

# Guidelines for Non-Revenue Water Reduction (Detailed Measures)

## Non-Revenue Water Prevention Measures Step-1

### Non-revenue Prevention Measures Step-1

Basic consideration for non-revenue prevention measures was discussed using text of "Guidelines" in Stage-1. Stage -2 discusses specific measures. As discussed in the Guidelines the prevention measures include leakage prevention, maintenance of meters, renovation of pipelines, supply pipes and proper operation and maintenance of service and supply pipes.

Therefore main measures of non-revenue prevention such as leakage prevention will be discussed.

## 1. Leakage Prevention Measures

Before going into detail, as a basic understanding, actual condition of leakage and its references and data by visual recognition will be introduced.

### I. By Uses

Specification of leakage cases in FY2003

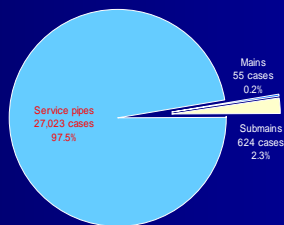


Figure 1 Percentage of Cases of leakage Repair

## Specification of leakage cases in FY2003

### II. By Causes

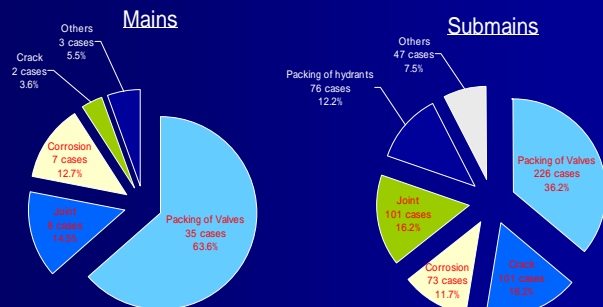


Figure 2 Percentage of Cases of Leakage

## Specification of leakage cases in FY2003

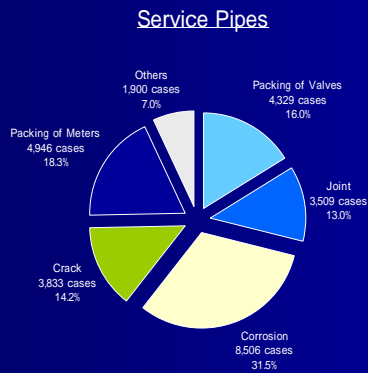


Figure 3 Percentage of Causes of Leakage

## Estimate Amount of Leakage by Broken Shape

Water Pressure 5 kgf/cm<sup>2</sup> at Measuring Time

Unit: Upper m<sup>3</sup>/d Below m<sup>3</sup>/h

Size of Whole (cm <sup>2</sup> )	Water Pressure (kgf/cm <sup>2</sup> )					Shape of Broken Part		
	3.0	4.0	5.0	6.0	7.0	Circle	Square	Irregular Shape
1.0	76.0	88.0	98.0	107.0	116.0			████████
	3.160	3.660	4.080	4.450	4.830			████████
0.6	54.0	63.0	70.0	76.0	83.0			████████
	2.250	2.620	2.910	3.160	3.450			████████
0.5	52.0	60.0	67.0	73.0	79.0			████████
	2.150	2.500	2.790	3.040	3.290			████████
0.4	50.0	57.0	64.0	70.0	75.0			████████
	2.800	2.375	2.660	2.910	3.120			████████
0.3	33.0	38.0	43.0	47.0	51.0			████████
	1.370	1.580	1.790	1.950	2.120			████████
0.2	27.0	31.0	35.0	38.0	41.0			████████
	1.120	1.290	1.450	1.580	1.700			████████
0.1	17.0	20.0	22.0	24.0	26.0			████████
	0.700	0.830	0.910	1.000	1.080			████████
0.08	15.5	18.0	20.0	22.0	24.0			████████
	0.640	0.750	0.830	0.910	1.000			████████
0.06	11.6	13.4	15.0	16.4	17.7			████████
	0.480	0.550	0.620	0.680	0.730			████████
0.04	7.70	8.90	10.00	11.00	11.80			████████
	0.320	0.370	0.416	0.450	0.490			████████
0.02	3.90	4.50	5.00	5.50	5.90			████████
	0.160	0.180	0.200	0.220	0.240			████████
0.01	1.30	1.60	1.80	2.00	2.10			████████
	0.050	0.060	0.075	0.080	0.080			████████

Reference-1: Leakage Amount by Eye Measurement

## Visible Leakage Amount (by cartoon)

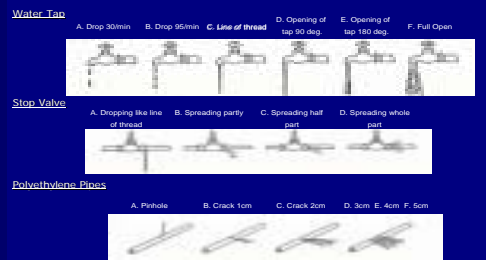


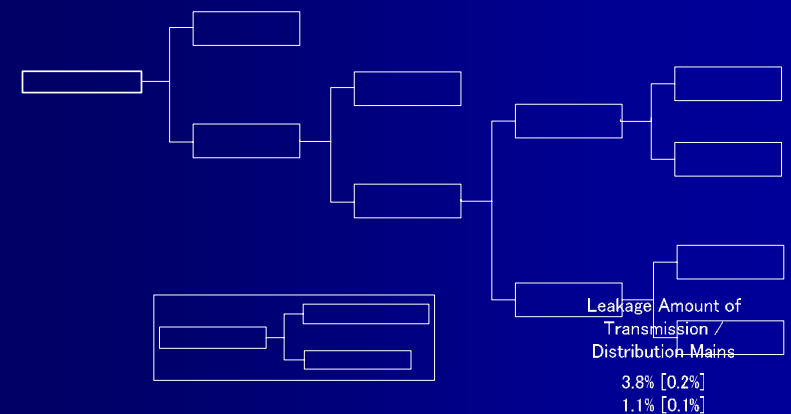
Table of Flow Amount (Measured by dynamic water pressure 3.5 kgf/cm<sup>2</sup> and converted to kgf/cm<sup>2</sup>)

Unit: Upper m<sup>3</sup>/d Lower m<sup>3</sup>/h

Item	Condition	A	B	C	D	E	F
Water Tap		0.011	0.036	0.09	30.9	39.6	56.8
		0.0015	0.004	0.004	1.29	1.65	3.36
Installation of Stop valve		0.045	2.3	3	7.1		
		0.002	0.096	0.125	0.296		
Polyethylene Pipe	0.03-0.05	2.7	15.4	28.4	43.8	68.8	
	0.001-0.002	0.113	0.41	1.18	1.83	2.86	

\* Figures show pipe material of diameter of 13mm

## Leakage Amount Analysis



Total Leakage Amount

## Non-Revenue Water Prevention Measures Step-2

### Non-revenue Prevention Measures Step-2

#### 1) Cause of Leakage

There are two causes : One is "Natural Causes" and the other is "Human Causes".

#### 1) Cause of Leakage

Natural causes includes

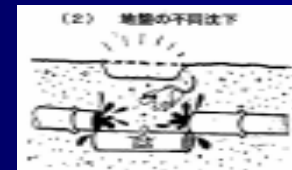
Natural causes includes

##### (1) Earthquake and volcanic activities



Earth quake and volcanic activities will be a factor damage to whole pipeline.

##### (2) Land subsidence



Land subsidence will be a factor to cause damage to pipeline route.

#### 1) Cause of Leakage

Natural causes includes

##### (3) Pipe deterioration

Pipe deterioration will cause to

- i) easily
- ii) leakage



##### a) Micro Cell Corrosion

Micro cell will occur at the positive and negative pole on the surface of underground pipes due to environment of surface condition of pipe, and corrosion starts at the positive portion of pipe.

##### b) Macro Cell Corrosion

Macro cell will occur at the positive and negative pole at the underground pipe due to difference of current caused by different metal and earth, and corrosion starts at the positive portion of pipe.

#### 1) Cause of Leakage

Human factor

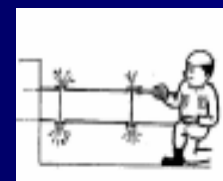
Human factor

##### (1) Vibration and load by traffic



Any road where heavy traffic is normal:  
By continuous load weight and vibration, land subsidence will occur which be a factor to cause damage to pipeline and jointing portion.

##### (2) Poor construction



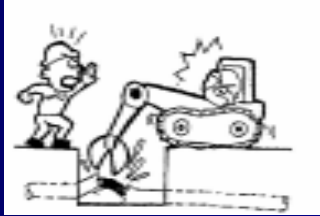
The reasons are due to construction by:

- a) Unskilled workers
- b) Lack of construction knowledge
- c) Improper back filling
- d) Improper supervision

## 1) Cause of Leakage

Human factor

- (3) Damage due to construction by other enterprise



- a) Increase of difficulty to find location of pipe due to many other underground obstructions.
- b) Increase of shoddy construction due to increase of construction works.

## 2) Effect by leakage

- (1) Financial constraints

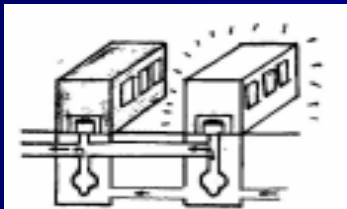


Leakage cause to

- Shortage of supply
- b) Revenue deduction
- c) Financial problems

## 2) Effect by leakage

- (2) Function of the water Facilities will be degraded

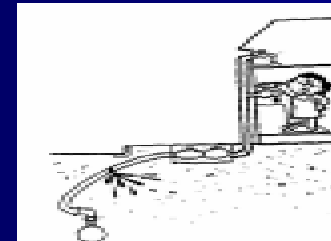


Large amount of leakage requires

- Necessity of expansion of treatment facilities
- b) Increase of pumping facilities to cover low pressure
- c) Development of new water source

## 2) Effect by leakage

- (3) Constraints to water output

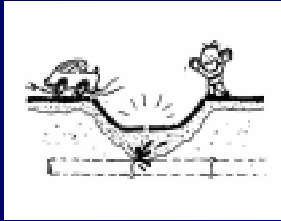


Leakage causes

- Low water pressure
- b) Constraints to water supply output
- c) Worsening of water quality

### 3) Causes of Secondary Disaster

#### (1) Sinking of road

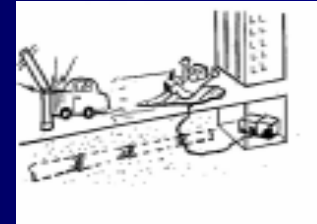


Leakage flows out earth and sand underground causing:

- Sinking of road
- b) Stoppage of traffic and finally bring traffic congestion

### 3) Causes of Secondary Disaster

#### (2) Inundation of road and accident by slippery



- a) Leakage on the surface of road causes frozen road during winter time which will bring easily the road slippery and cause of accidents.
- b) Leakage underground causes inundation of building basement giving causing damages to warehouse and equipment installed.

### 3) Causes of Secondary Disaster

#### (3) Pollution of treated water is feared in the pipeline

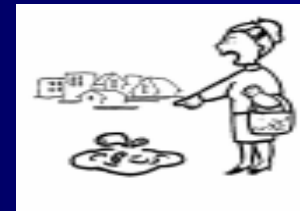


Occurrence of water suspension or low water pressure by leakage.

- Inner pipe pressure will be negative
- b) Polluted water is sacked through leakage hole and potable water will be polluted

### 4) Detection of leakage on the surface of road

#### (1) Report by pedestrians or citizen informing that the road is wet



- a) Caused by underground leakage
- b) Overflow to surface of the road from underground leakage

#### 4) Detection of leakage on the surface of road

(2) Report by pedestrians or citizen informing that the road becomes hollow

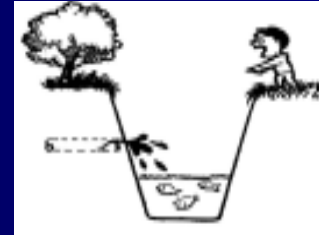


Collapse of road occurs because

- Earth and sand were washed by leakage

#### 4) Detection of leakage on the surface of road

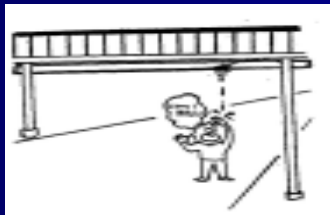
(3) Report by pedestrians or citizen informing that water flows out from river bank



Leakage water flows out from lower part of the river

#### 4) Detection of leakage on the surface of road

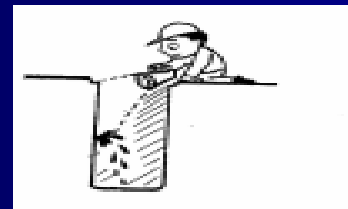
(4) Report by pedestrians or citizen informing that road water is dropped from bridge



Water comes out from pipe bridge because leakage occurred on some part of the pipe

#### 4) Detection of leakage on the surface of road

(5) Report by pedestrians or citizen informing that water comes out from mahole



Leakage water appeared in the manhole for swage, electricity, or transmission cables

## 5) Leakage Survey

### (1) Leakage Survey



- a) Leakage survey includes survey to check whether or not leakage occurs on pipeline that is called "Survey by line"
- b) And to determine leakage points by "Survey by point"

## 5) Leakage Survey

### (2) Survey by line



Detection by service pipeline

- At the point of survey
  - i. Exposed pipe in meter chamber
  - ii. Stop valve
- b) By usage of detection equipment
  - i. acoustic rod (sound bar)
  - ii. Electronic leakage detector
  - iii. Time integral type leakage detector
- b) By hearing the sound of leak noise on service pipes.  
This detection is called household detection

## 5) Leakage Survey



Detection by distribution pipeline

- Detection points
  - i. Where distribution pipe is exposed
  - ii. By fire hydrants or sluice valves
- b) By usage of detection equipment
  - i. acoustic rod (sound bar)
  - ii. Electronic leakage detector
  - iii. Time integral type leakage detector
- b) This survey is called survey of surface of road, mainly ground of distribution pipeline road.

## 5) Leakage Survey

### (3) Spot survey

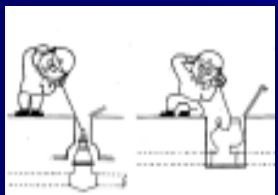


- a) At the point of survey
  - i. Sounding is made along the pipeline route, using electronic leakage detector, moving forward and afterward and left and right.
  - ii. In-between two points of leak portion with the correlation type leakage detector.
  - iii. Boring at the assumed leakage point on the pipeline route.
  - iv. By the method of tracer along the

When leakage is found through survey by line. Detection is carried out for the service pipeline routes and the distribution pipeline routes.

## 5) Leakage Survey

### (4) Kind of leakage detection equipment and its usage



#### a) Acoustic rod

- i. This is called stethoscope of leakage detection, as a simple method detect the leak sound with an acoustic rod of "1m x 7 mm diameter" with "acoustic chamber (55mm diameter x 0.1mm vibration plate)"
- ii. Holding acoustic chamber at the right hand palm
- iii. Place the tip end of rod tightly to spot to hear the noise and attach an ear to chamber
- iv. Close the other ear by left hand (to shut other noise)

- \*1 Inside of meter chamber: Exposed portion of pipe or meter.
- \*2 At the stop valve: To hear the sound at the head of stop valve
- \*3 At the sluice valve: Head of the sluice valve
- \*4 At the fire hydrant: hear the sound close to the pipe

## 5) Leakage Survey

### b) Electronic leakage detector

- i) This equipment is used to detect precisely the leak and its location.
  - ii) The equipment is composed of pick up and main body.
  - iii) Pick up the amplified leakage noise electrically on ground surface
- Particulars
- Small size and light weight
  - Easy to handle and small noise other than leakage noise
  - Sensitivity is accurate than acoustic rod

### c) Time integral type leakage detector

This equipment has the same function as electronic leakage detector, however element of time concept is added and detect leakage more accurately.

- i) Equipment is composed of "Pick up and main body"  
Main body contains clock portion, small computer (calculation and memory indicator) and main switch portion.

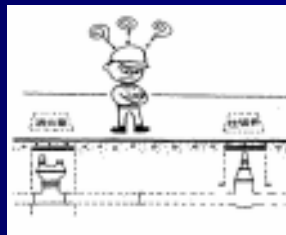
Function: pick up attached to the pipe, computer in the main body recognizes automatically leakage sound or other noise and the result is shown on liquid crystal panel.

## Non-Revenue Water Prevention Measures Step-3

### Non-revenue Prevention Measures Step-3

#### 1) Detection of underground pipes and others

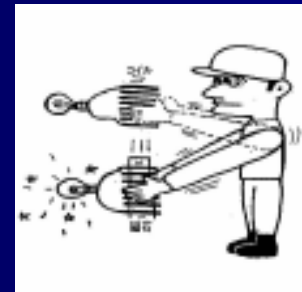
##### (1) Why location of pipes and fittings become obscure



Reasons to be unknown the location are due to expansion of land spaces or land readjustment (by zoning), expansion as well as piling of road and pave construction and also other gas and cable construction. So that detection by equipment is required.

## 1) Detection of underground pipes and others

### (2) Detection for metal pipes



- a) Principle of metal pipe detection  
Pipe detection is possible by the principle of generation of electricity, passing through magnetic coil.
- b) Condition of detection  
Detection portion with magnetic coil is necessary to detect pipe body.

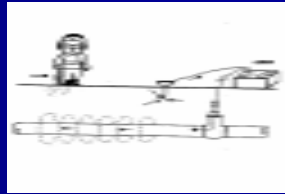


## 1) Detection of underground pipes and others

### (3) Function

"Transmission" + "Main Body (coil + amplifier + indicator)"

- a) Transmission  
Underground pipe generates magnetic directly or indirectly.
- b) Main Body  
Coil portion catch magnetic generated from the pipe and send to amplifier portion
- c) Amplifier portion  
Amplify the electric current transmitted by coil



## 2) Detection of Inner Portion of Pipe

### (1) Detection of inner portion of pipe



- a) Aims to find condition of inner portion of pipe (existence of scale, corrosion, leakage)
- b) Procedures are to attach tracer dosing metal fitting to fire hydrants, air valves, and meters, and dose tracer (helium gas, laughing gas (nitrous oxide) etc.)

## 3) Repair, Others

### (1) Repair of Transmission and Distribution Pipes

#### a) Repair of sleeve

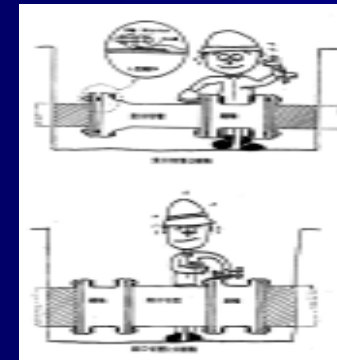


- I. Method:  
Under the condition of stoppage or fall off of water, repair work is carried out from outside of the pipe
- II. Machinery and materials: Sleeve (for ductile iron pipe), ace joint (for asbestos pipe), plug (for steel pipes), repair band and sleeve (for polyethylene pipe) .

## 3) Repair, Others

### (1) Repair of Transmission and Distribution Pipes

#### b) Repair by cut pipe



- I. Method:  
Repair is done under the condition of water shut.
- II. Machinery and materials:  
Damage portion is cut off and jointing with new replaced pipe. Materials include cut pipe with socket, sleeve and cut pipe of spigots and two pieces of sleeves (K type sleeve) .

### 3) Repair, Others

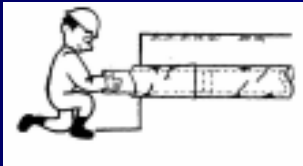
#### (1) Repair of Transmission and Distribution Pipes

##### c) Repair of inner portion of pipe



- I. Application:  
This method is applied to large diameter of leakage of joint portion of bigger pipes 800 mm diameter or above.
- II. Method:  
Repair inside of the pipe using stainless steel plate inside the pipe stopping the water.

##### d) Pipe in Pipe Method



This method is applied to the pipes located under heavy traffic road or pipes aged too old after installation. Steel pipes are inserted to inside of old pipe. This method is applied to pipe to innovation purpose.

### 3) Repair, Others

#### (1) Repair of Transmission and Distribution Pipes

##### e) Hose Lining Method

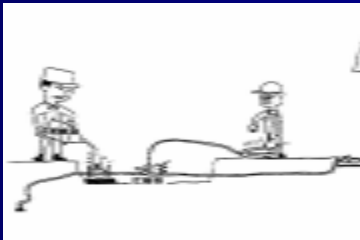


This method is to install hose turning into with adhesive paste after pipe is cleaned and dried

### 3) Repair, Others

#### (2) For Service Pipe

##### a) Frozen Method



- I. With mixture of liquid air (mixture of liquid nitrogen 80% and liquid oxygen 20%, service pipes are frozen and repair.
- II. Method of repair:  
Suspension of water is made at the upstream of damaged pipe and water is frozen and stopped. Damaged pipe is removed and replaced with new pipe.

### 3) Repair, Others

#### (2) For Service Pipe

##### b) Plug-displacing Method

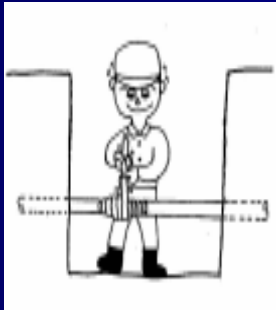


Method of repair:  
Damaged portion of pipe is cut off and removed and then insert rubber made plug and stop water flow and replace with new pipe.

### 3) Repair, Others

#### (2) For Service Pipe

##### c) Strip of Tape Method

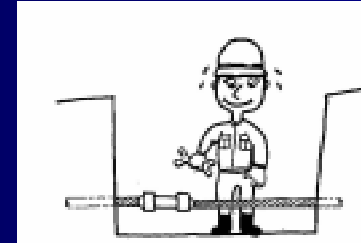


Oil and sand of the damage portion is removed by iron-bras. After stopping of water, binding of special gum-band tape, repair is made by rolling strip of tape with special glass-fiber.

### 3) Repair, Others

#### (2) For Service Pipe

##### d) MC Coupling Method



Method:  
In case damaged pipe is located in narrow underground space with many other installation of gas and cable pipes, after suspending water flow, damaged part is cut off and MC coupling (vinyl made with bolt tightening of both ends) will be installed.

### 4) Simplified Water Quality Test

#### a) What is simplified water quality test?

##### i) Purpose for Use:

Sampled water from road and excavated ground is tested on the spot to judge whether or not water is leakage water from pipe or from sewage pipe or drain water.

##### ii) Testing Water Quality Items :

Residual chlorine  
PH  
Conductivity  
Water  
Temperature

#### b) Comparison with Tapped Water

##### Method:

Potable water sampled nearby the area and water sampled from other than pipes water is compared with the water quality item

If it is difficult to judge by simple test, it should be judged by analysis with test using chlorine compound. The existence of chlorine compound is judged through an analysis by gas chromatograph.