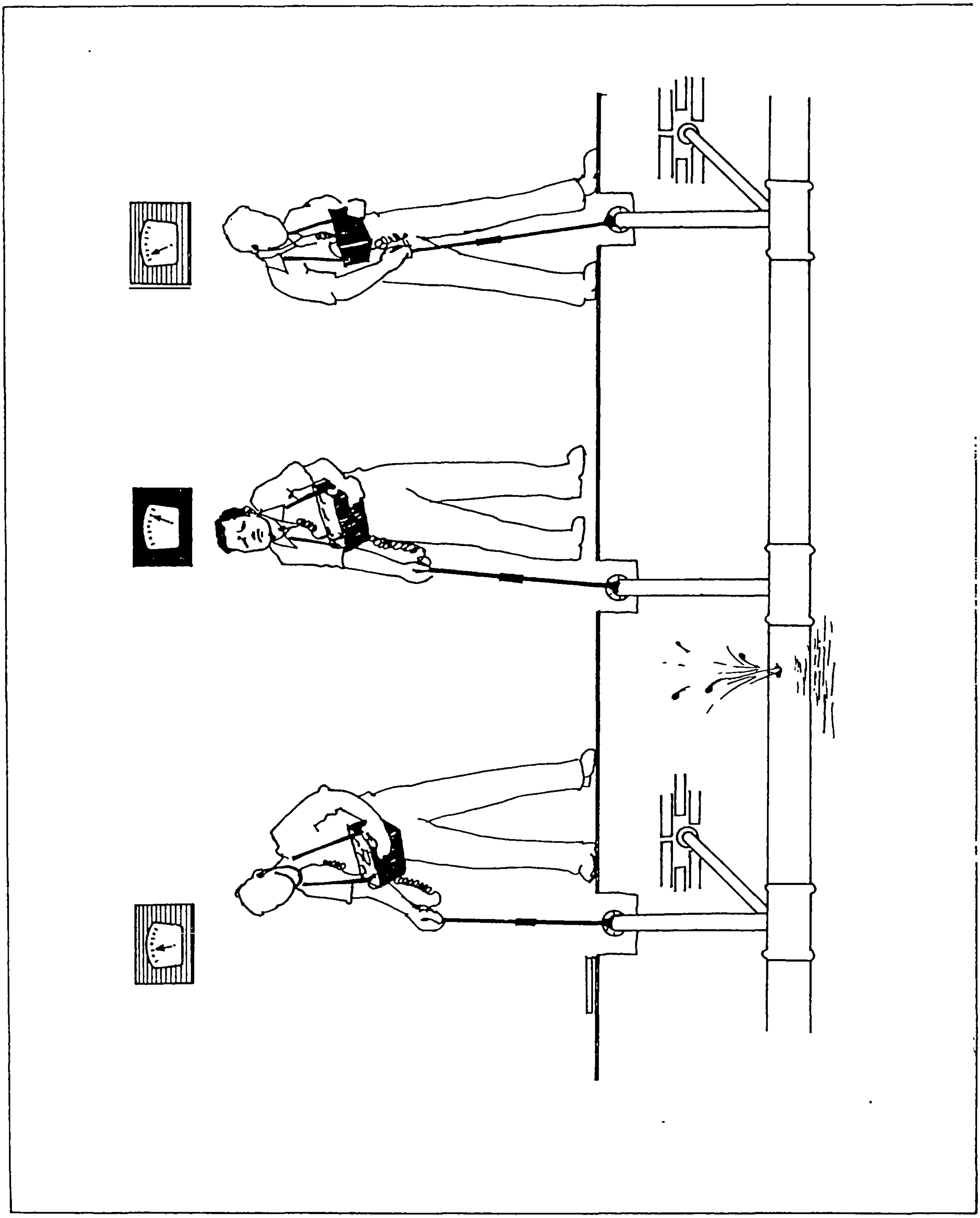
5. SUMMARY

Listening surveys are conducted as a follow up to step-test or when no meters are available.

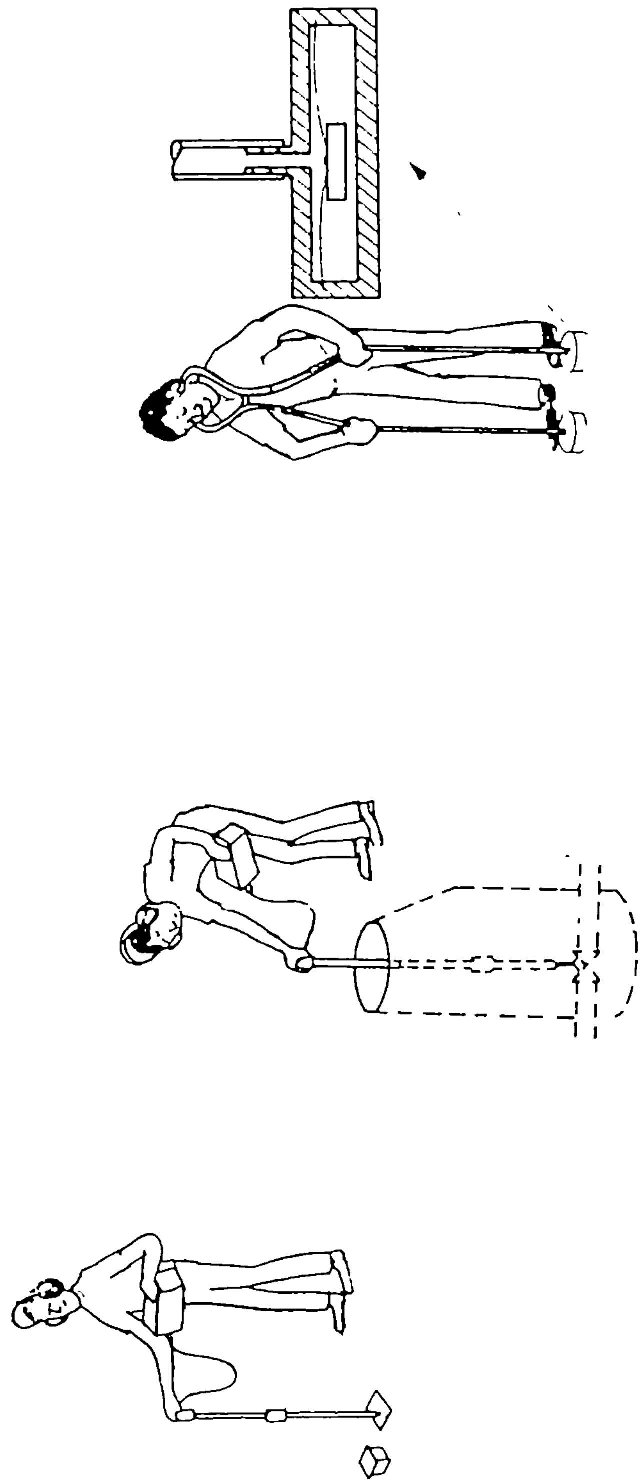
* * *

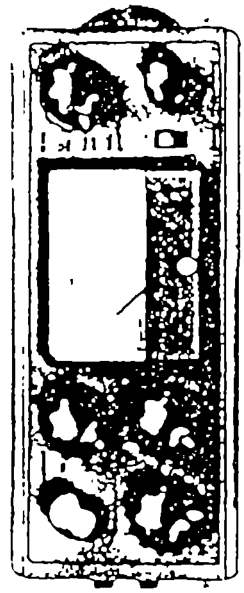
Module : LISTENING SURVEYS	Code : TDO 635
	Edition : 19-09-1984
Annex : V I E W F O I L S	Page : 01 of 08



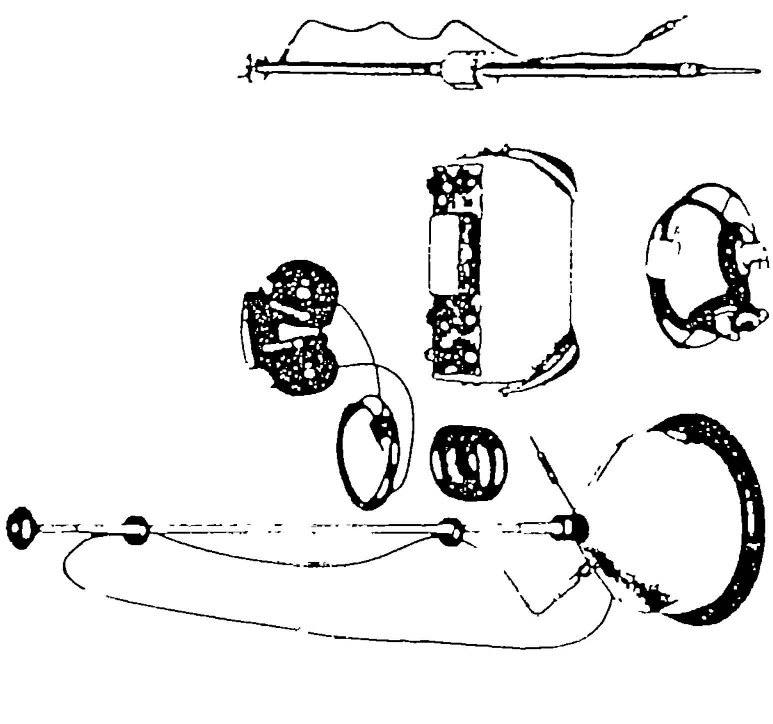


Listening devices (1)

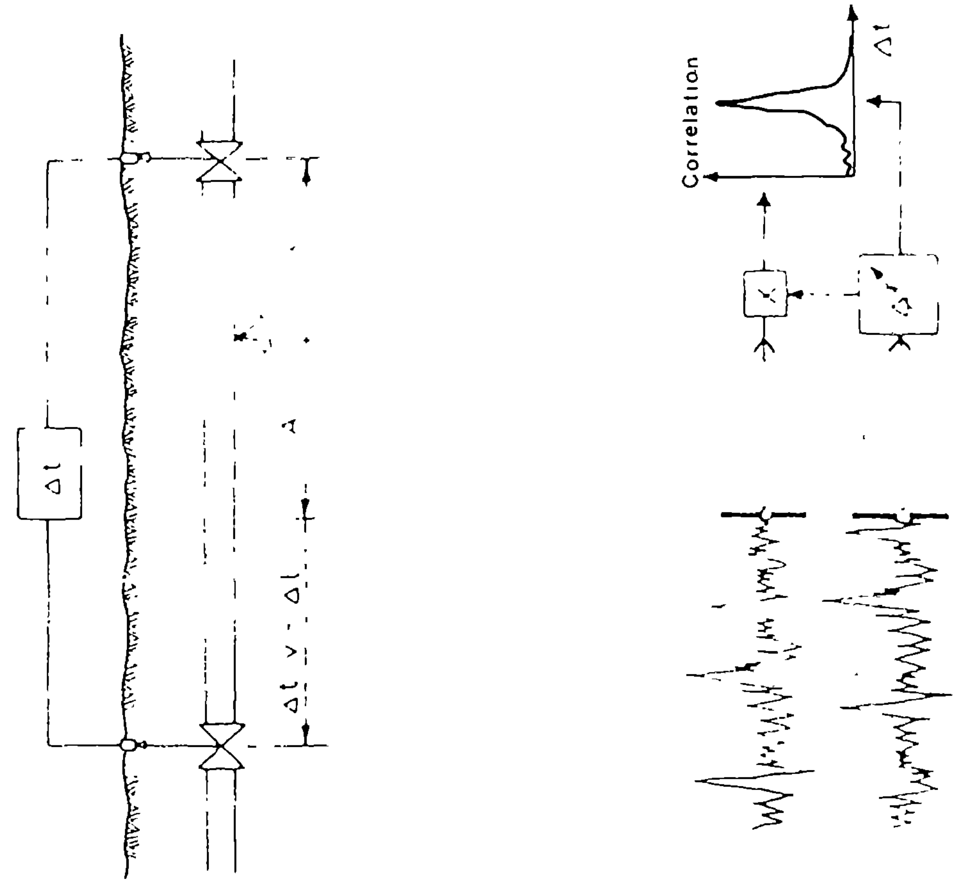


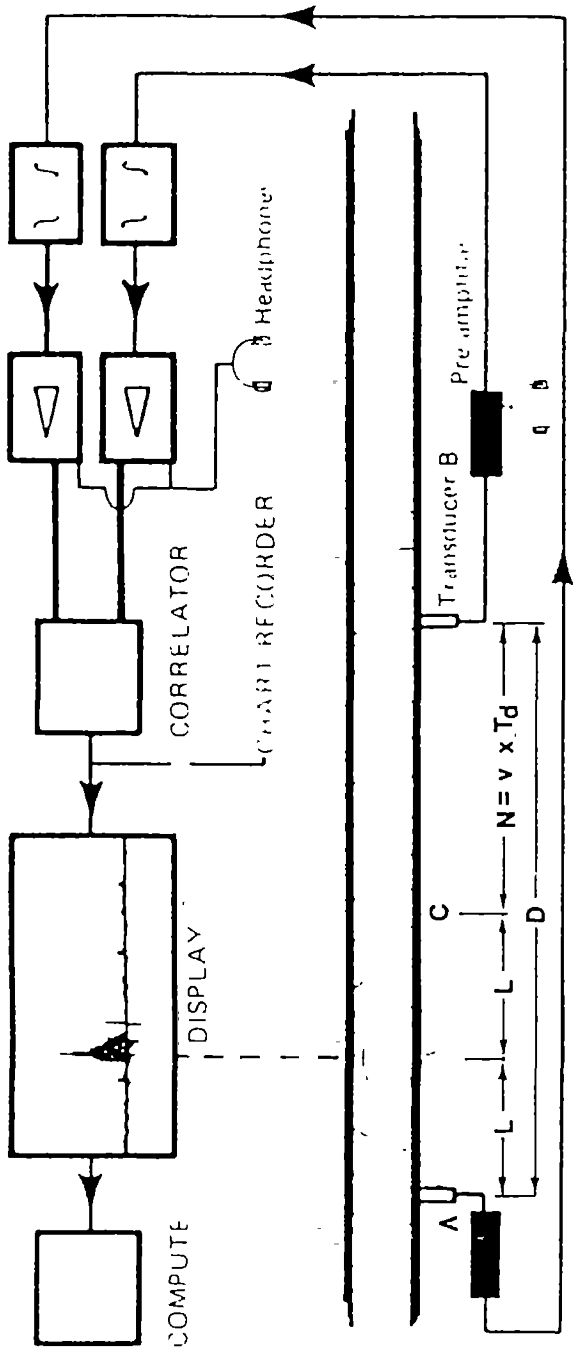


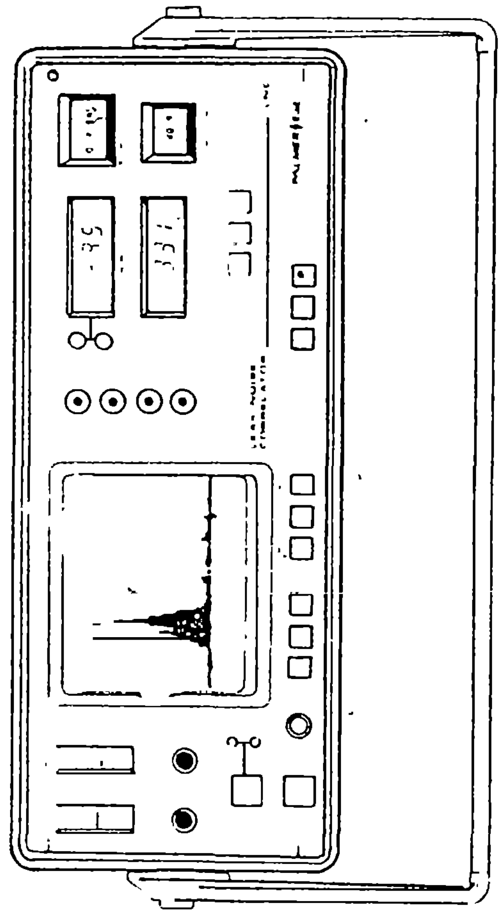
DETAIL OF RECEIVER UNIT

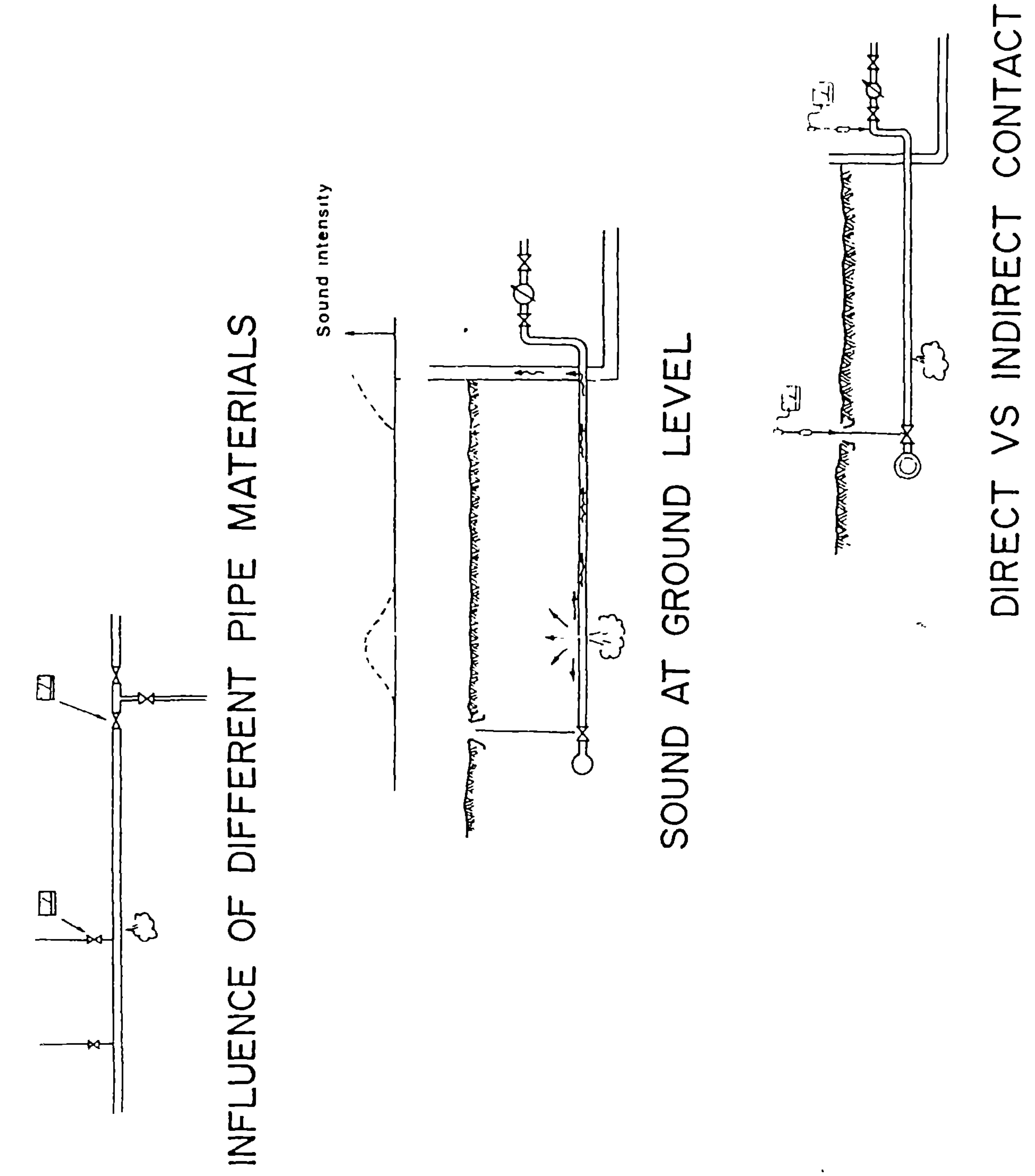


ELECTRONIC LISTENING EQUIPMENT


Correlation
Δt


DISPLAY
CORRELATOR
Headphone
Transducer B
A
C
L
L
N = v x Td
D




INFLUENCE OF DIFFERENT PIPE MATERIALS
Sound intensity
SOUND AT GROUND LEVEL
DIRECT VS INDIRECT CONTACT

Module : INTRODUCTION TO SERVICE CONNECTIONS	Code : TCC 100
	Edition : 26-09-1984
Section 1 : INFORMATION SHEET	Page : 01 of 01/11

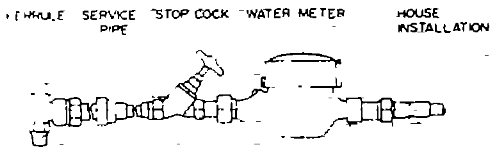
Duration :	45 minutes.
Training objectives :	After the session the trainees will be able to: - list the basic components of a service connection; - list the most common ways of making a tapping to a water main.
Trainee selection :	- Head of Section Distribution; - Head of Sub-section Distribution & Connections; - Pipelayer; - Pipeline Inspector; - Head of Sub-section Water Meters; - Head of Section Consumer Relations; - Head of Sub-section Consumer Services; - Head of Sub-section Meter Reading.
Training aids :	- Ferrules; - Clamp saddles; - Under-pressure tapping equipment; - Dry tapping equipment; - Viewfoils : TCC 100/V 1-8; - Handout : TCC 100/H 1.
Special features :	-
Keywords :	Service laying/tapping mains/tapping under pressure/dry tapping/service pipe/water meter.

1. Introduction	
- A service forms the bridge between the Water Enterprise main and the consumer's tap.	Show V 1
- It is normally a small-diameter pipe controlled by a ferrule at the water main and a stop tap at the meter.	
2. Tapping mains	
- The connection is made to the water main by means of a tapping.	
- A ferrule is then installed in the main.	Show V 2-4 Show : - clamp saddles - ferrules
- Tappings are made basically in two ways: a. under pressure; b. dry.	
3. Tapping under pressure	
- Standard method is as follows: . a watertight tapping machine is clamped to the water main; . the machine has a rotating turret at the top with facilities to fit a drill and a ferrule; . the drill is fixed in position and rotated to cut a threaded hole in the main; . the turret is rotated through 180° and the ferrule screwed into the main; . the ferrule is plugged with the self contained plugging screw; . the tapping machine is removed from the main, leaving the ferrule in place.	Show V 4-5 Show under-pressure-tapping equipment
- Sometimes self-tapping ferrules are available: . a saddle is clamped on the main with the ferrule attached; . at the base of the ferrule are cutting teeth;	Show self-tapping ferrule and explain

. when the ferrule is rotated a hole is cut in the main and simultaneously the ferrule is screwed into the main.	
4. Dry tapping	
- Carried out on water mains containing no water: . tapping machine clamped on water main; . drill head rotated to drill tapped hole in water main; . machine removed from main; . ferrule inserted in hole.	Show V 7 Show dry tapping
5. Service pipe	
- A service pipe is a small diameter pipe from ferrule to water meter. - Joint is made at ferrule. - Pipe is laid 80 cm deep. - Connected to stop-tap at meter.	Show V 1
6. Meter	
- Meter normally in chamber. - Raised to approximately ground level by 90° bends. - Stop tap on ferrule side of the meter.	Show V 8
7. Consumer	
- Pipe work after the meter is responsibility of the consumer.	
8. Summary	Give H 1

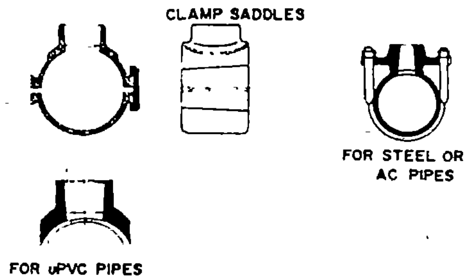
Module :	**INTRODUCTION TO SERVICE CONNECTIONS**	Code :	TCC 100
		Edition :	26-09-1984
Section 3 :	**T R A I N I N G A I D S**	Page :	01 of 02

Service connection assembly — TCC 100/V 1

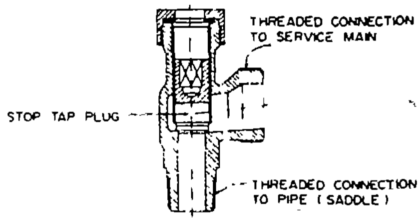


TYPICAL SERVICE CONNECTION ASSEMBLY

Clamp saddles — TCC 100/V 2

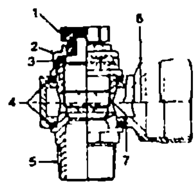


Section stop tap ferrule — TCC 100/V 3



CROSS SECTION OVER STOP TAP FERRULE

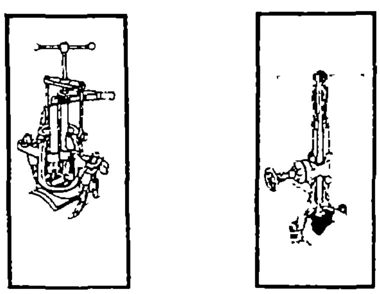
Typical ferrule — TCC 100/V 4



PART NO	DESCRIPTION
1	TOP PLUG
2	TOP CAP
3	TOP CAP WASHER
4	BANJO WASHERS
5	FERRULE STEM
6	BANJO
7	INNER PLUG

TYPICAL FERRULE

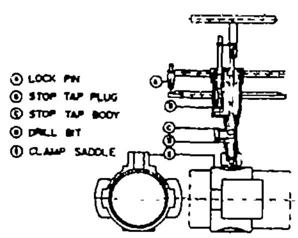
Tapping equipment I — TCC 100/V 5 (a-b)



FOR AC STEEL FOR PVC

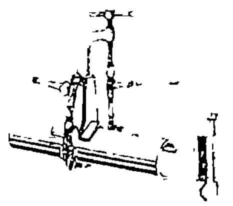
UNDER PRESSURE TAPPING EQUIPMENT

Tapping equipment II — TCC 100/V 6



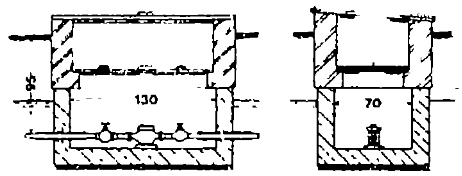
EQUIPMENT FOR TAPPING UNDER PRESSURE (uPVC PIPE)

Dry tapping equipment TCC 100/V 7



DRY TAPPING EQUIPMENT

Water meter pit TCC 100/V 8



WATER METER PIT

Introduction to service laying TCC 100/H 1

1. INTRODUCTION

A service is the bridge or link between the Water Enterprise's water main and the consumer's tap.
It normally comprises a small diameter pipe which is connected to the water main by a ferrule and runs to a stop-tap meter at the consumer's premises (see Fig. 1).

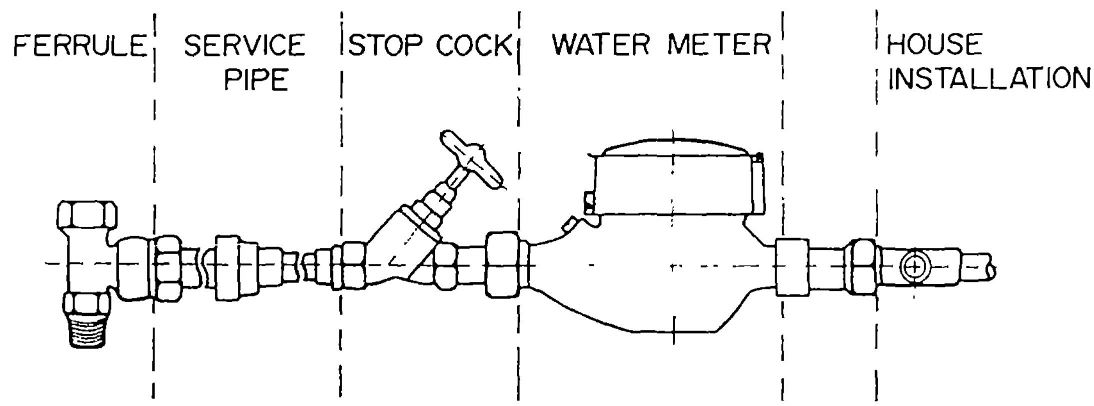
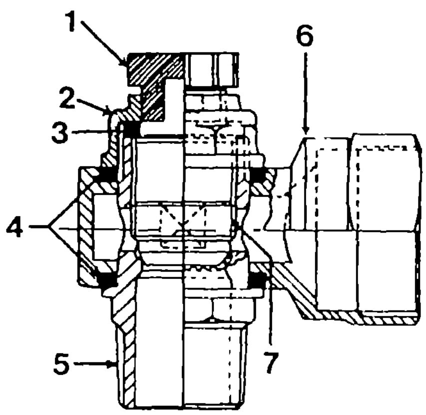


Fig. 1. Typical service connection assembly.

2. TAPPING MAINS

The connection of the service pipe is made to the main by tapping the main and inserting a ferrule (see Fig. 2).



PART NO	DESCRIPTION
1	TOP PLUG
2	TOP CAP
3	TOP CAP WASHER
4	BANJO WASHERS
5	FERRULE STEM
6	BANJO
7	INNER PLUG

Fig. 2. Typical ferrule.

Tapping can be done in two ways :
a. under pressure;
b. dry.
Tappings are made either directly in the pipe, or using clamp saddles (see Fig. 3).

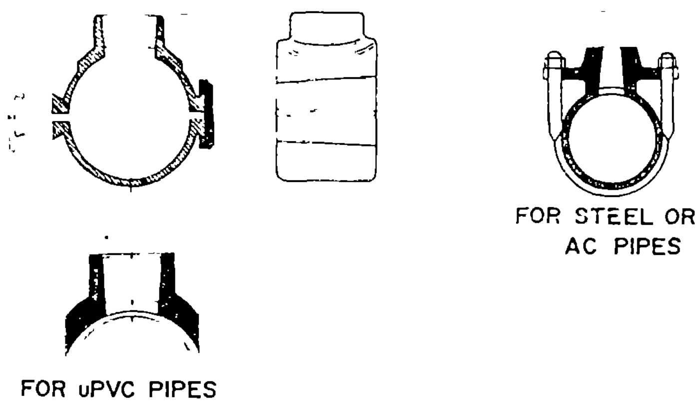


Fig. 3. Clamp saddles.

3. **TAPPING UNDER PRESSURE**

This type of tapping is used when the water main is filled with water under pressure (See Fig. 4 and 5 hereunder).
A tapping machine is clamped to the water main. It comprises a saddle and watertight chamber mounted on top of it.
On the top of the chamber there is a turret, to which a drill and a ferrule are attached (inside the chamber).
The turret can be rotated around a vertical axis.
The drill is used to cut a hole in the water main and at the same time tap threads in this hole.
The turret is then rotated over 180° and the ferrule inserted in the hole.
The ferrule is plugged by a plugging screw which is already inserted in it.
The machine is then removed, leaving the ferrule in place.
Some ferrules are self-tapping, that is they do not require a special tapping machine.

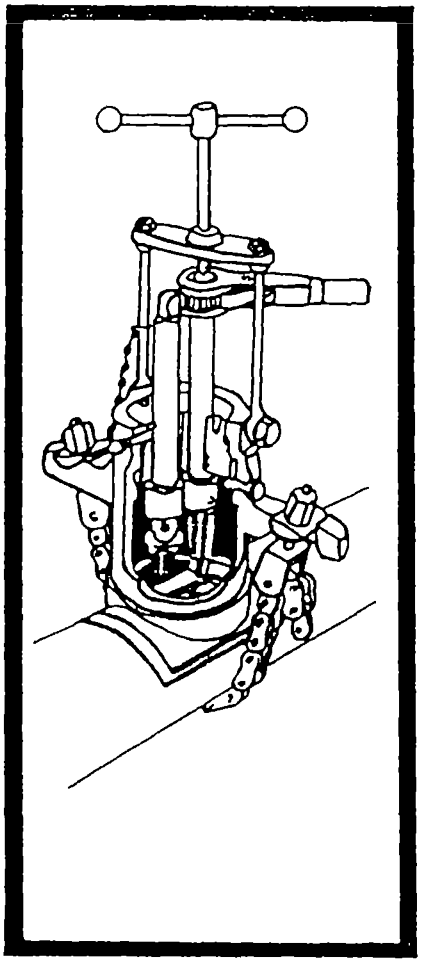


Fig. 4. Equipment for tapping A.C./steel pipes under pressure.

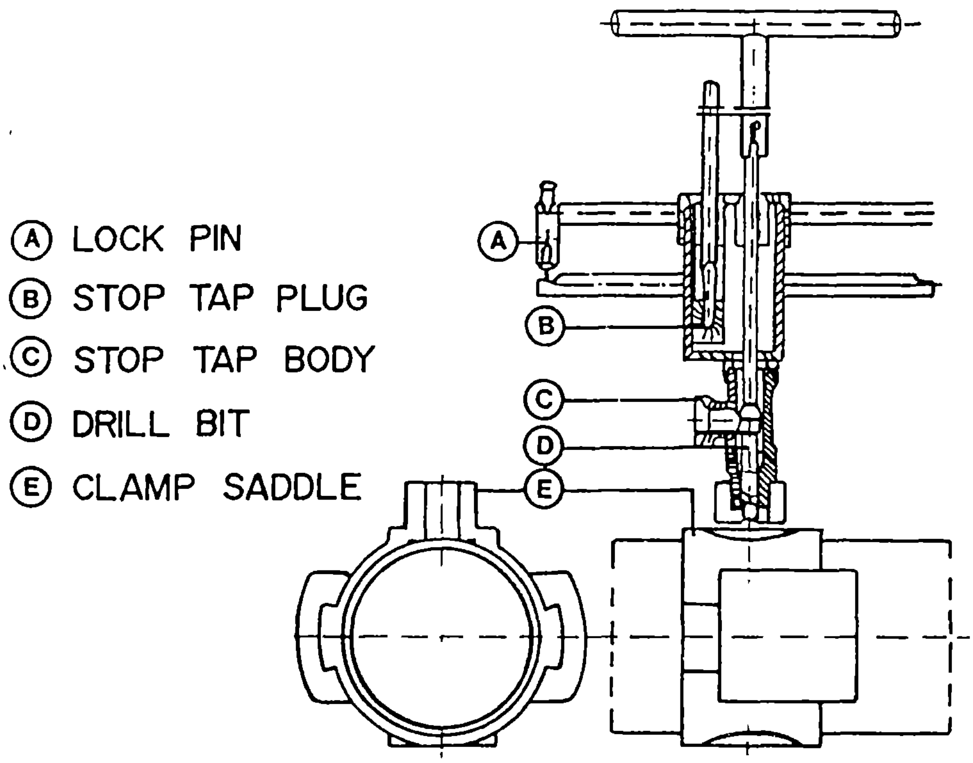


Fig. 5. Equipment for tapping uPVC pipe under pressure.

Such a ferrule is inserted in a saddle that is clamped on the main. The ferrule is screwed down, at the same time cutting and threading the main.

4. DRY TAPPING

This is carried out when the water main is not filled with water.
A tapping machine is clamped on the main. It essentially cuts and taps a hole in the main. The ferrule is then inserted (See Fig. 6).

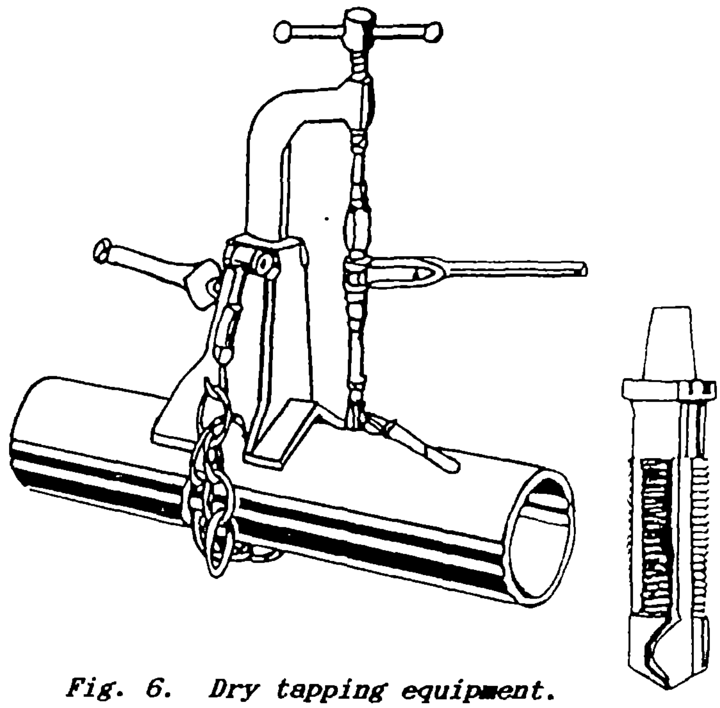


Fig. 6. Dry tapping equipment.

5. SERVICE PIPE

The service pipe is jointed to the ferrule and to the stop tap at the meter. It is normally laid underground, at a depth of approx. 80 cm.

6. METER

The meter is installed on the service pipe, to register the consumption. A meter is normally located in a chamber with a stop tap inserted between the service pipe and the meter (see Fig. 7).
When necessary, the meter is raised to approximately ground level by 90° bends.

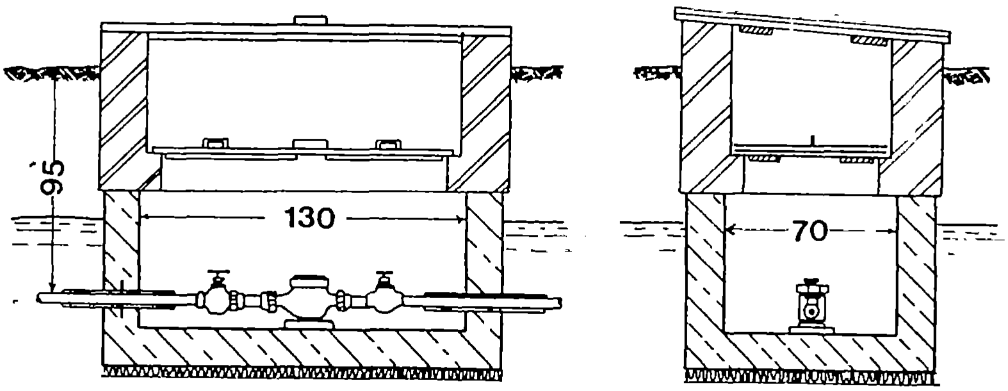


Fig. 7. Water meter pit.

7. CONSUMER

The pipework after the meter (including all in-house plumbing) is normally the responsibility of the consumer.

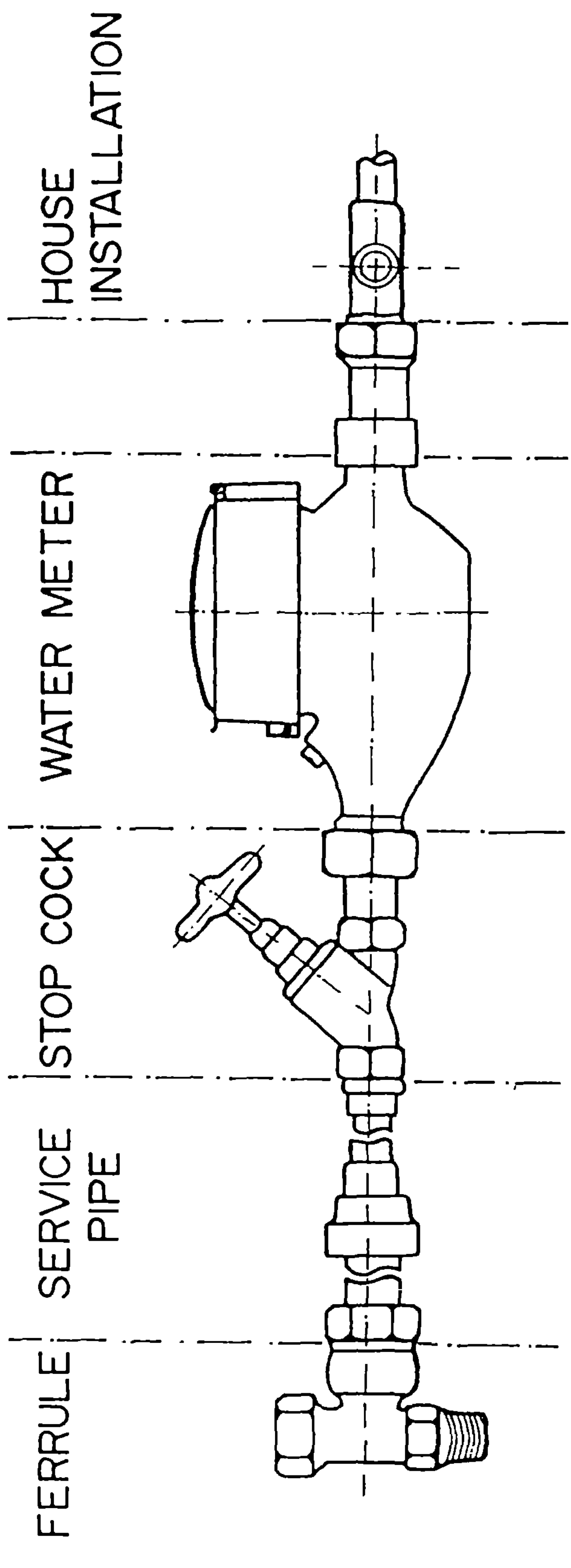
8. SUMMARY

The service takes water from the W.E. main to the consumer and comprises:

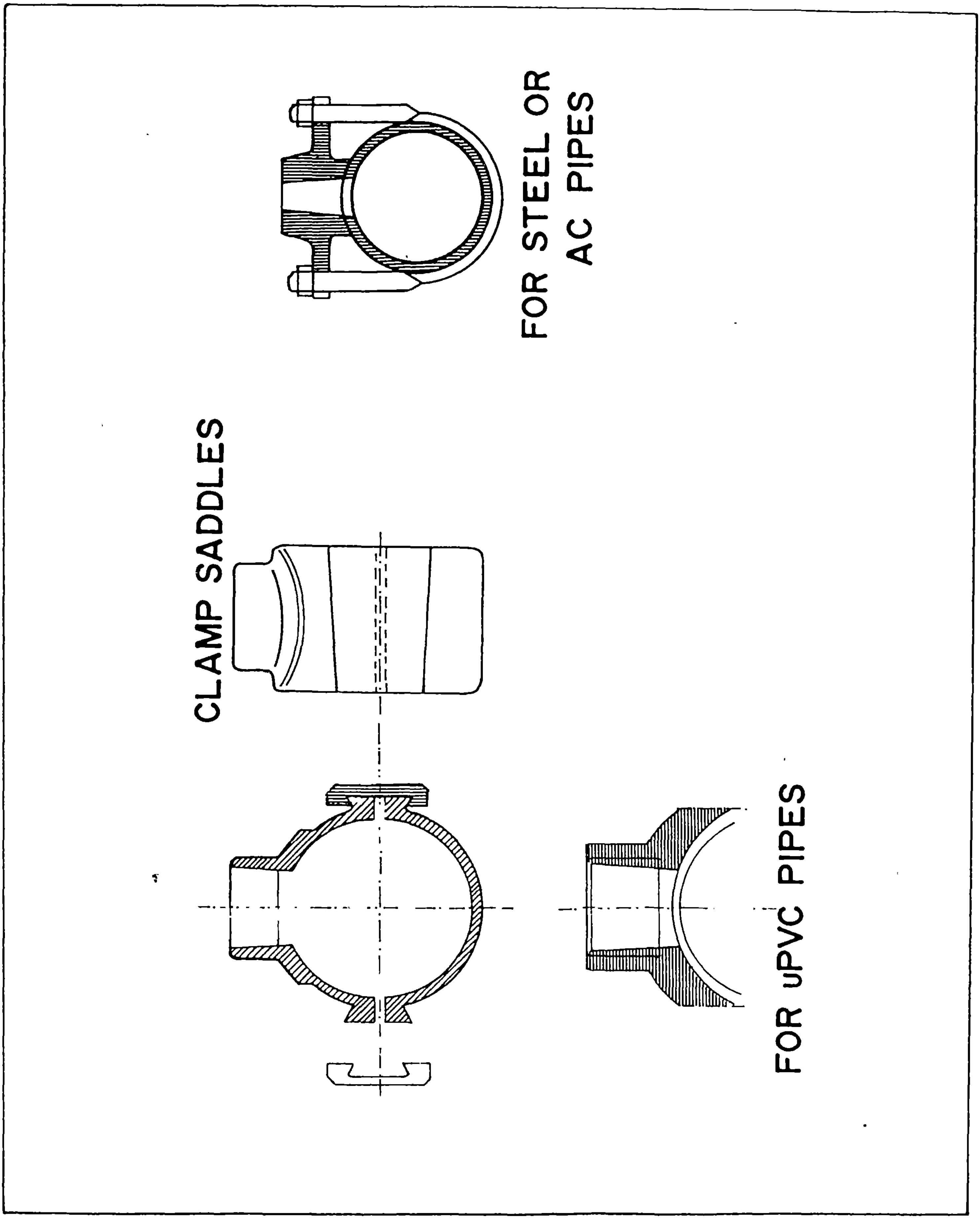
a. tapping on the main;
b. ferrule;
c. service pipe;
d. stop tap;
e. meter.

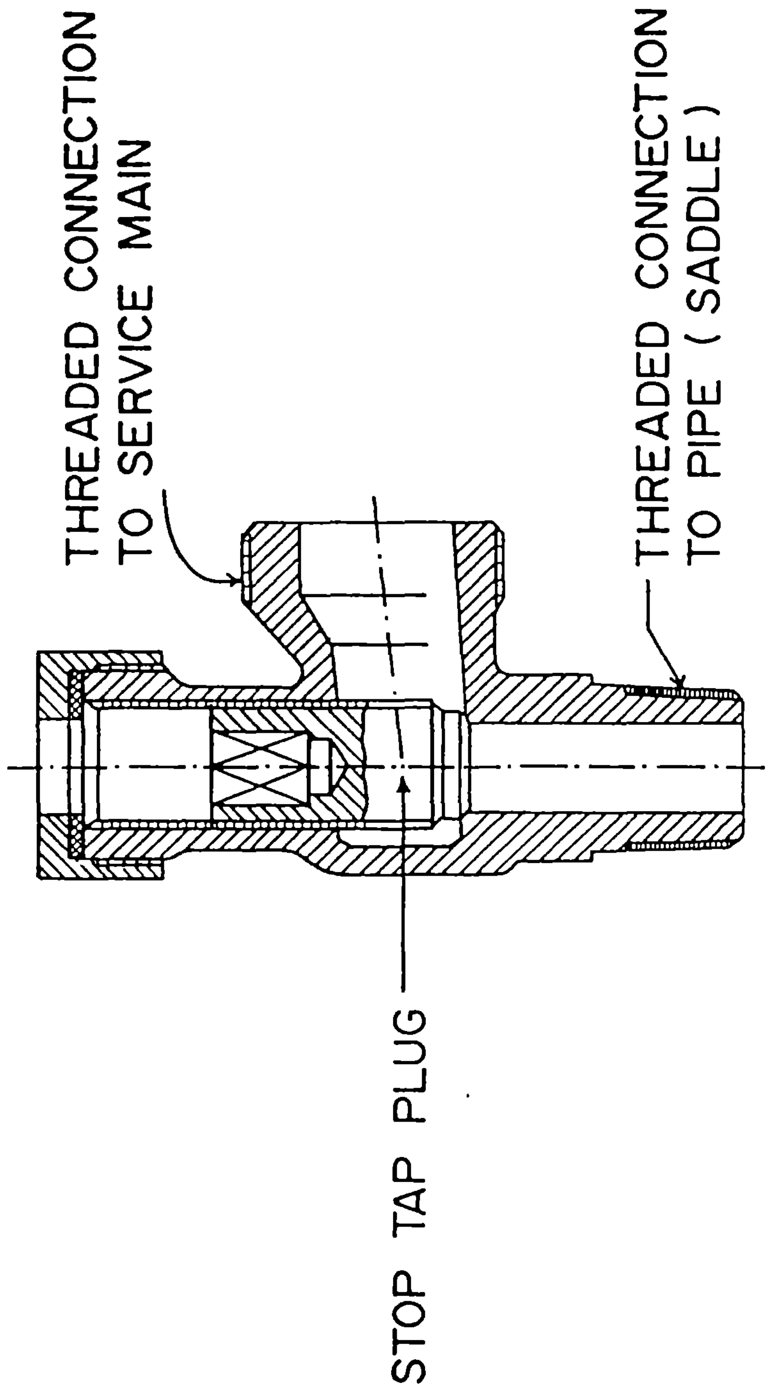
* * *

TITLE :	CODE :
1. Service connection assembly	TCC 100/V 1
2. Clamp saddles	TCC 100/V 2
3. Section stop tap ferrule	TCC 100/V 3
4. Typical ferrule	TCC 100/V 4
5. Tapping equipment (I)	TCC 100/V 5
6. Tapping equipment (II)	TCC 100/V 6
7. Dry tapping equipment	TCC 100/V 7
8. Water meter pit	TCC 100/V 8

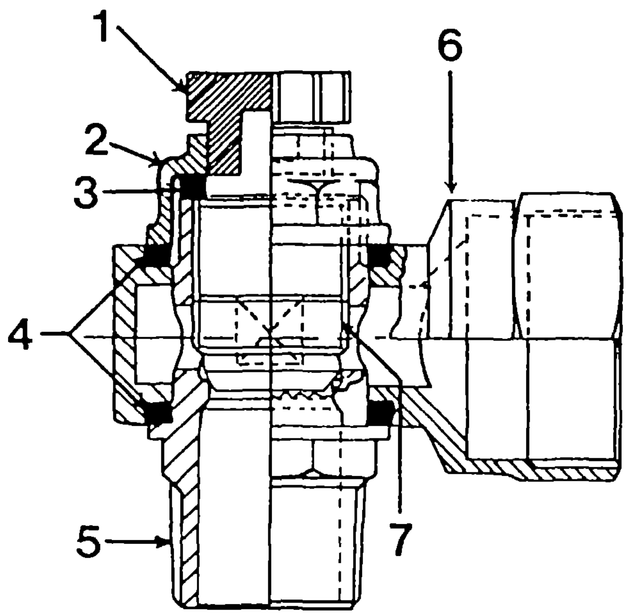


TYPICAL SERVICE CONNECTION ASSEMBLY


CLAMP SADDLES
FOR STEEL OR
AC PIPES
FOR uPVC PIPES

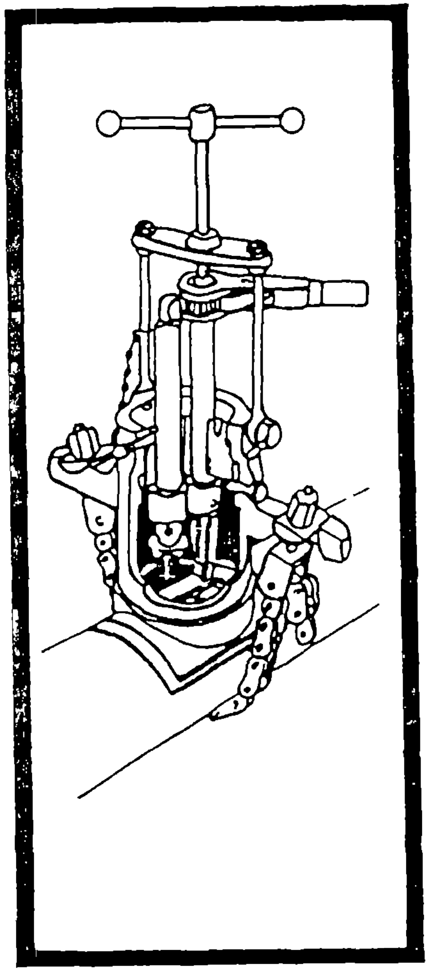


CROSS SECTION OVER STOP
TAP FERRULE

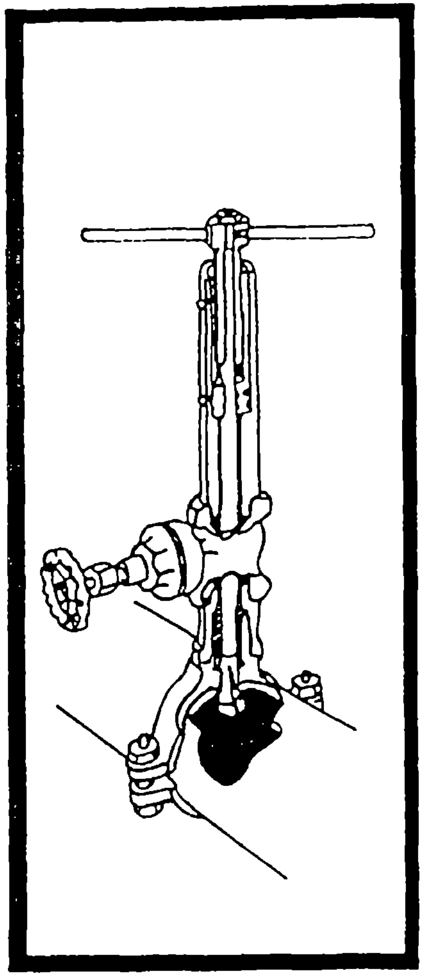


PART NO	DESCRIPTION
1	TOP PLUG
2	TOP CAP
3	TOP CAP WASHER
4	BANJO WASHERS
5	FERRULE STEM
6	BANJO
7	INNER PLUG

TYPICAL FERRULE

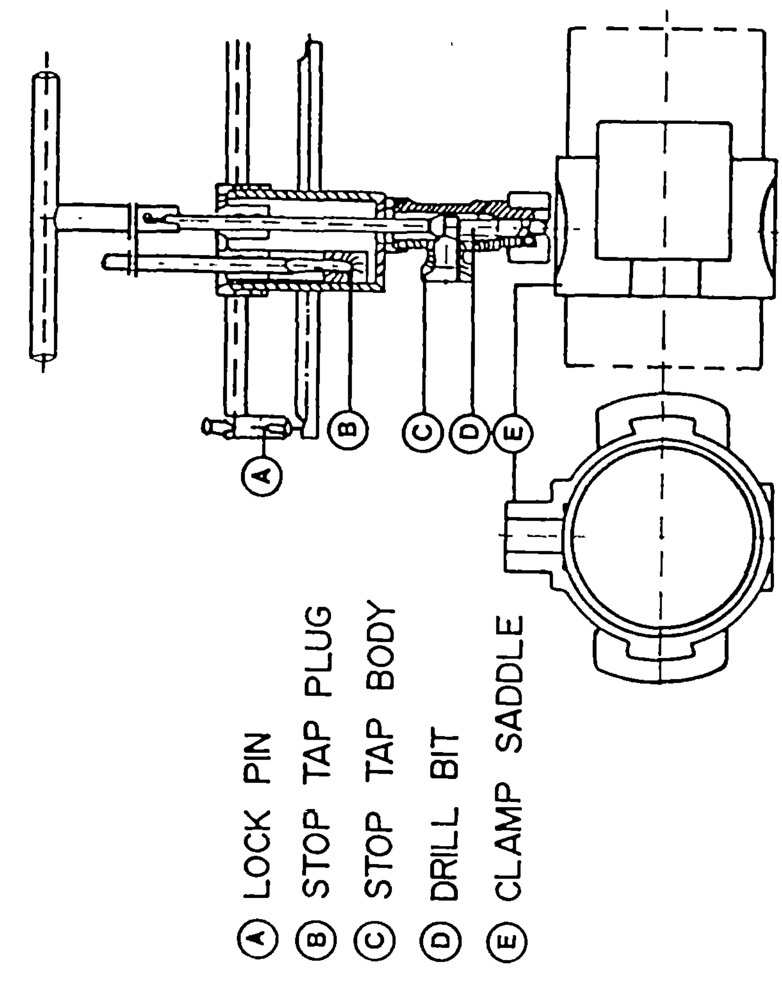


FOR A.C / STEEL

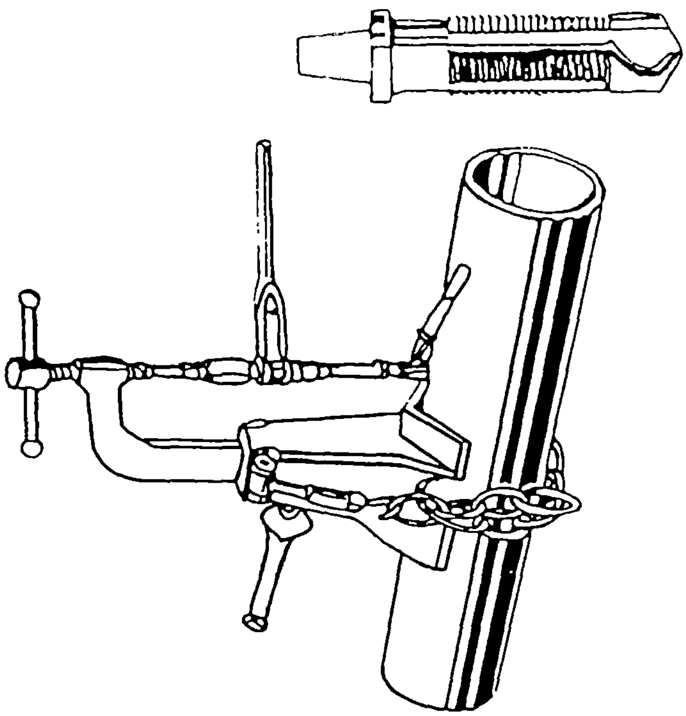


FOR uPVC

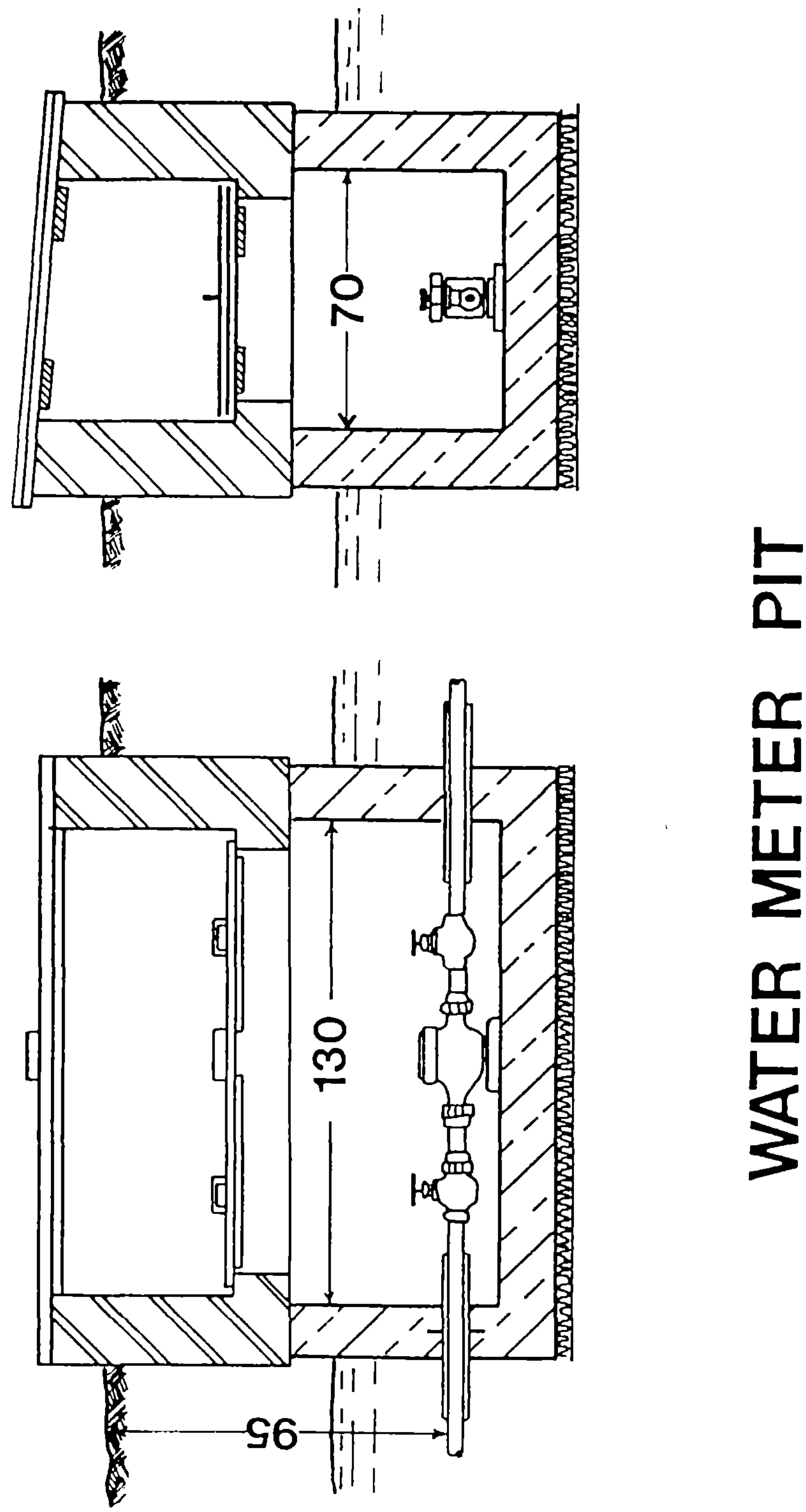
UNDER PRESSURE TAPPING EQUIPMENT



EQUIPMENT FOR TAPPING UNDER PRESSURE
(uPVC PIPE)



DRY TAPPING EQUIPMENT


WATER METER PIT
70
130
95

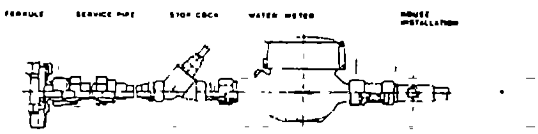
Module : LAYING SERVICE PIPES	Code : TCC 170
	Edition : 18-09-1984
Section 1 : INFORMATION SHEET	Page : 01 of 01/07

Duration :	135 minutes.
Training objectives :	After the session the trainees will be able to: - list the methods for cutting and jointing uPVC and GI service pipes; - lay service pipes of uPVC and GI.
Trainee selection :	- Head of Sub-section Distribution & Connections; - Pipelayer; - Pipeline Inspector.
Training aids :	- uPVC service pipe; - GI service pipe; - Pipe cutting and threading equipment; - Solvent cement for uPVC pipe; - Viewfoils : TCC 170/V 1-4; - Handout : TCC 170/H 1.
Special features :	-
Keywords :	Service laying.

Module : LAYING SERVICE PIPES	Code : TCC 170
	Edition : 18-09-1984
Section 2 : S E S S I O N N O T E S	Page : 01 of 01

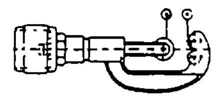
1. **Introduction**	
- Service pipes connect the consumer to the Water Enterprise's main.	Show V 1
- Usually they are laid in: a. uPVC b. GI.	
2. **Laying**	
- Service pipes are : . laid at a depth of 80 cm; . cut and jointed as required; . connected between the ferrule and stop-tap at meter.	Show V 2-4
3. **Summary**	Give H 1

Typical service main assembly — TCC 170/V 1



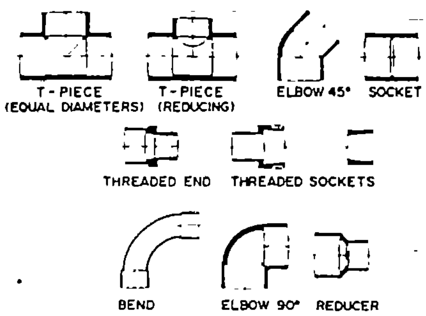
TYPICAL SERVICE CONNECTION ASSEMBLY

Pipe cutter (small diameter pipe) — TCC 170/V2



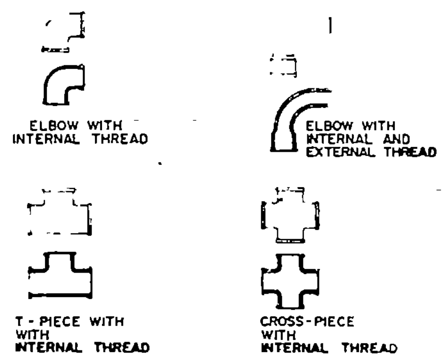
PIPE CUTTER (SMALL-DIAMETER PIPE)

PVC pipe fittings — TCC 170/V 3



PVC PIPE FITTINGS

GI pipe fittings — TCC 170/V 4



G.I PIPE FITTINGS

Laying service pipes — TCC 170/H 1

1. **INTRODUCTION**

Service pipes are laid to connect the consumer with the Water Enterprise's water main. They are generally small diameter pipes, made of either:
a. uPVC
b. GI.

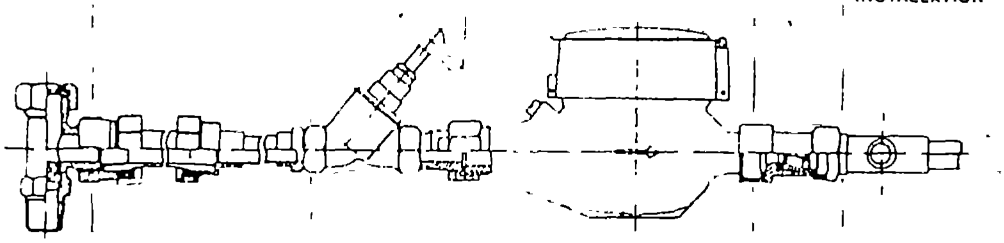


Fig. 1. Typical service connection assembly

2. **LAYING**

The pipes are cut to length and jointed to the ferrule. Then they are laid to the stop-tap at the meter.
Any jointing, cutting or the use of bends is done as and when required.
uPVC pipes as well as GI pipes are cut using either a hand saw or a pipe cutter.

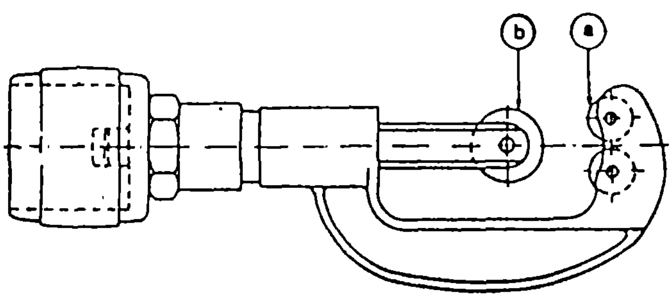


Fig. 2. Pipe cutter (for small-diameter pipe)

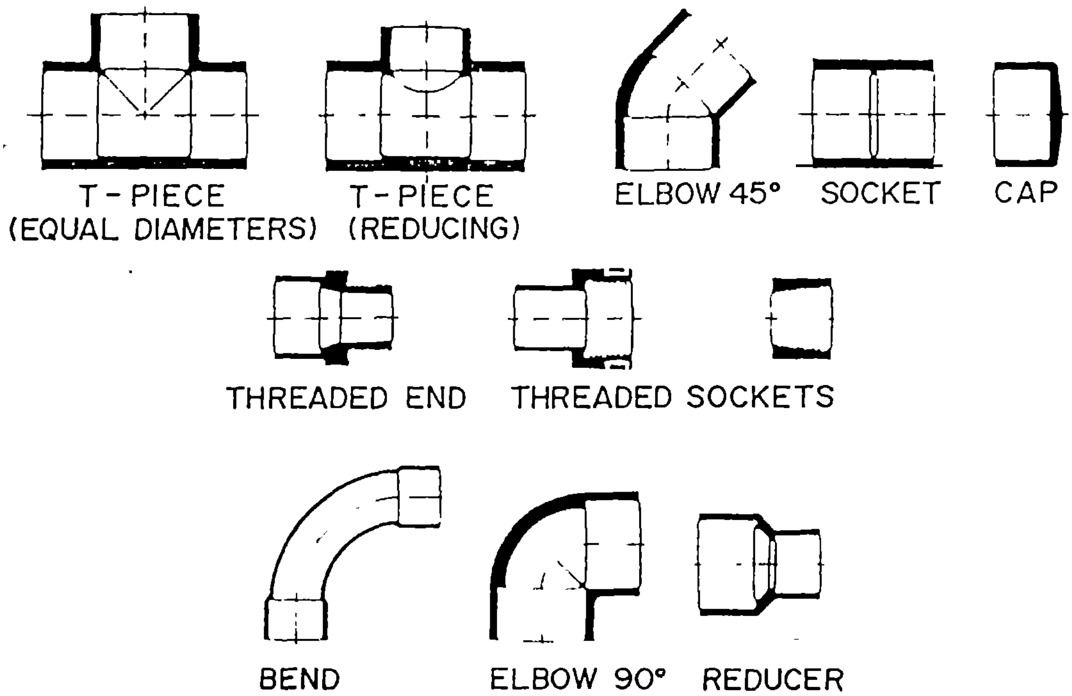


Fig. 3. PVC pipe fittings

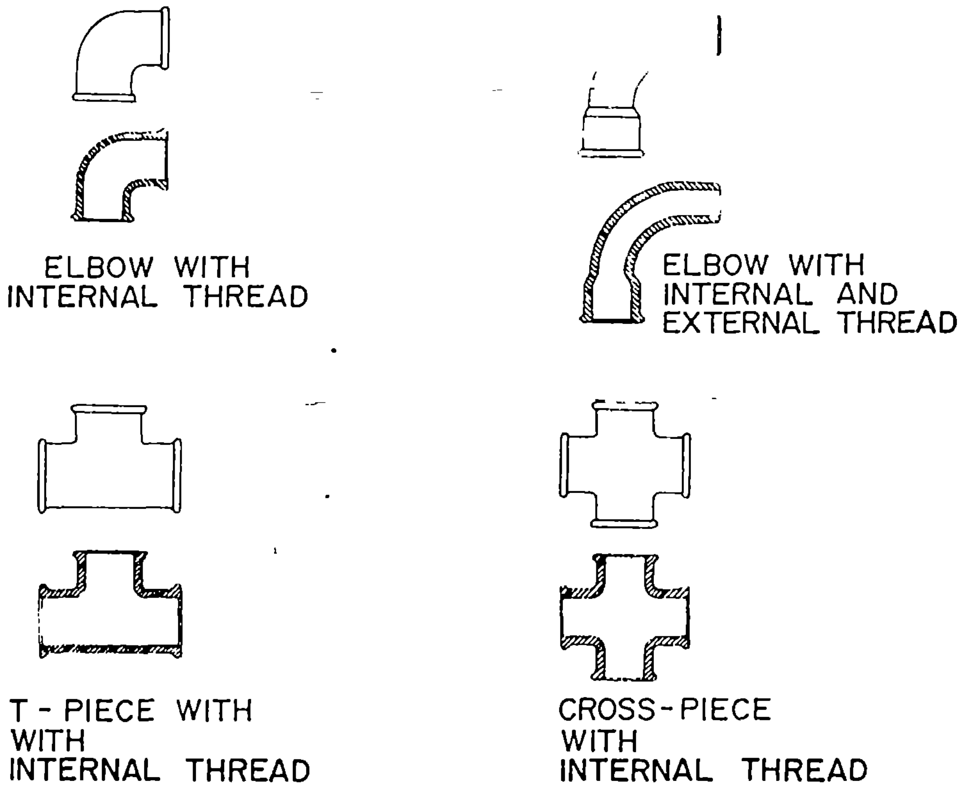


Fig. 4. G.I. pipe fittings

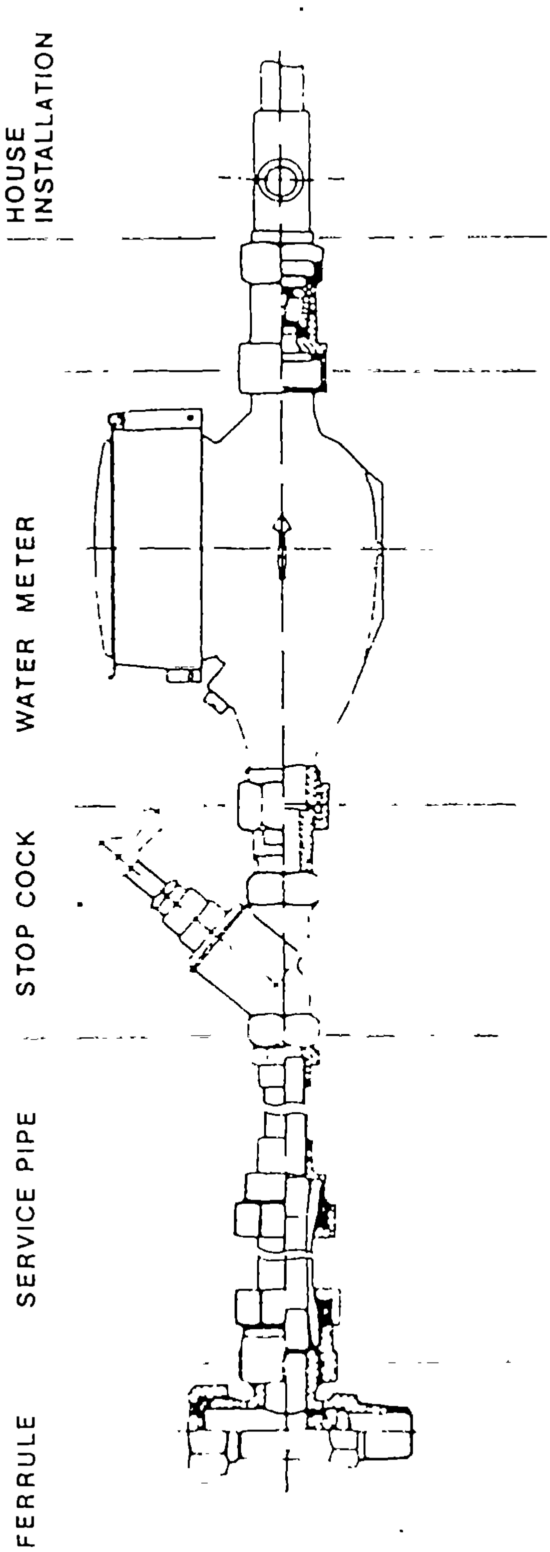
uPVC pipes for service pipes are jointed with solvent cement fittings, whereas GI pipes are jointed with threaded malleable fittings.

3. SUMMARY

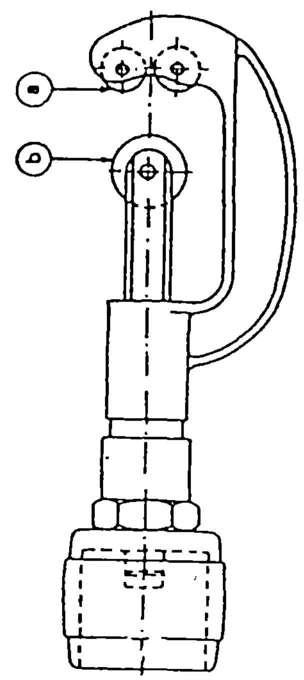
Services are laid to connect the consumer with the Water Enterprise's water supply. They are generally laid in:

a. uPVC pipe;
b. GI pipe.

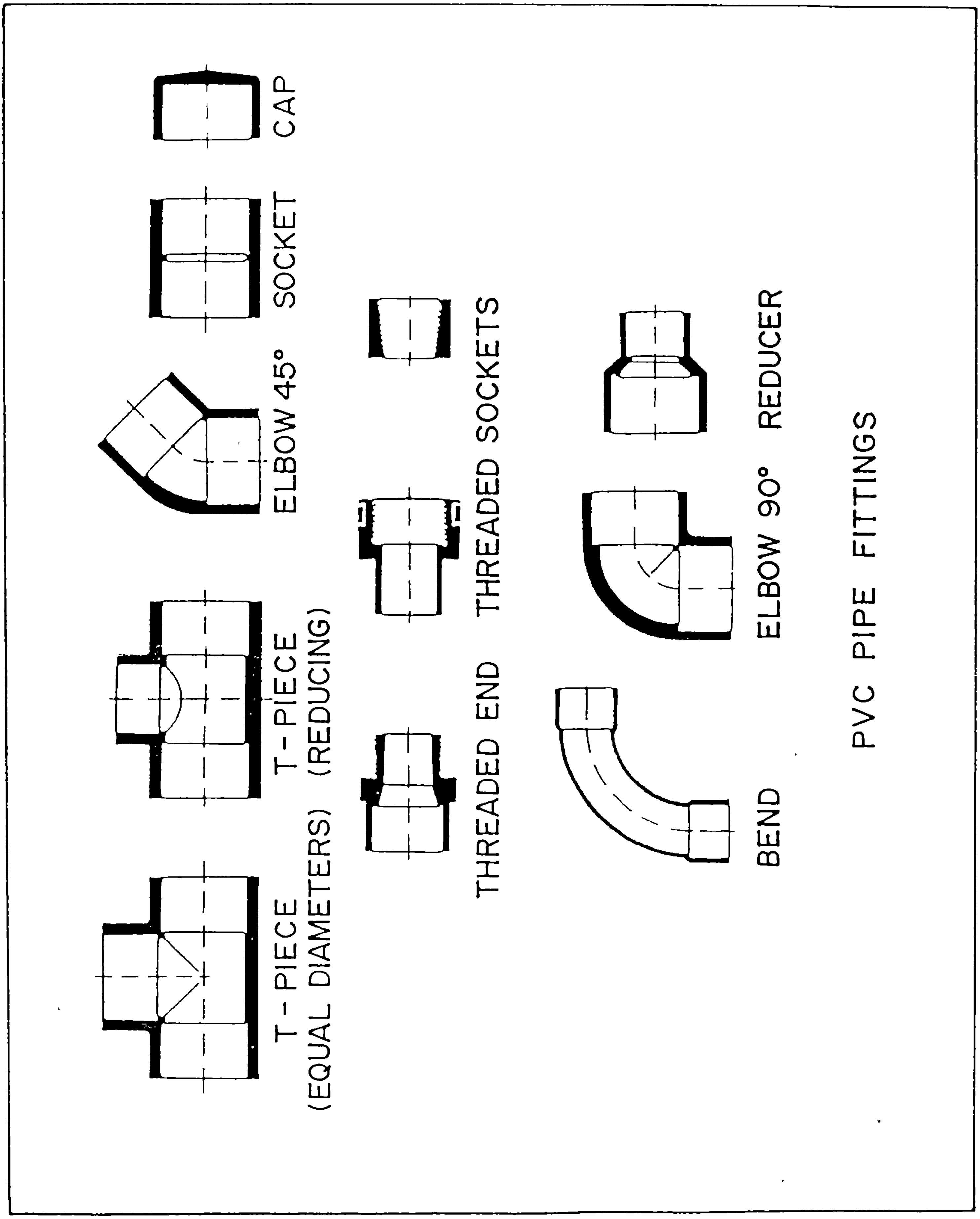
* * *

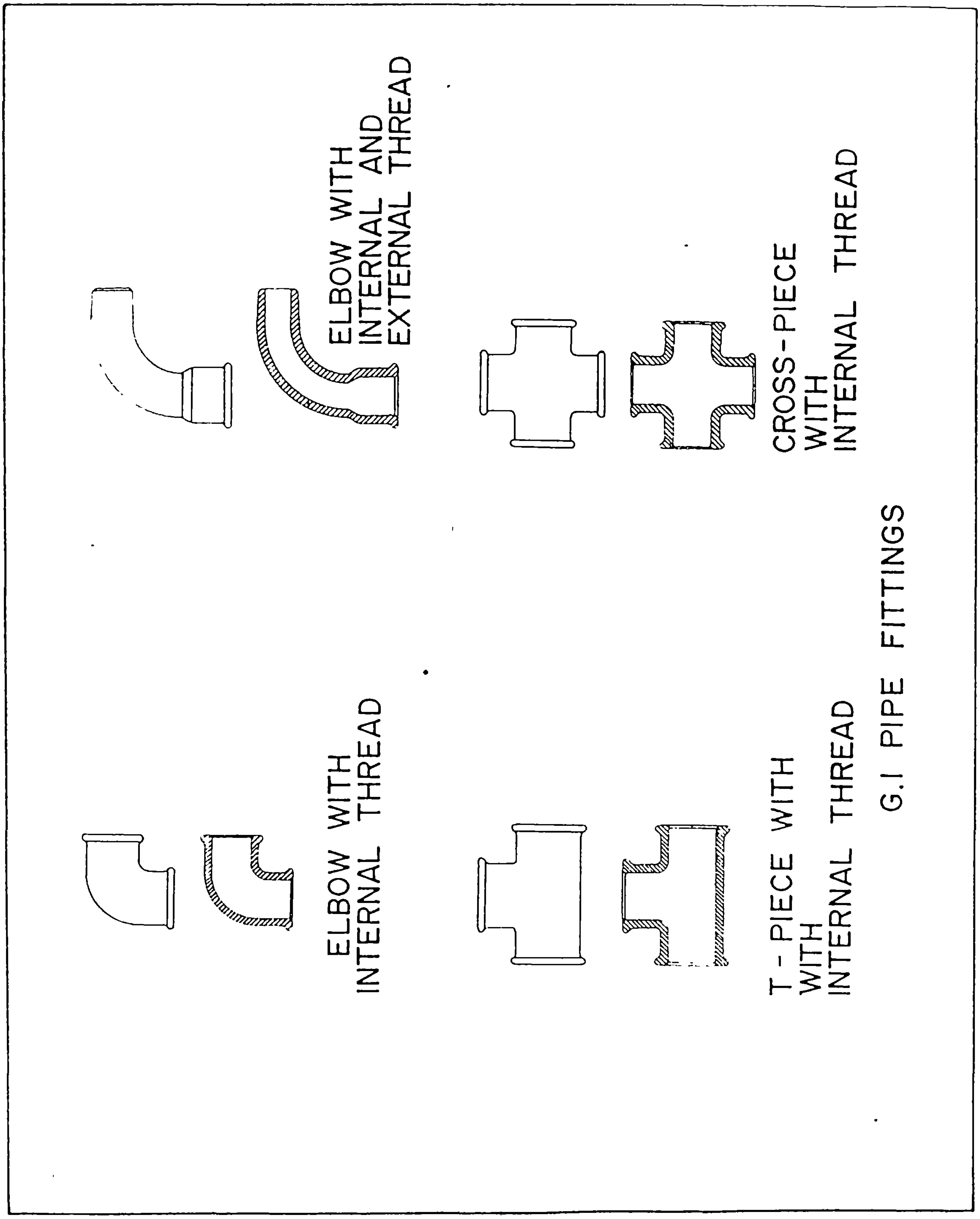


TYPICAL SERVICE CONNECTION ASSEMBLY



PIPE CUTTER (SMALL-DIAMETER PIPE)


CAP
SOCKET
ELBOW 45°
T-PIECE (REDUCING)
T-PIECE (EQUAL DIAMETERS)
THREADED SOCKETS
THREADED END
REDUCER
ELBOW 90°
BEND
PVC PIPE FITTINGS



G.I PIPE FITTINGS

Module : CONNECTING WATER METER	Code : TCC 210
	Edition : 18-09-1984
Section 1 : INFORMATION SHEET	Page : 01 of 01/04

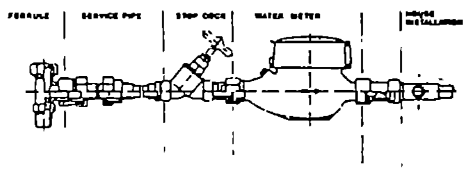
Duration	90 minutes.
Training objectives	After the session the trainees will be able to : - connect water meters to service pipes.
Trainee selection	- Head of Sub-section Distribution & Connections; - Pipelayer, - Pipeline Inspector.
Training aids	- Water meters; - Plumber's tools; - Pipe and bends/elbows; - Meter box; - Viewfoils : TCC 210/V 1; - Handout : TCC 210/H 1.
Special features :	-
Keywords :	Water meter/connecting water meter.

Module : CONNECTING WATER METER	Code : TCC 210
	Edition : 18-09-1984
Section 2 : S E S S I O N N O T E S	Page : 01 of 01

1. Introduction	
- Meters are installed on service pipes to measure the water consumption by the consumer.	Show V 1
- They are normally installed in a meter box.	
- Only cutting and jointing techniques are required.	
2. Installation of meter	
- Service pipe may enter at bottom of meter box, or through its side.	Demonstrate
- In the first option, a 90° bend is installed to bring service pipe to near ground level.	
- Another 90° bend is installed on to which stop tap is connected.	
- In the second option all appurtenances are in a straight line, after each other.	
- Meter is installed after the stop tap.	
- Additional pipework is the responsibility of the consumer.	Let trainees practice
3. Summary	Give H 1

Module : CONNECTING WATER METER	Code : TCC 210
	Edition : 18-09-1984
Section 3 : T R A I N I N G A I D S	Page : 01 of 01

Service connection assembly — TCC 210/V 1



TYPICAL SERVICE CONNECTION ASSEMBLY

Connecting water meter — TCC 210/H 1

Module : CONNECTING WATER METER	Code : TCC 210
	Edition : 18-09-1984
Section 4 : H A N D O U T	Page : 01 of 01

1. INTRODUCTION

Meters are installed on a service pipe to measure the consumption by the consumer.
They are normally installed in a box and only basic cutting and jointing techniques are required.

2. INSTALLATION OF METERS

The pipe normally enters the meter box either at the bottom or through one side. In the first option it is diverted by means of 90° bends to allow the meter to be installed in the pipe near the surface.
In the second case all appurtenances (service pipe, stop cock and water meter) are in a straight line (see figure below).

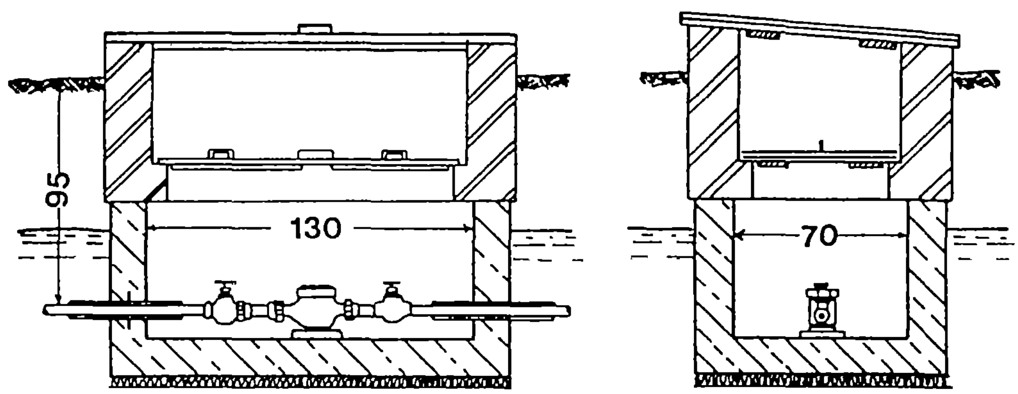


Fig. 1. Typical meter box

A stop-tap is installed on the ferrule side of the meter.

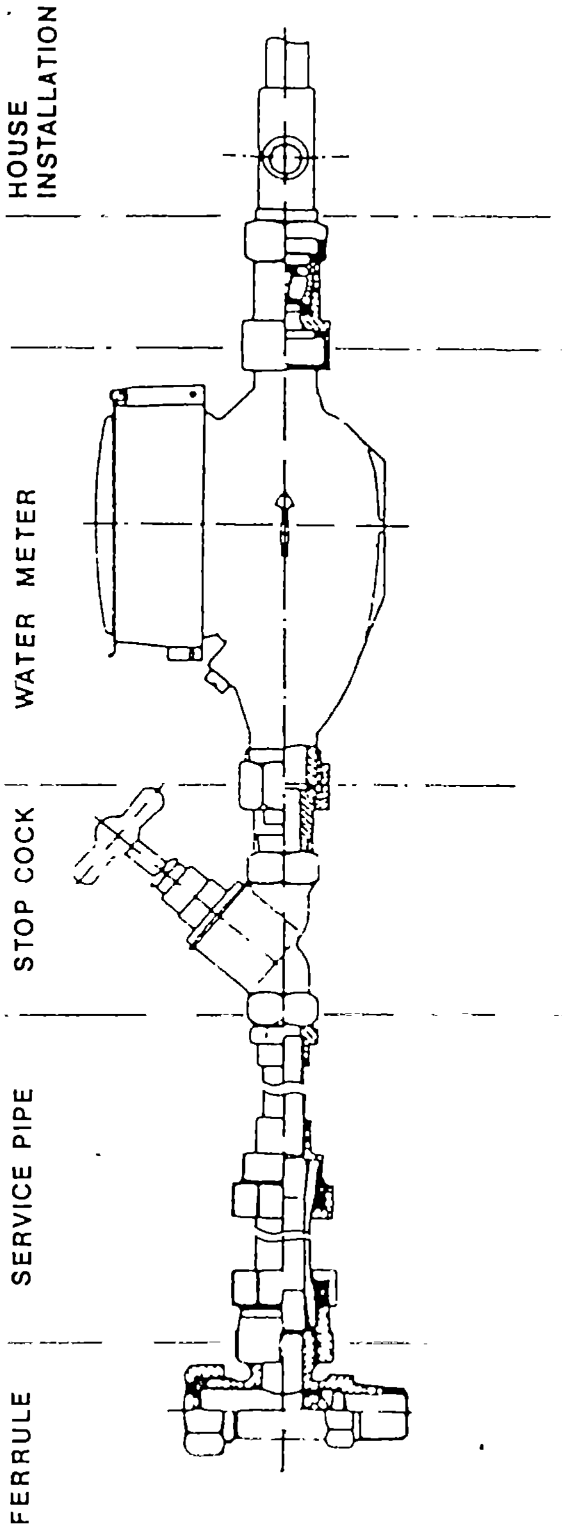
3. SUMMARY

Meters are installed to measure consumption and are normally set in a meter box.

* * *

Module : CONNECTING WATER METER		Code : TCC 210	
		Edition : 18-09-1984	
Annex : V I E W F O I L S		Page : 01 of 02	

TITLE :	CODE :
1. Service connection assembly	TCC 210/V 1



TYPICAL SERVICE CONNECTION ASSEMBLY