SCRAPING AND LINING OF THE "OLD 20" AND THE "DUPLICATE 20" WATER MAINS FROM LABUGAMA TO AMBATALE

by

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1) INTRODUCTION

Water is one of the basic needs of man, which can be obtained from several sources. Generally, for domestic use, there are two Main collection methods.

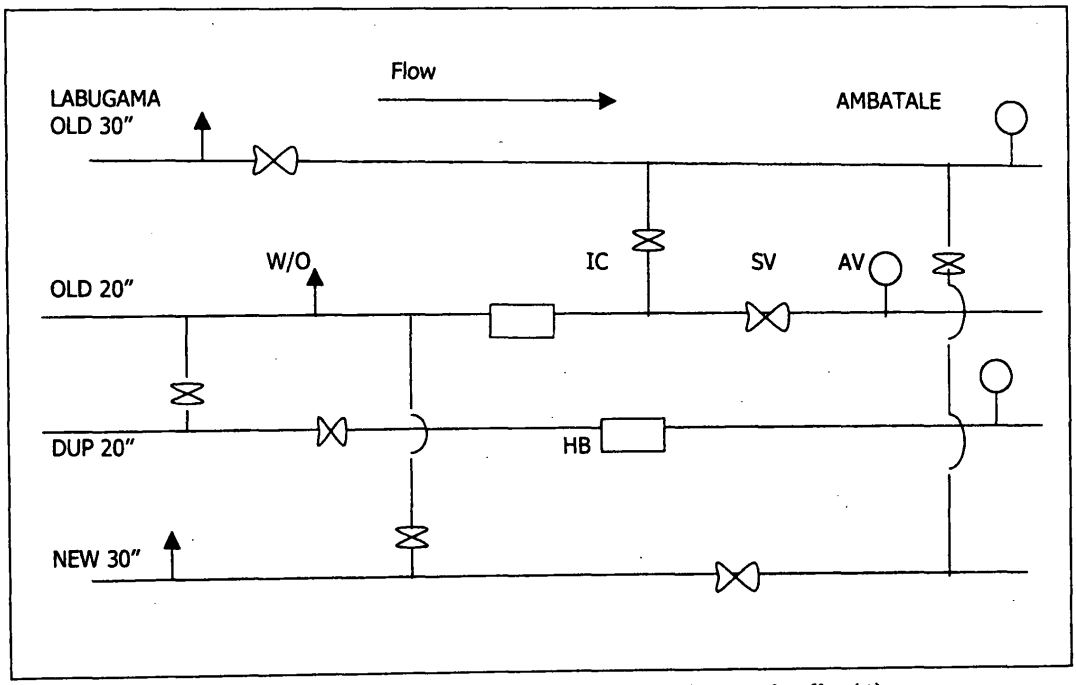
1). Wells/Boreholes/springs/Rivers (Mostly in the Rural Area)

2.) Distribution Pipes (Mostly Developed Area i.e.:- Urban)

There are several types of pipes. eg. Steel, Cast iron, Ductile iron, P.V.C., Concrete, Polyethylene etc. In Sri Lanka, up to now Cast Iron, Ductile iron, Steel, Asbestos Cement and P.V.C. Pipe.

bottom. Therefore, from time to time cleaning of mains has to be done. The cleaning processes could be by "Scraping" or "Swabbing". Thereafter Lining with cement mortar or other materials (Bitumen, epoxy or Polyethylene) is done for a long, lasting hydraulic performance of the pipe.

There are four transmissions Mains, Old 30", New 30", Old 20" & Duplicate 20" running parallel from the Labugama reservoir to to Ambatale, a total length of approximately 31.5-Km each. The objective of the project, which lasted from 1994 to 1996, was to scrape and cement line the D-20" and O-20".The. The work was carried out by Biwater Rehabilitation Limited, a British contractor.



A typical sketch of the pipelines is shown in fig (1)

It is natural that, when water flows in unlined C.I. or Steel pipes, after some period, it gets encrusted. The quality of the water plays a role in this regard. Further some unforeseen blocks, and silt could lie on the pipe

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2) Facts verified for scraping & lining of pipes during the planning process

1. Whether the Main is a Transmission or Distribution.
2. Diameter, age, length and material of pipe.
3. Based on "As built Drawings" all the Fittings, locations of the pipes, and depth. Turns of the Valves, Direction of opening, limit of the pipe shutdown periods, location of the access holes etc.
4. If a Distribution Main, Number of houses Connections, Location, Tapping details (Ferrule or Tee), temporary bypass location and diameter etc.
5. Arrangement of water for cleaning & lining operations.
6. Arrangement for disposal of waste water after flushing debris.

Especially for this type of Project, the "As Built Drawing" was very important. As all the details to prepare a proper B.O.Q could be extracted only from that. An inaccurate or incomplete document leads to unnecessary delays and costs.

Other aspects considered were,

Step 1

Measurement of the outer diameter of the pipe (O.D.).

1). Near Bridge crossings, Where mostly the Pipes are above Ground level

2). At steep slopes

3). Wherever the pipes were under Marsh Area

After collecting the OD of all the pipes " MAXIFIT" type couplings or adaptors, which were flexible enough to cover variations in pipe diameters, were obtained.

Step 2

Generally, when scraping & lining, all the fittings except the bends may be replaced with new fittings. If not, "Remove & Refurbish" or "Insitu Refurbish" of the fittings can be done. This had a wide range of meanings, which gave rise to wide interpretations.

Step 3

In removing & Refurbishing, how can the fittings be removed? eg. If it is a Sluice valve, is the Manhole opening enough to take the valves out? If not, demolishing the chamber cover, reconstruction costs, and prolonged traffic problems arise. When preparing the B.O.Q. the different types of chambers. i.e. those on middle of the Road, off the Road, edge of the Road, & also different types of covers. (R/F Concrete, Steel plate, CI) should have been categorised separately.

Step 4

WASH OUTS (W/O)

It was decided whether all the washouts were going to be replaced or refurbished. W/O are not like Sluice valves (SV), Air valves (AV) or Inter connection (IC) valves, because always a W/O is under pressure on one side only. The out-let side was mostly blocked with mud sand and silt so that wear and tear was more. So before preparing the contract document, it would have been better to have opened all the W/Os one by one to check the condition. Based on this we decided, the need for either replacement or refurbishment. In W/Os the following were commonly observed.

- Seating did not fit.
- Leak on the gate.(Due to one side pressure)
- Leak on the stem

Step 5

INTER CONNECTION VALVES (I.C.)

Inter connection valves, are that which connects the parallel mains. i.e. the scraping main and other mains, which may/may not be charged. If the other line is charged we should close the I.C. valve. So, before hand we checked whether all the I.C. valves could be fully closed. If leaking, we needed to have two more access holes & that distance hand lined. If the leak was big, arrangements were made to block the leaks as well as deal with additional traffic congestion due to additional holes in close proximity.

Step 6

Hatch Boxes are openings in the pipe for inspection. Hatch Box (HB) and Venturimeter location were studied carefully, to decide how scraping and lining should be done.

3) Methodology and sequence of scraping and lining

Excavation

Once the main is properly identified, (from the 2-20"s and 2-30"s battery running parallel) mark the access holes location, avoiding the middle of the road, away

from the fittings by at least 5.0 m avoiding other utilities. The distance between access holes also depended on the available hose reel length. The access holes were excavated and the pipe was exposed all round.

Pipe Cutting

The pipe is cut using a hand held pipe cutter. The cut piece for entry is called the spool piece. Spool length partly depends on the length of the scraping & lining machines. i.e. cut length long enough to insert the machine and allow for working space in pit.

After cutting the spool, without damaging the pipes, the spool is removed carefully, generally using a small backhoe.

Scraping

By using two winch tractors from both sides, first send the "teeth scrapers" from access hole (X) to (Y) and vice versa, (See fig 2) roughly 5 or 6 times. After that, send the" flat scrapers" in the same manner, until there is no debris in the section (Pipe should not be damaged). We cannot get the line100% debris free. It must be free from all tubercules, but not necessarily spotlessly clean. In this project, scraping length in one cycle was approximately 170 ~180 m. In a section with more bends shorter lengths between cuts are used. As it was not acceptable to discharge the debris laden water directly in to the public drainage system, it was collected in tractors and dumped in the excavated pits and closed.

When the debris, with the "flat scrapers" comes about the size of a tennis ball, it is advisable to stop the scraping. Next, send the "plungers" and remove the remaining debris and water from pipes.

Before starting scraping, ensure that all the Sluice valves, Bypass valves, Air valves have been removed, tagged & stored safely. The washout valves should be removed and blank flanged.

A variety of problems can cause difficulty during scraping operations. These are unmapped check valves and bends, reduction in pipe size, bad joints, intrusion of ferrules, roots, lead from joints, foreign bodies etc. If illegal house connections were found, they were disconnected. After this send the close circuit television camera (C.C.T.V.) and check whether

1) The main is clean enough.

2) All the fittings & specials tally with the As built drawing, and update.

Lining

Lining was with cement mortar of a 1:1 mix, using fine sand (silica material) uniformly graded from coarse to the No 150 (0.1mm) sieve & Portland cement, by weight. The hose & Lining machine is introduced from the far end of the pipe and withdrawn through the pipe by means of a Winching hose reel, which is mounted on a self powered trailer unit knowns as a "CAROUSEL". The air driven lining machine working on a centrifugal action provides an even 360-degree "orange peel finish" coating the pipe wall while it is being withdrawn. The size of the centrifugal lining machine determines the diameter of the revolving dispersing head, which ejects mortar. Since the lining machine travels at a constant speed & extrudes a constant quantity of mortar, the lining thickness is directly proportional to the lineal progress of the machine .

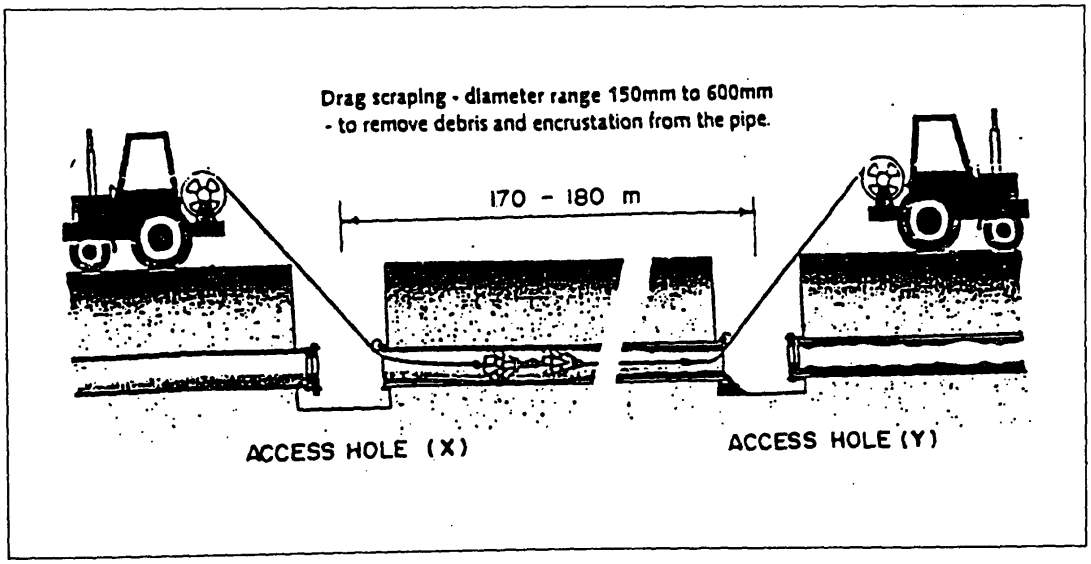


Fig. 2

The surface finish can be further improved by pulling a conical trowel (which is flexibly bladed) behind the lining machine. It is very important to maintain the water cement ratio. About 0.35 in large pipes & about 0.42 in small pipes. By adding soap or phenol we could improve the workability.

Skill and experience of the operators would play a major role in good lining if the water cement ratio was maintained by experience more than measurement.

Fig 3 shows the arrangements. When the lining commences from A to B at a rate of about 1m/20sec. Thickness of the lining specified depends on the diameter of the pipes. For 20" Cast iron main, thickness is 5~7 mm. While lining, the thickness is measured at end A by inserting a depth gauge. If the thickness is more, the speed is increased. If not, vice versa. Check the thickness at the other end too. Next day, the

3) If the pipe cross section is not circular, lining may fail. For this there is no remedy before hand. Man entry pipes (dia > 500mm) can be repaired by hand trowel. Other wise cut & piece up with a new pipe.

4) Traffic will be a major problem. If, it is a highway or wherever the pipe is very close to the ground surface, due to vibration, the inner upper portion of the lining may collapse immediately after the lining. Even when lining, it may fall down. Then inner lower pipe thickness might increase, at the expense of upper pipe lining. For this we must stop the traffic on the lining day. Also wherever the pipe is very close to the ground surface, was advisable to close the road on the lining day, as even for slight vibrations by whatever cause, the lining tended to collapse.

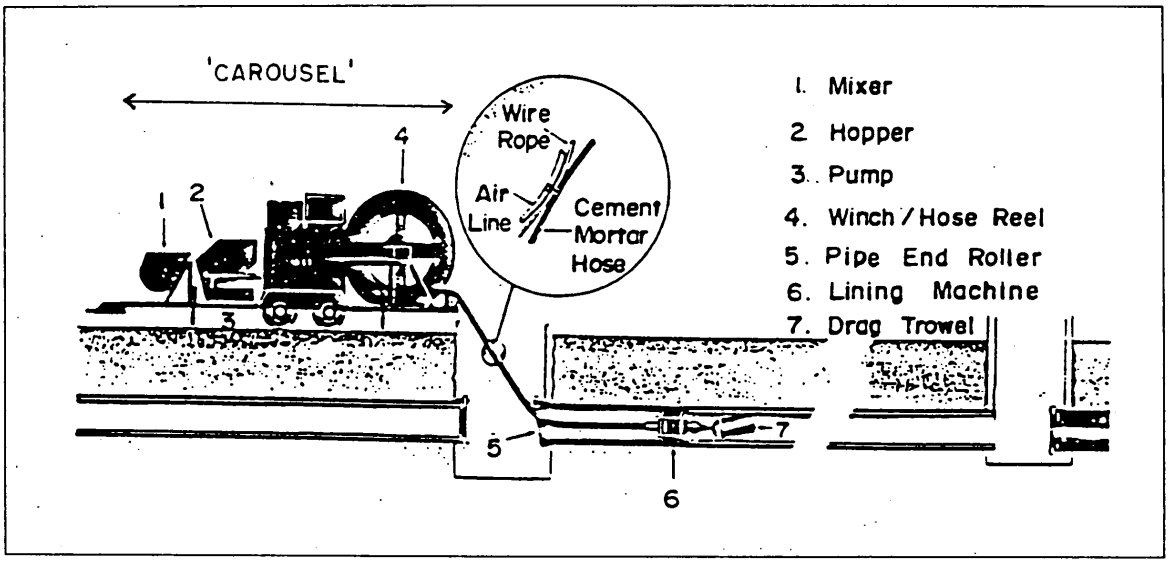


Fig. 3

C.C.T.V. is sent and checked for any damages or less thickness. A man is sent inside 20" pipe on a trolley to rectify observed defects. To prevent fatigue, reduce temperature and as a safety precaution, air was pumped into the pipe during such an exercise.

4) Salient points of the lining process

1) Use the specified Cement, Sand and water/cement ratio & get the proper mixture. Other wise, lining may fail. This particular skill mostly depends on experience.

2) Lining machine should be set exactly at centre of the pipe, because this action is centrifugal. If this alignment is wrong, lining might fail.

5) Before lining, check the lining machine slots. If the slots are blocked, lining may fail, due to non-uniformity.

6) If the scraping or lining machine gets stuck, by measuring the hose reel or rope length an additional pit is cut to get the machine out.

After lining, on the next day, send the C.C.T.V. & check the lining. If there was any damage, repair & recheck the lining. Once the lining is satisfactory, fix the valves, (either new or refurbished). Next piece up the spools. Before piecing up, spools must be lined & edges of the spools and pipes cleaned and bitumen coated. V.J. Couplings are protected against corrosion with Denso Mastic and Denso tape. Later, hot pour Bitumen (115/15) was also used, as it was cheaper. After that backfilling to achieve 95% compaction and as-

phalting can be done. For backfilling, sand was used because,

1) It was easy to identify, during pressure testing time, if the V.J. couplings were to leak.If leaks occur in the V.J. Couplings, during pressure test time it will be easier to identify.

2) During future maintenance work, it is easier to identify the holes.(other places earth filled)

3) Less need for compaction, and fast progress of back filling.

3) Especially in this case, mains being close to Kelani river area transport costs of sand was less.

5) Pressure Testing

Select a convenient length (1.5~2.5 Km) for pressure testing. Make sure all the spools & valves are fixed. Convenient length maybe 1.5~2.5 Km. If a lengthy section is selected ,and reasonable pressure tightness cannot be obtained, leaks can be expected from V.J. couplings, pipe joints, valves & cracks of the pipes. (Since these were old mains).

Before pressure testing, ensure that all the air valves & Sluice valves (SV) are open. All other inter connection valves and washout valves should be closed properly. Fill the main. Leave for the required time period (24 hrs) to allow the lining to absorb water prior to being charged.

The Pipes were pressurised to the testing pressure of 9 bar (1.5 * working pressure) and tried to measure the drop. But since these were old mains (O-20" > 100 years, D-20 > 80 years) due to wash out leaks (seating), inter connection leaks, lead joint weeping etc. we could not maintain the pressure. All the visible leaks were rectified. Even with the correlator, (leak detection equipment). No leaks could be located as due to heavy traffic, over head high tension electric and Telecom cables & under ground cables disturbed the sensor equipment.

The main was pressurised again to 9 bar and maintained for an hour by pumping water, while measuring the pumped water by flow meter. No limits could be set for allowable leakage, because different sections, had different amounts of leakage, depending on the of wash outs, inter connections and poor condition of lead joints. All the possible and visible leaks were repaired again. The flow meter reading was compared against allowances made for such leaks. When results were "satisfactory" section was passed. However the difference between the "before and after" unaccounted water was not measured. As such the reduction in leakage could not be properly quantified.

6) Flushing

The water used for pressure testing, was used for thoroughly fluhing out the main. A section (7~10km) was selected. Flushed via 1st up stream wash out, while the other wash outs were fully closed. In the mean time, all other inter connection valves were closed & Air valves were opened. But, since it was an old main, it was not capable of with standing surge high pressure. Therefore a number of pipes bursts occurred while flushing due to air locks and water hammer. Through trial and error the following method of flushing was devised to avoid such bursts.

7) Sterilization

Pipes carrying potable water need to be disinfected. Disinfection was done after completion and acceptance of the specified leakage and pressure test. After flushing, the main should be left with standing water for several days, to ensure that residual chlorine from the existing water is absorbed into the new lining. See Fig (4) for indicates the sequence of the operation methodology.

1. The section to be sterilised was isolated, and the pressure released. The up stream ends an air valve AV (1) was removed and a connection made to a pump unit.

2. Barrels of high concentration bleaching solution premixed at the location (up steam).

3. The main charged and a gradual flow introduced, with controlled discharge at the far end of the test section via a convenient washout, W/O (n).

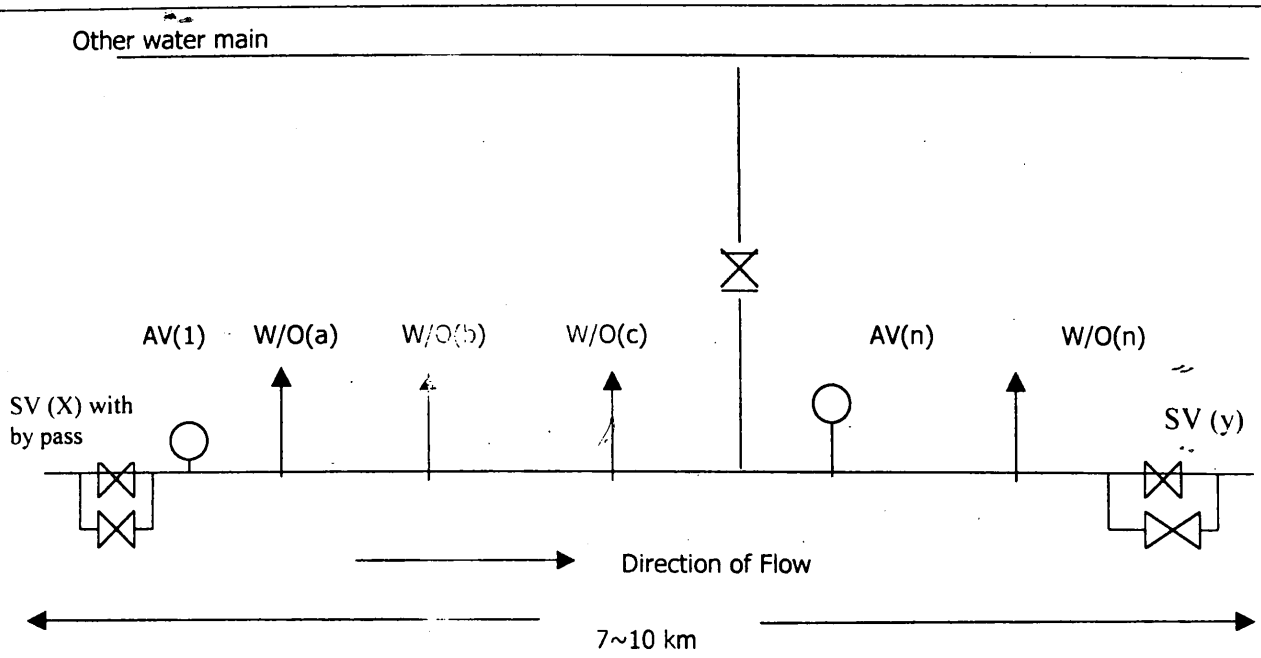
4. The premixed bleach solution introduced via a high-pressure pump and a washout valve discharge monitored until the bleaching solution is detected.

Dosage of bleaching powder is calculated as follows:

The dose at an initial concentration of 30 parts per million.
As the bleaching powder concentration is only 35%.

$$\frac{30}{1{,}000{,}000} \times \frac{V}{0.35} = V_r(\text{Lit})$$

Volume of the water in the section - V (in liters)
Quantity of the Bleaching liquid required - V_r (in lit)



SV - Sluice Valve
AV - Air Valve
W/O - Washout
I/C - Interconnection Valve

- Open the upstream SV.
- Close the down stream SV (Y) & made sure all the AVs opened & IC valves closed and open the W/O (a) fully, till water visibly runs with fair amount of pressure.
- Then slowly opened the W/O (b) fully & slowly closed the W/O (a) fully, till the water is clear in (b), and quantity increaseswith fairly high pressure.
- Continue the process up to the last down stream W/O.
- When we were flushing the main, where the pressure was too high, we partially opened one or two addi tional washouts down stream, to avoid bursts.
- Made sure all the washouts were closed after the flushing operations.

Fig (4)

As the saturated density of bleaching liquid is almost 1Kg per liter, the requirement is V_r Kilograms of powder (at 35% concentration).

- The down stream washout, W/O (n) discharge satisfied the 30 ppm test.
- Spot-checked other random washouts, in that section.
- When all these have passed the 30 ppm concentration, slowly close the up stream sluice valve SV (X), while partially opening one or two close by W/Os in the previous section. Once the up stream SV (x) fully closed, slowly close the opened W/Os in the previous section one at a time. (We found sudden closure of SV (X) causing water hammer and several bursts. That was the reason we partially opened washouts in the previous section).
- Stop the pumping of chlorine.
- The main was left standing for 24 Hrs. After this period the residual chlorine level was checked (at W/O (n) and randomly at a few wash outs).
- In the meantime another sample was collected in the same W/Os for the bacterial test.
- When the sample had > 1mg/l residual chlorine and satisfied the Bacterial test, the section was passed.
- W/O (n), down stream end of the main was opened, and fresh water introduced by opening SV (X). The main was flushed until residual chlorine level fell below 0.5 mg/l.
- After this washout was closed and main put into service.

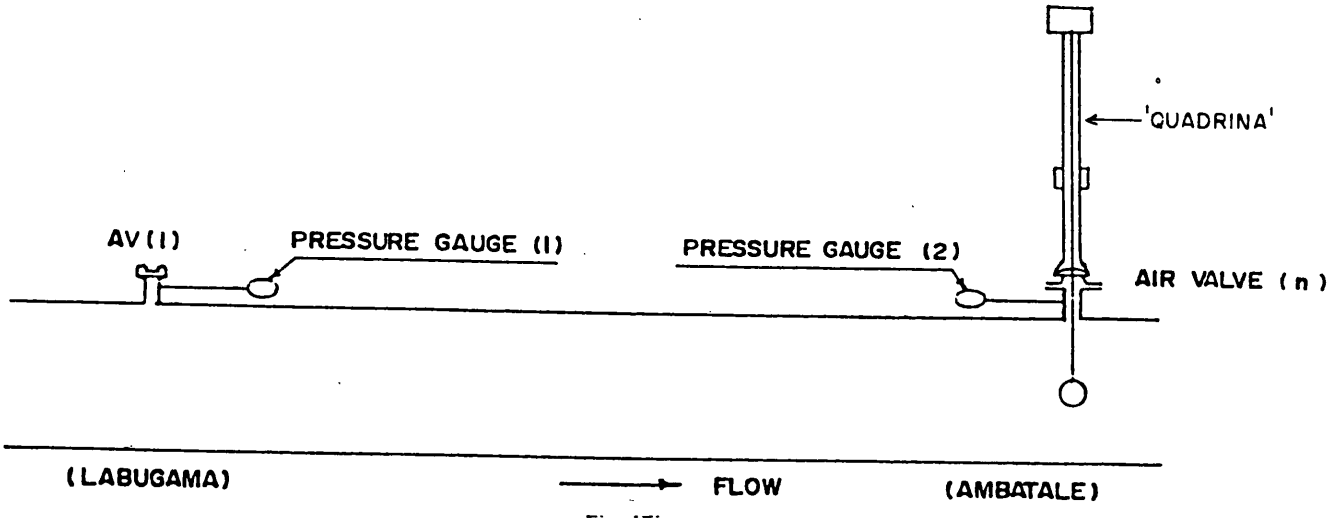
Following important points were noted

- We used 35% concentration, as more could affect the gasket and flat packing in the valves. But in some places, which had debris & mud we were forced to use 40%, These either absorb the chlorine or reduce its concentration (especially where the pipes were under marshy area).
- When sterilising, it should be ensured that section last down stream of sluice SV (Y), should be closed fig (4) and all other SVs be kept open. Inter connection valves (and by pass) should be closed. All air valves should be fully opened. Other wise bursts could occur. Due to Leaks in the mains and Inter connection valves leaks, Water can flow from/to other charged mains. In fact we found chlorine content in the main getting diluted.

8) "C" (Hazen Williams Coefficient) Value Test

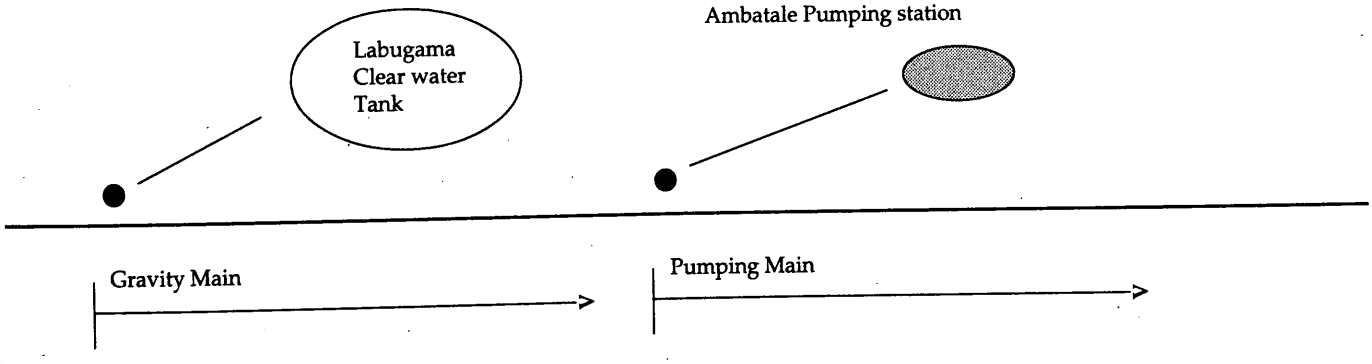
Scraping and lining was done to improve the "C" value. The purpose of the "C" value test was, to assess the pipe friction of the new lining. The method is as follows.

The "C" value was calculated using formula below. **The day had been chosen when there was no pumping down stream of the relined main, from Ambatale.**



- Choose an u/s AV (1) & d/s AV (n).
- Install the pressure Gauge (1) at u/s AV(1).(Selected as per main working pressure)
- Fix the pressure Gauge (2) at d/s AV (n), where the Air valve was removed, to insert the "Quadrina" (flow measuring equipment) in the main.

Fig (5)



i.e.

$$C = \frac{Q * 10^5}{(0.359 * D^{2.63} * I^{0.54})} \qquad I = \frac{(p_1+H_1)-(p_2+H_2)}{L}$$

Where

Q = Flow (l/s)
D = Internal diameter of the pipe line (mm)
I = Hydraulic gradient, calculate using the formula
P_1 = Pressure at upstream point (m)
P_2 = Pressure at downstream point (m)
H_1 = Height above datum of upstream point (m)
H_2 = Height above datum of downstream point (m)
L = Effective pipeline length (m)
If the 'C' factor was not in the required range, we checked for the reasons & rectified.

We could not get the proper 'C' values, with Ambatale pumping, due to change in hydraulic gradeline.

Result of "C" value test:

Main	Before lining	After lining
OLD 20"	65~70	110~120
DUPLICATE 20"	65~70	110~120

9) Special Aspects too be Considered in Scraping & Lining of Distribution Mains

* In the distribution mains there were house connections. So before isolating the mains we should arranged water supply for the householders, either by Bowser or fixing a by pass line and supplying through it.

* All the ferrules or tees must be cleaned during the scraping time, and after lining, with compressed air, to blow back blockages.

10) The Cost of cement Mortar Lining Will Depend on the Folliwing Factors

- Length & Diameter of pipes
- pe of pipe i.e. New or Old
- Location and difficulties of terrain and layout
- No of cycles of operation
- Excavation
- Scraping & lining
- Curing
- Flushing & Pressure testing
- Sterilisation
- "C" value test
- Dewatering(if needed)
- Pipe cutting & Piecing up (Rejointing)
- Backfilling & Reinstatement

11) Advantages of Scraping and Lining

1) Lining improves "C" value resulting in better carrying capacity.

2) Cement mortar-lining seals minor leakages in pipes. Plastering of lead joints in C.I. Pipes, has been very effective for stopping leakages.

3) Pin holes and slight leaks at joints (which will never be picked up by leak detectors) would be sealed during the lining process. This would also minimise possibilities of contamination.

4) Cost of refurbishment cost is very much less than relaying. Approximately 1/2 ~1/3 of the cost.

5) Minimal traffic interference and public complaints because, this type of work causes few interruptions to normal traffic operations compared with laying of additional pipes, by continuous excavation.

6) Saves cost on account of road excavation and road restorations.

7) Lowers pumping cost due to less friction.

8) Portions to be scraped and lined could be recommissioned within a very short time, say 48~60 hours.

9) If the C.C.T.V. camera is used to check the pipeline. Unknown connections, partly jammed or hidden sluice valves, illegal connections etc., can be located. At the same time drawings could be updated too.

10) The lining tends to plug ferrules, which then needs to be blown back with compressed air. This could be used to identify illegal and unknown connections.

11) Lining reduces the bore by 10~20% in very small pipes(app 80 ~150mm) & 5~8% in medium pipes(app 200~400mm). But this is more than compensated for by the increase in bore after removal of the encrustrationencrustration.

12) Prevention of encrustrationencrustration by lining reduces chlorine demand.

13) Decreases number of future leaks and road excavations.

14) Reduces the bacterial growth in the pipe wall.

In our country,

1) These pipes buried in the ground over many years, are the greatest assets of the water industry. It is well worth refurbishing these to its maximum potential, and defer or cut back costs, of reinforcement.

2) The basic materials required in the operation, namely cement and fine silica sand, are freely available.

3) At least 70% of the length of water mains in Colombo falls within the 3", 4", 5", and 6" diameter (C.I.) category, which can be scraped and lined by small equipment.

So, obviously greater consideration could be given to relining the pipes rather than merely relaying.