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Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

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PROVISION OF SERVICES RELATING TO THE ASSESSMENT, INSTALLATION, COMMISSIONING, START UP AND TRAINING OPERATION FOR TANNERY EFFLUENT TREATMENT PLANT AT AFRICA TANNERY IN MWANZA, TANZANIA

FINAL REPORT
On a mission to Tanzania 18 jan - 03 feb 1995

Based on the work of
Mr. Pentti Rantala, Effluent Treatment Expert
Mr. Immo Sundholm, Effluent Treatment Technologist
Tampere, FINLAND, 12.06.1995

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1
ABSTRACT

This is the final report of Africa Tannery effluent treatment project in Mwanza, Tanzania (US/URT/110).

The task of the Consultant has been to provide services related to the assessment, installation, commissioning, start up and training operations for tannery effluent treatment plant at Africa Tanneries in Mwanza, Tanzania. UNIDO has contracted Soil and Water Ltd. from Finland to execute these services.

The project has been delayed due to reasons beyond the control of the Consultant. However, at the moment the effluent treatment plant has been rehabilitated and it is operational. The tannery has started the production and the effluent treatment system has been operated to some extent from the very beginning of the production.

The operational staff has been trained to operate the plant and the operation manuals are enclosed to this report.

The effluent treatment plant, its operation, maintenance and management requires continuous development and recommendations are given in this respect.

2
INTRODUCTION

2.1
Background

The Mwanza Tannery has been established in the early 1980's as a national tannery. After that in the early 1990's it was privatized and taken over by the new owners, The African Trade Development (ATD) and re-named as Africa Tannery. The UNIDO project US/URT/91/110 has provided technical assistance to the new owners. The consultant has advised the tannery to rehabilitate the effluent treatment plant for the tannery and trained the staff to operate and maintain the plant independently.

In order to facilitate these services the experts of Soil and Water Ltd. have been working in the project. Mr. Pentti Rantala has been working as an effluent treatment expert and Mr. Immo Sundholm as a tannery effluent technologist.

The experts of Soil and Water Ltd have visited four times the project area and once the UNIDO headoffice in Vienna. Effluent treatment expert Mr. Rantala visited Mwanza in April-93 and August-93. Effluent treatment technologist Mr. Sundholm visited Mwanza in July-93 and Jan-Feb-95.

Between the visits Mr. Rantala and Sundholm have been frequently in contact with UNIDO (Vienna and Nairobi) and the management of the tannery giving advises for rehabilitating the plant and assisting in installing the equipment.

2.2
The Production Situation

The production was started in April 1994 first with half of the capacity and later on with full capacity (1000 hides a day) until the production difficulties were encountered. The production was even completely stopped in September and October 1994 and again in January 1995. The approximate production capacity from April-94 to March 1995 is shown in Table 1 (February-95 and March-95 are estimates).

Table 1.
The approximate production of the Mwanza Tannery in 1994 and 1995.

Month	Production hides a day
April-94	500
May	500
June	500
July	500
August	300
September	-
October	-
November	1000
December	1000
January-95	-
February	1000 (estimated)
March	1000 (estimated)

The production of 1000 hides a day can be reached quite easily if operational difficulties do not exist.

2.3
Effluent Quantity

The amount of effluent produced will depend on the production capacity of the tannery. The maximum amount of water used in the beamhouse process is about 58 m3 per drum. The total amount of water used in the beamhouse with full production capacity (1000 hides a day) is about 116 m3 per day.

The amount of water which will be discharged into the main effluent channel from the tanning process (for washing of the tanned hides) is about 80 m3 per day. The tannery is in production normally 6 days a week, and some 8...12 hours a day (depending also from electricity cuts).

The maximum amount of water discharged into the main effluent channel (when the production is at full capacity) is about 200 m3 per day.

The maximum amount of the chrome water discharged into the chrome precipitation system is 20...30 m3 of water in a week. Average amount of the effluent is shown in the Tabie 2.

Table 2.
Average amount of the effluent at the tannery in 1994.

effluent type	flow
- main effluent per day	200 m3/d
- main effluent per week	1200 m3/w
- main effluent per month	4800 m3/m
- chrome water per day	3-5 m3/d
- chrome water per week	20-30 m3/w
- chrome water per month	80-120 m3/m

The production capacity has been on average 43 % of the possible full capacity between April-94 and February-95. The effluent during that period did never reach the big maturation pond because of the low effluent flow and very efficient evaporation at the effluent treatment plant.

3
STATUS OF THE PROJECT

3.1
General

UNIDO has been assisting the new owners of the tannery to rehabilitate the tannery. The production process has been studied by the UNIDO experts and based on their recommendations the tannery has been rehabilitated to start the production. The tannery buildings can facilitate further production increase and it is also possible to improve the quality of the product. These production improvements require additional investments.

As an integral part of the UNIDO assistance the environmental impacts of the tannery have been analyzed and recommendations given (UNIDO report US/RAF/88/100/11-10C/J13104). The discharge of the effluent is the major environmental impact of the tannery. Therefore it has been recommended that the effluent treatment plant should be rehabilitated as well. UNIDO has engaged a consultant, Soil and Water Ltd. to assist the tannery and to supervise the rehabilitation.

The experts of Soil and Water Ltd. have been visiting the project area and they have been giving advises for rehabilitating the plant and assisting in installing the equipment. During the latest visit to the tannery in January-95 the tasks of Mr. Sundholm included

- supervising and assisting in installation of the equipment
- commissioning of the rehabilitated plant
- training the operators
- preparing the draft operation manual of the effluent treatment plant

Further improvements of the effluent treatment plant were also discussed.

3.2
Present Situation

3.2.1
Electrification

All electric switches and boards of the water and effluent treatment plants were damaged or in poor condition when the rehabilitation project started. New switches and boards were needed to the plants as follows.

- new main distribution board
- new electric board for the water treatment plant
- new electric board for the effluent treatment plant
- connection box for the submersible lake pump
- level and pressure switches for the pumping

All electric equipment, boards, switches e.g. are now installed, fully operational and tested at the site. Last electric boards were installed and tested when Mr. Sundholm visited the tannery in early 1995. In the future it will be very important to ensure good maintenance for the electrical system.

3.2.2
Water Supply

The water supply of the tannery is based on Lake Victoria. A submersible pump draws the water from the lake. The raw water goes through a sand filter and purified water is pumped to the tannery production lines. The following actions were necessary to secure the water supply service for the tannery.

- new submersible lake pump
- new electrical lake cable for the pump
- two new water pumps at the filter house
- new electric board
- new switches
- new sand inside the sandfilter

The rehabilitation of the water supply system was not part of the UNIDO assistance but the consultant gave minor assistance also in this respect. The tannery has purchased all the equipment and made the installations for the water supply system with their own funds. The water supply system is now operational. Operators of the water treatment plant are also trained to use the plant and they are capable of maintaining the water supply system. It is still recommendated to buy a spare submersible lake pump and a spare water pressure pump for the water treatment plant.

3.2.3
Effluent Treatment Plant

The effluent treatment system has been originally designed for treatment of mixed total effluent. Obviously very small amount of the effluent of the tannery has ever gone through the original treatment process. The effluent treatment plant was in the need of major rehabilitation when the new owners took over the tannery. The concrete structures of the old effluent treatment plant were in fairly good condition.

UNIDO assisted in preparing the rehabilitation plan for the ETP of the Mwanza Tannery. The implementation was designed in such a way that it is possible to rehabilitate the ETP in stages. The main rehabilitated effluent treatment system included the following process features.

- chrome waters and other effluent flows are separated inside the tannery before the purification
- chrome water is precipitated as hydroxide and sludge dried before final disposal (dumping), supernatant will be mixed with the main effluent (totally new process stage)
- main effluent will be screened efficiently before any other process step (new screens)
- the equalization of flow and effluent quality is designed to improve the efficiency of the effluent treatment plant
- presettling
- preaeration to oxidize the sulphides (new compressor and aeration system)
- oxidation phase will also reduce the organic loading to the lagoon
- clarification before the lagoon will reduce some solids but in the future the clarification process should be improved
- sludge drying beds have been constructed separately for both chrome sludges and main effluent sludges

The first stage rehabilitation included the following new equipment for the plant

- electricity boards
- mixer for the lime
- portable pH-meter
- pump for the chrome water
- pumps for the main effluent
- compressor for the aeration
- different pipes and valves

The Africa Tannery has now constructed new channels, new chrome settling tanks, other structures, cleaned the old tanks and lagoon and installed all new equipment. The rehabilitated effluent treatment plant is now ready for operation. When the plant is operated properly it can remove chrome and sulphides effectively, reduce suspended solids to a very large extent and reduce reasonable amount of organic loading. If the effluent flow remains low it is possible that due to the high evaporation at the effluent treatment plant no flow is discharged into the lake. The bottom of the lagoon is mainly fine sand and therefore some seepage will occur as well. This cannot be regarded as any danger since the seepage water will travel a long distance before reaching the lake. During this slow filtration process almost all impurities will be removed and the water will be very clean when it reaches the lake.

However, additional improvements will be needed in the future. Therefore it is important to follow carefully the operation of the effluent treatment plant and it is assumed that a new mechanical fine screen to improve the removal of solids at the early stage of the process and additional aerators to ensure the capacity of oxidation in all situations will be needed soon. A more detailed description of the process as rehabilitated by the tannery now is given in the Appendices.

The available slope in the channel system of the tannery has been very small due to the original construction. It has been possible to improve this situation only very little in the rehabilitation.

The chrome effluent treatment tanks have been constructed fairly large. This will allow future extension of the production and large size will give extra flexibility and operational safety without any harm to the chrome effluent treatment process.

3.2.4 Operation of the Effluent Treatment Plant

The chrome waters are now precipitated and separated chrome sludge dried on drying beds (2 beds) and dried sludge transported to final disposal to the special dumping areas. Supernatant water from chrome precipitation system is released into the main effluent channel. There are no laboratory results about the quality of the treated supernatant but based on the assessment at the site the chrome precipitation system can remove the chrome very effectively from the chrome waters.

The main effluent is screened (manual coarse screening), flow equalized, sulphides oxidised and effluent settled before it enters the big lagoon.

From the main effluent treatment plant the sludge is removed from the presettling and clarification basins to the sludge drying beds (2 beds) and after drying the sludge is removed to the dumping areas.

During the period of production in 1994 the effluent did not reach the big lagoon which is the last purification step before the lake. Therefore the lake was not at all environmentally affected by the tannery effluent.

3.2.5 Training of Operators

The operation staff of the effluent treatment plant includes six operators and one supervisor. This can be regarded adequate provided that additional (temporary) staff can be drawn from the tannery production.

The operators of the effluent treatment plant have been trained mainly on the job. UNIDO experts have given guidance during their visits and equipment supply included some technical instructions about the operation of the machinery. The Consultant has included a training component to all visits and the tannery management has given practical training on a daily basis.

The operators are now capable of running the effluent treatment plant on a routine basis. Further training is still needed. First priority should be placed on the analytical control procedures, trouble shooting and maintenance of the plant. More spare parts for mechanical and electrical equipment would be needed as well.

4
CONCLUSIONS

1. The production was started after privatization in Mwanza Tannery (new name Africa Tannery) in April 1994 with half a capacity and later on at full capacity. The production had several problems and therefore the average production was about 43 % of the possible planned production of 1000 hides a day.

2. The water supply system and effluent treatment plant have been now rehabilitated and they are ready for the production. Chrome precipitation and main effluent treatment systems with sludge drying beds have been constructed to enable the operation of the effluent treatment plant. Main part of the effluent system has been in use since April-94 when the production was started. All the new equipment have been installed.

3. Operators have received the basic training and the draft manual for operation is produced.

4. The effluent treatment system can be operated effectively. Chrome can be precipitated, sulphides oxidized and organic loading reduced to a large extent.

5
RECOMMENDATIONS

1. The Africa Tannery should implement the improvements of the effluent treatment process towards the further improvements. This would enable continuous present full capacity production and even increase of production if properly implemented. The major actions include.

   - Installation of a high quality mechanical fine screen into the main effluent channel.

   - increasing the presettling capacity eg. by increasing the wall height of the present presettling tank and reorganizing the pumping.

   - Improving the sludge handling.

   - Increasing the oxidation capacity.

- Modifying part of the existing main effluent treatment plant to operate as activated sludge process. New aeration capacity is needed and new settling tank with return sludge pumping system is needed.

- Improving the operational control systems of the effluent treatment plant.

2. The effluent treatment process should be followed up more carefully at different stages of the process. The laboratory of the tannery should be able to analyze selected key parameters like temperature, conductivity, pH (is made now), suspended solids, settleable solids, sulphides, turbidity, colour, organic matter (BOD7 or COD) and chrome concentration. In this respect the laboratory can be developed in phases to start with more simple analytical procedures.

3. The training of the operators should be continued. The management of the tannery should also be kept well aware of the developments and operation procedures of the effluent treatment plant.

4. Maintenance procedures should be developed. More spare units would be needed. Water supply system should be secured by purchasing spare pumping units and the possibility of constructing an overhead water tank to hold one shift water consumption should be carefully considered. The effluent treatment plant should have spare pumps and spare equipment for oxidation.

5. The overall management and organization needs improvements. This is a very complex issue but selfsufficiency in all aspects to such a maximum degree will be of great help in difficult situations in the case of Africa Tannery operating in Mwanza. This will require extensive efforts and commitment.

Tampere 12.06.1995
Finland

Immo Sundholm
Effluent Treatment
Technologist

2

Photo 1. New chrome effluent separation wall was built between chrome tanning area and main effluent channel inside the factory.

Photo 2. Chrome effluent is discharged into the chrome effluent channels.

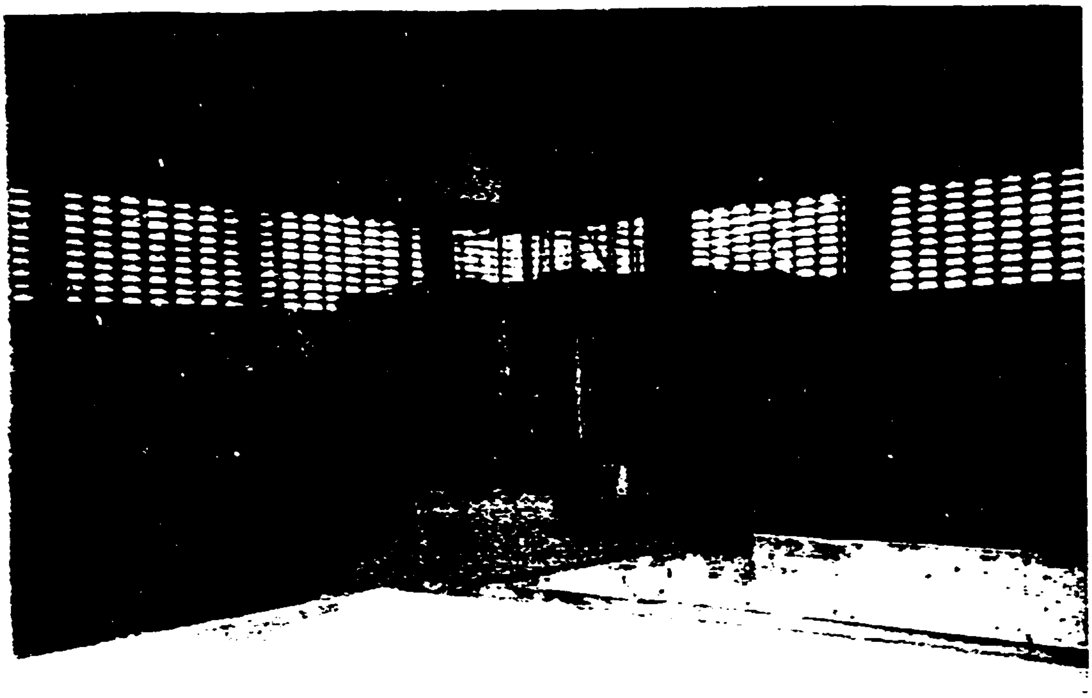

Photo 3. New chrome precipitation tanks have been built inside the factory for chrome precipitation.

Photo 4. Chrome effluent pumping from equalization basins to the precipitation tanks and supernatant valves and pipes to the main effluent channel.

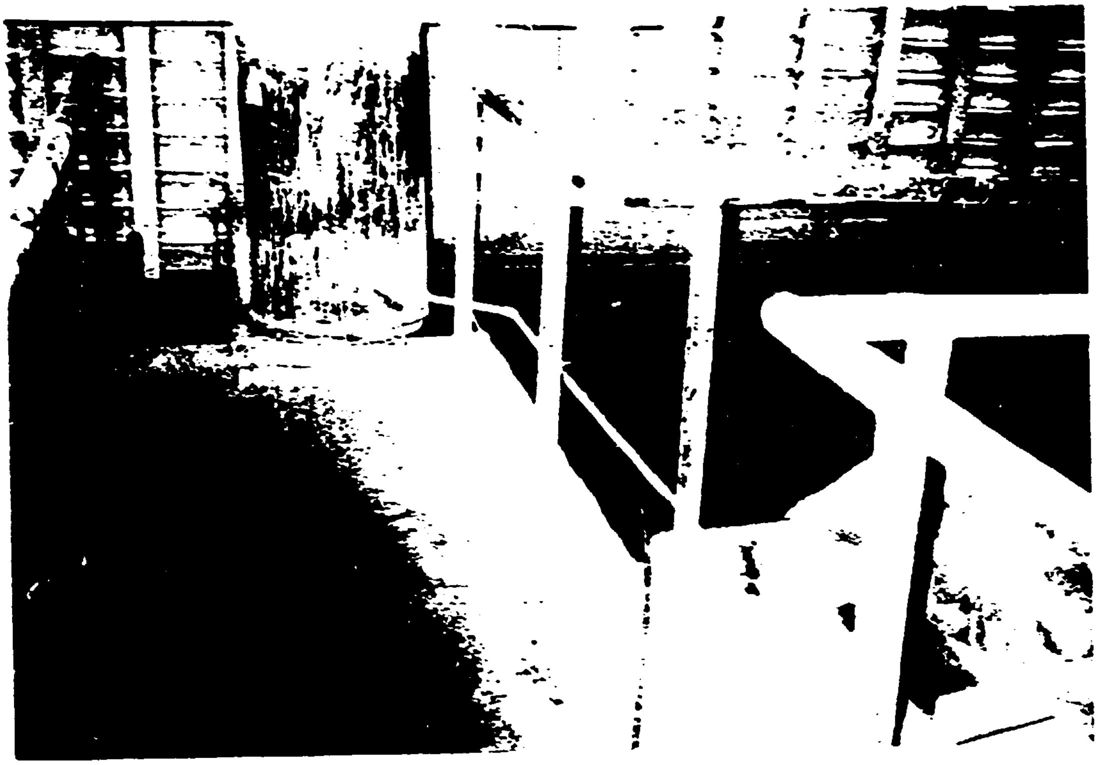

Photo 5. Lime milk dosing tank, pipe and valve.

Photo 6.
Hydraulic flocculation
was constructed for the
chrome precipitation
system.

Photo 7. After precipitation and sedimentation the chrome sludge is released occassionally by hydrostatic pressure to the chrome sludge drying beds.

Photo 8. Chrome sludge drying beds were constructed near the factory.

Photo 9. Chrome sludge is dried in chrome sludge beds before final disposal.

Photo 10. Drainage from drying beds is by gravity to the main effluent channel.

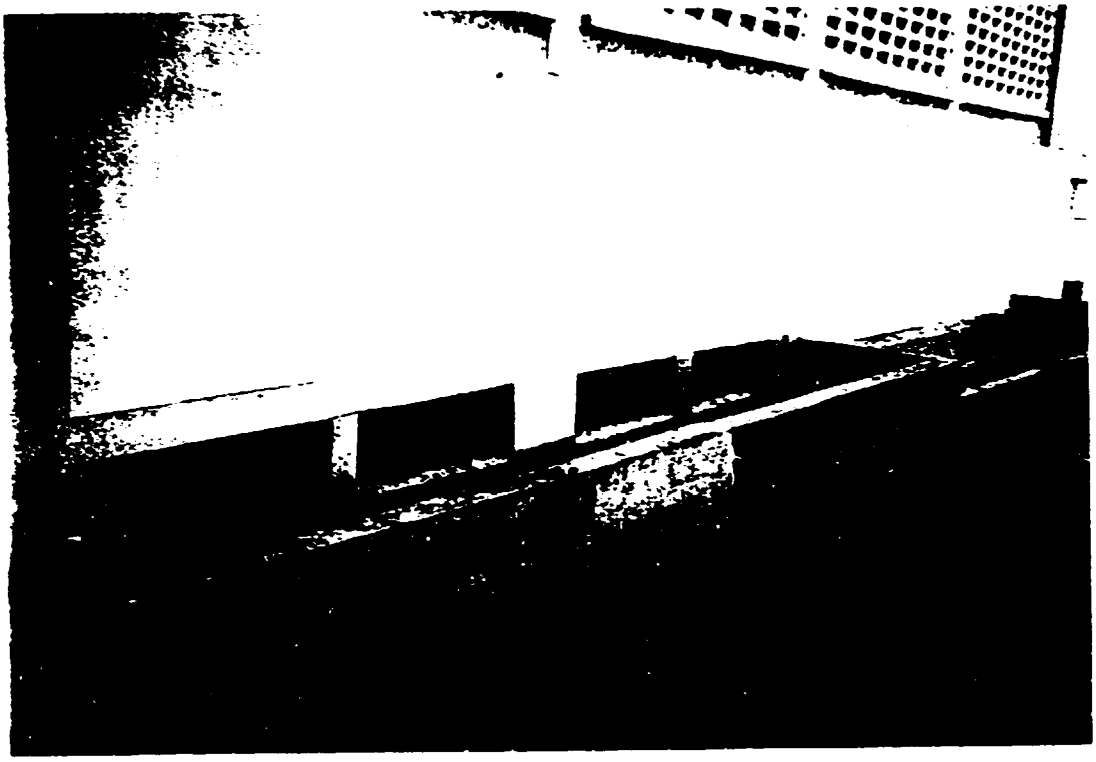

Photo 11. New main effluent channel with coarse screening.

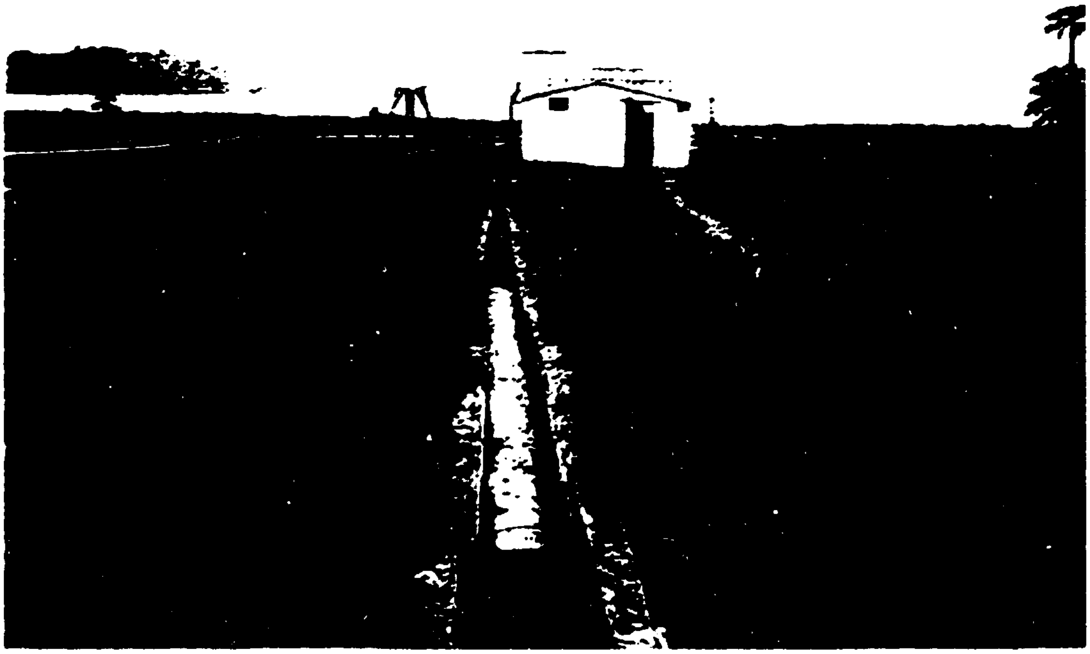

Photo 12. Coarse screens inside the main effluent channel before effluent treatment plant.

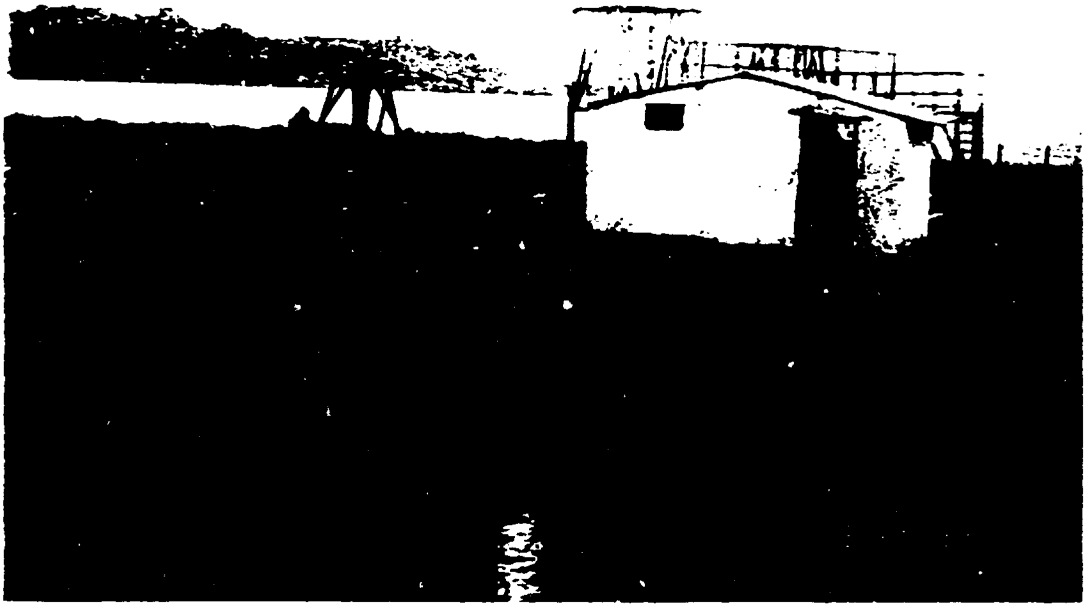

Photo 13. Effluent treatment plant electric board and compressor building.

Photo 14. Pumping the effluent from equalization tank into the presettling tank.

Photo 15. Presettling tank and new sludge removal pump.

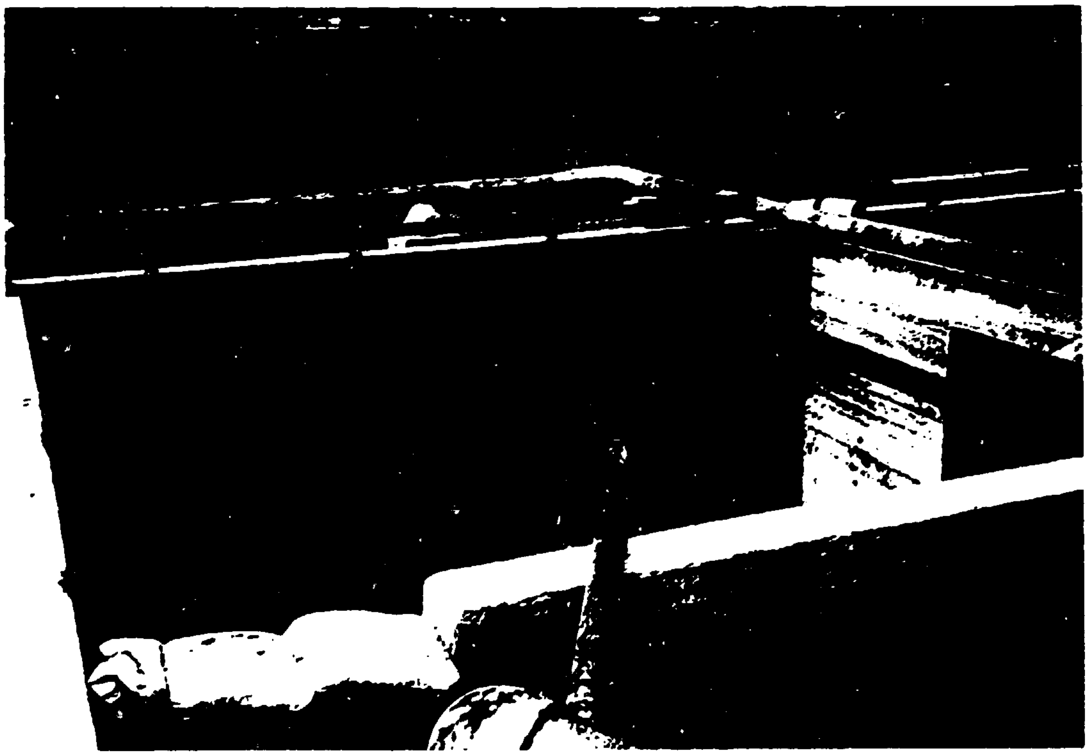

Photo 16. New aeration valves and pipes are installed in to the prearation tank.

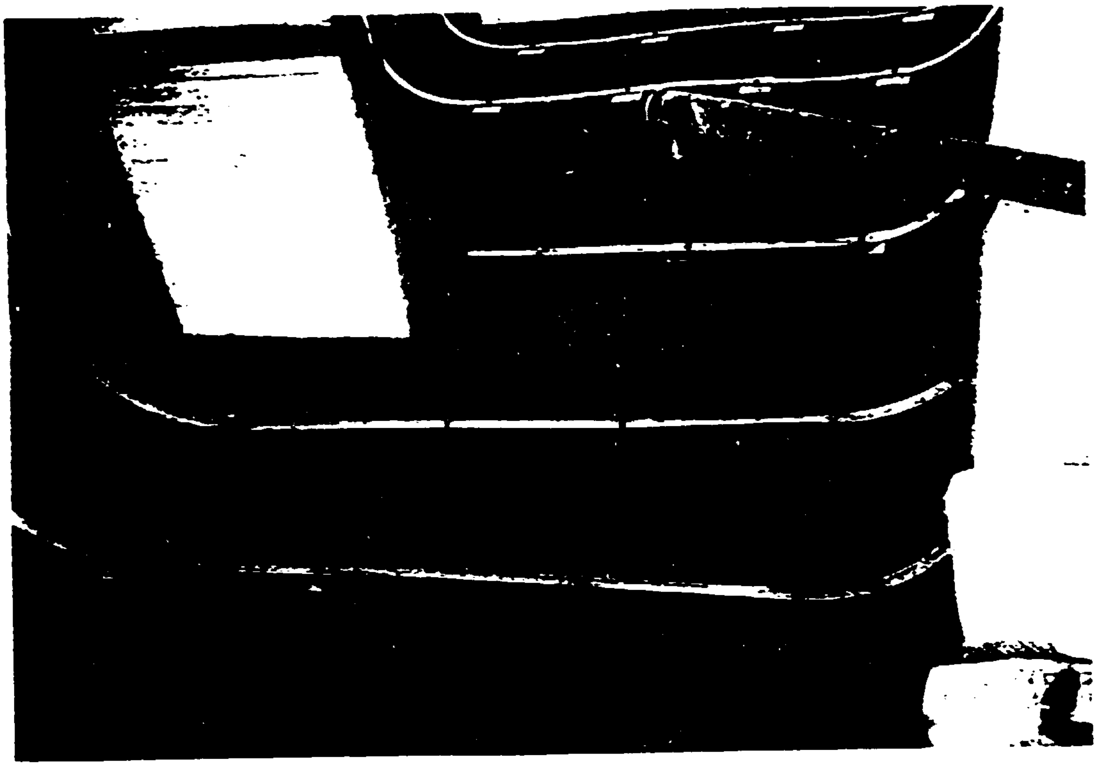

Photo 17. New coarse bubble bottom aeration pipes.

Photo 18. New compressor installed and tested.

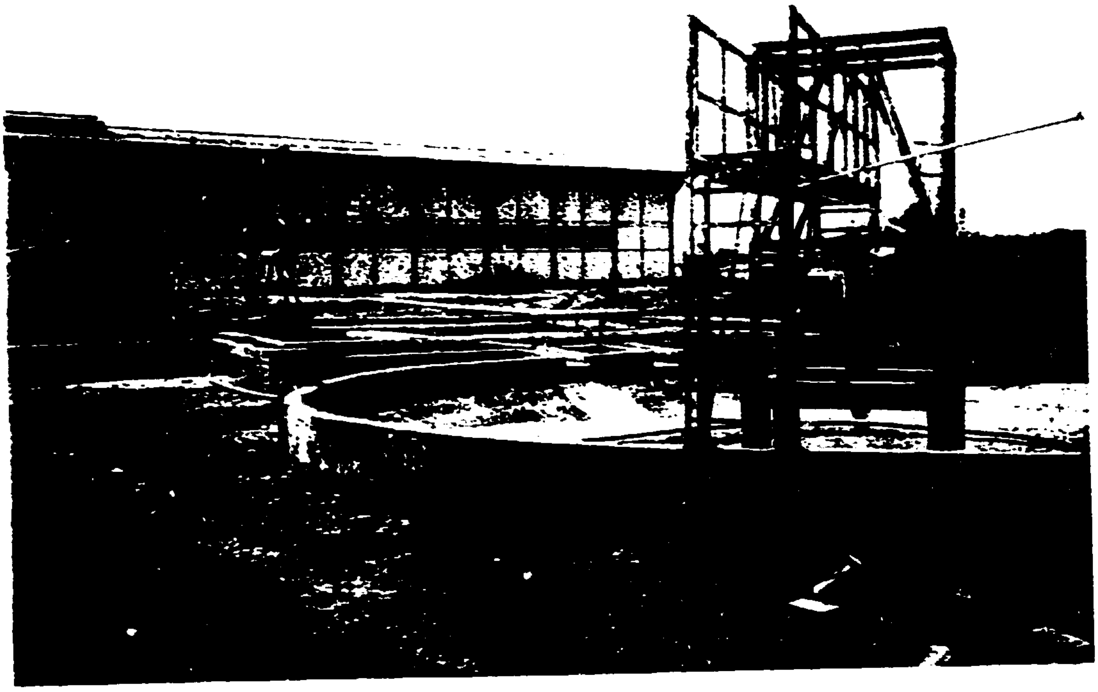

Photo 19. New coarse bubble aeration pipe and one old surface aerator is installed for oxidation inside the tank 1.

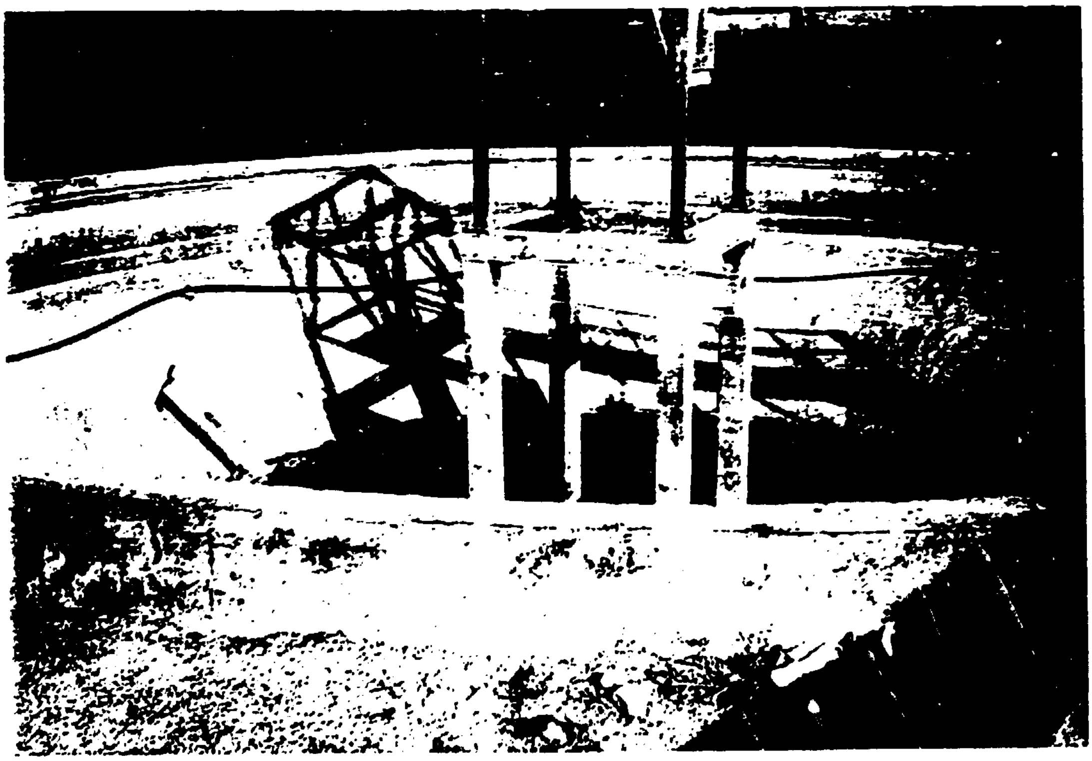

Photo 20. New coarse bubble aeration pipe inside the oxidation tank 2.

Photo 21. Clarifiers are cleaned and ready for use.

Photo 22. Final purification in a big lagoon. Any effluent did not even reach this lagoon in 1994 when 43 % of production capasity was used.

Photo 23. The sludge from the effluent treatment plant is pumped to the sludge drying beds.

Photo 24. Sludge drying beds.

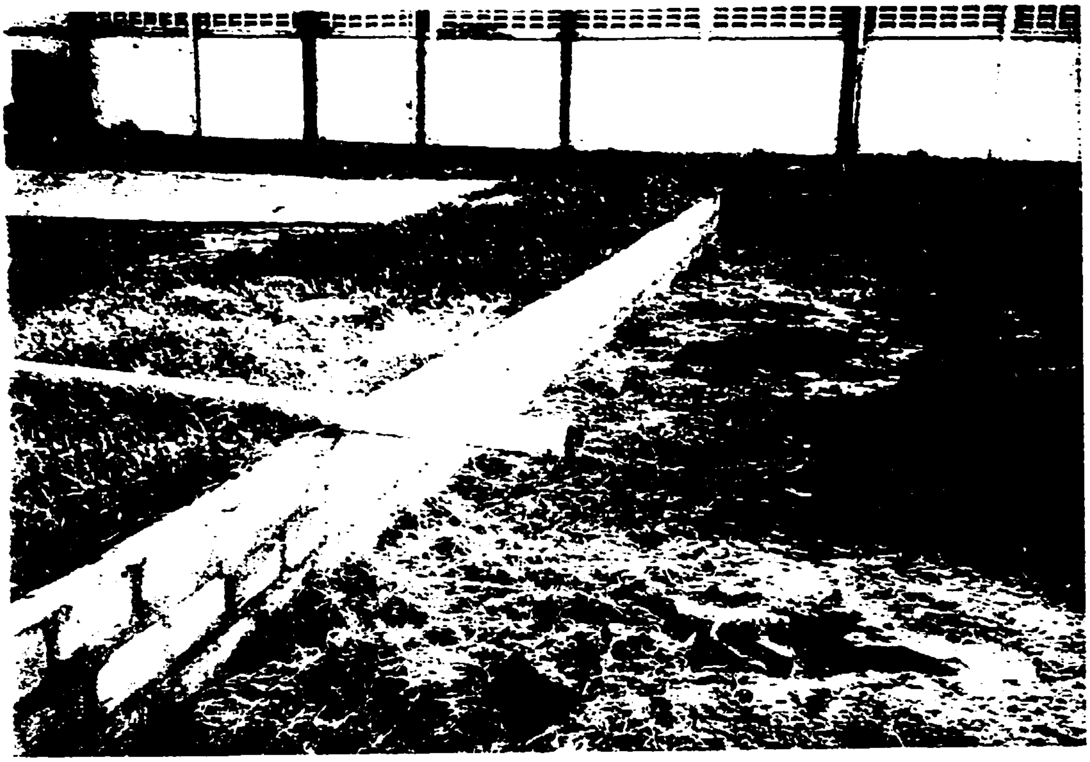

Photo 25. Dried sludge inside the sludge drying bed.

Photo 26. Drainage from the drying beds is back to the effluent treatment plant.

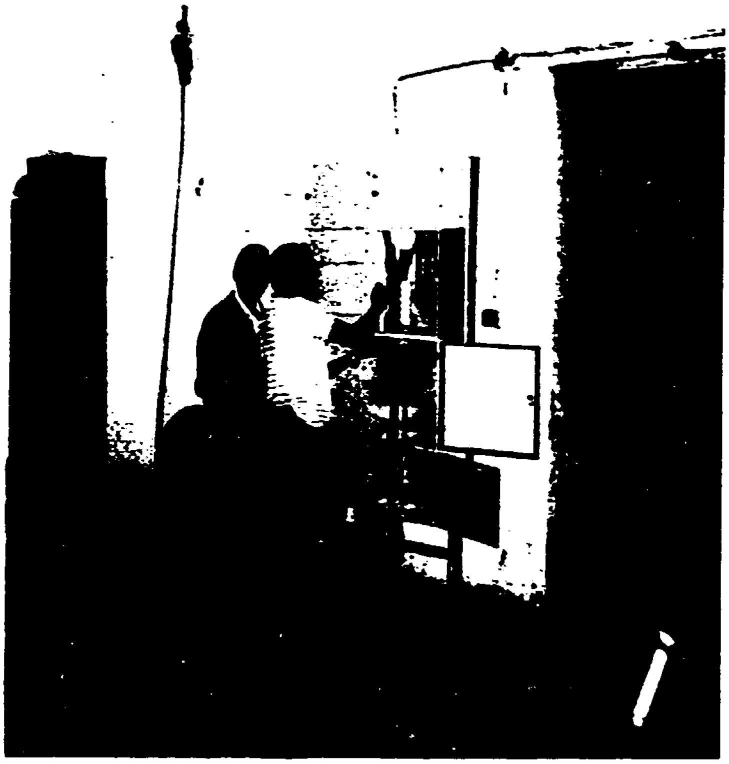

Photo 27. New main electric distribution board of the water plant is just installed and tested.

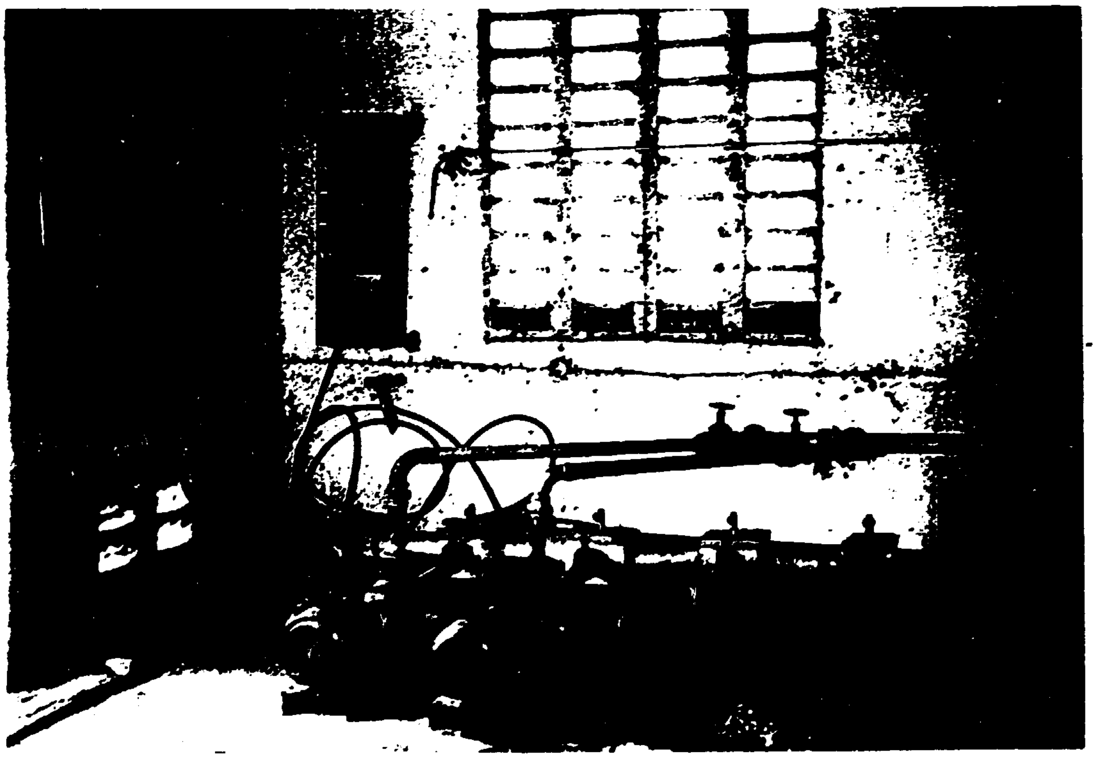

Photo 28. New water pumps, cables and electric board are installed.

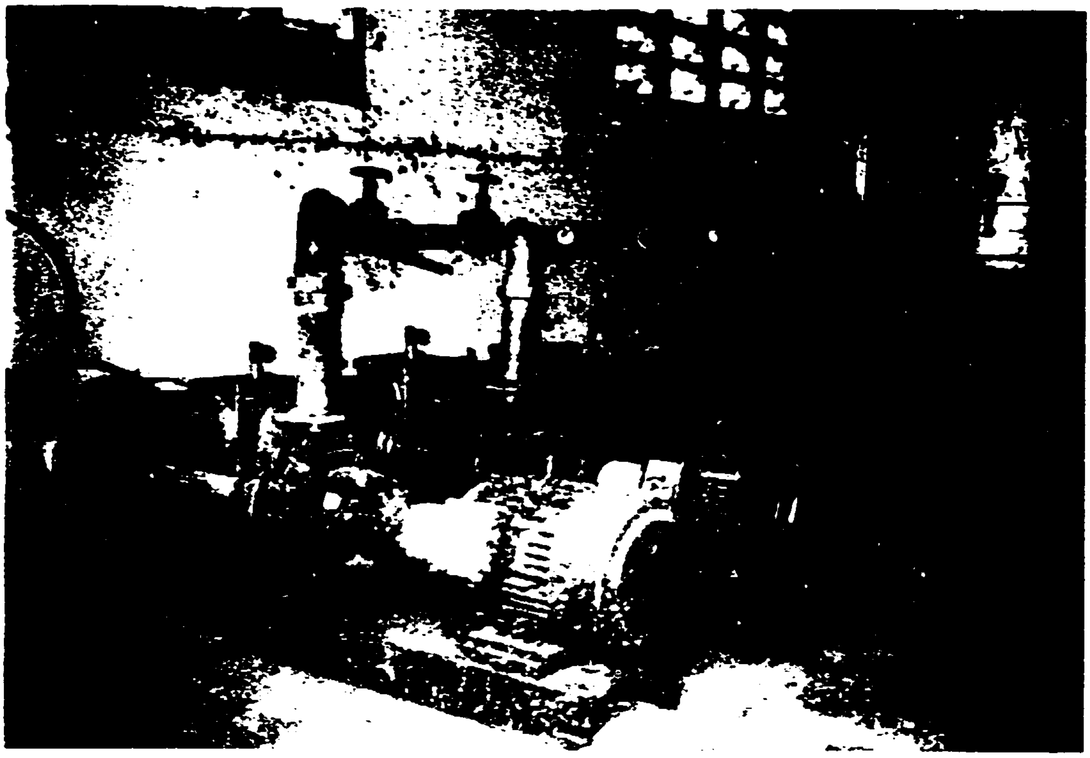

Photo 29. New water pumps will pump water into the pressure tank.

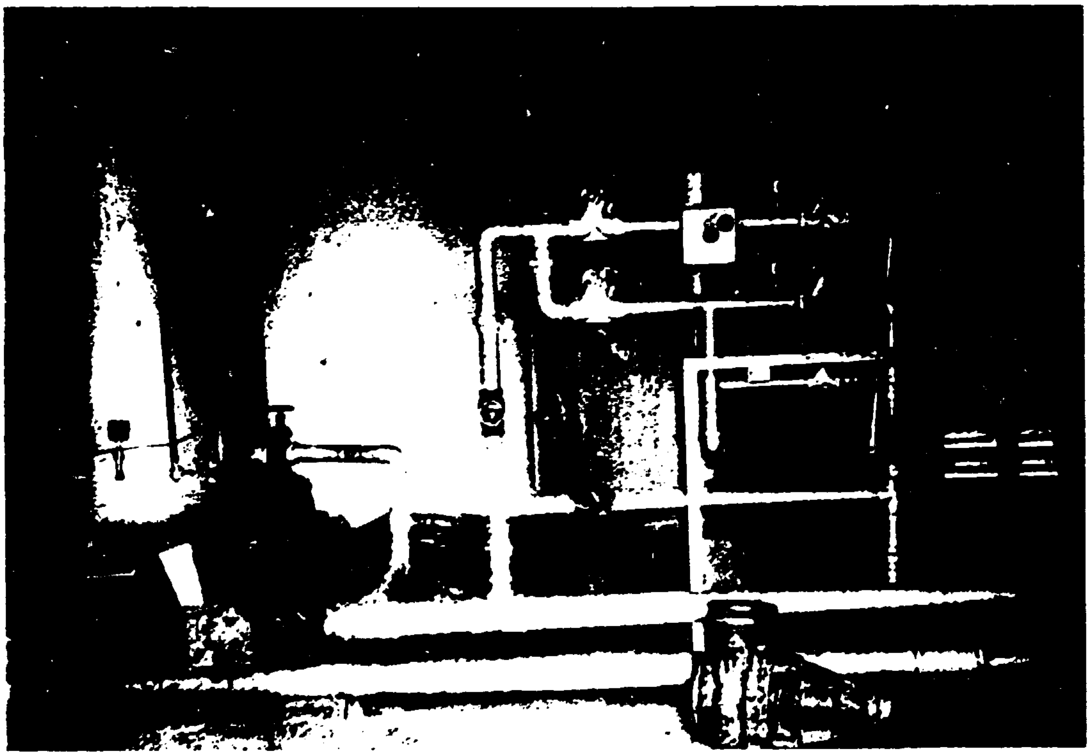

Photo 30. Pressure tank is cleaned and the sandfilters sand has been replaced into.

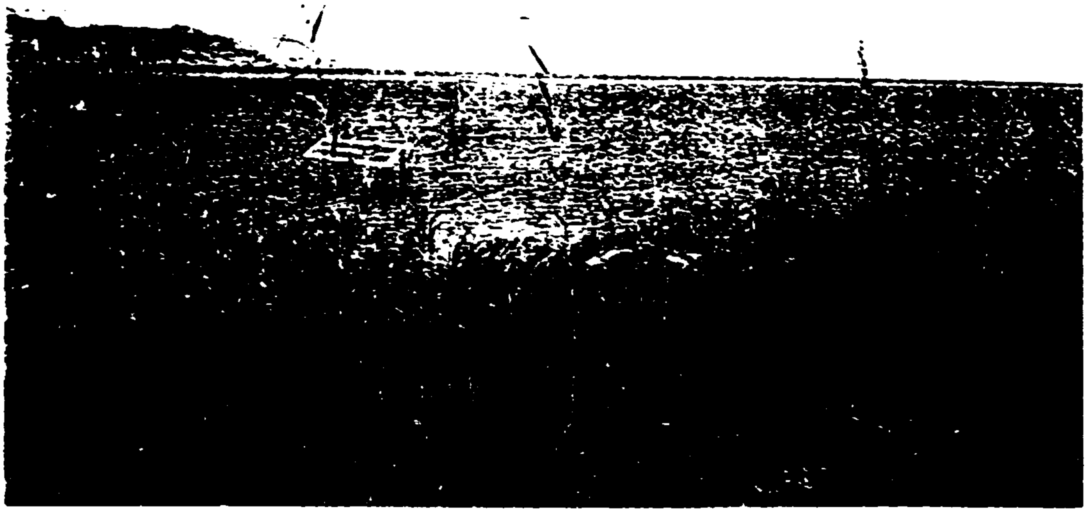

Photo 31. New submersible lake waterpump installed and pumping water to the water treatment plant of the tannery.

Photo 32. The laboratory needs to be upgraded to make necessary analyses for effluent treatment plant. The laboratory has been rehabilited mainly for the need of the leather production.

3

UNIDO Contract No. 93/242
Project No. US/URT/91/110
Activity Code: J13104

PROVISION OF SERVICES RELATING TO THE ASSESSMENT, INSTALLATION, COMMISSIONING, START UP AND TRAINING OPERATION FOR TANNERY EFFLUENT TREATMENT PLANT AT AFRICA TANNERY IN MWANZA, TANZANIA

MANUAL FOR THE OPERATION

On a mission to Tanzania 18 jan – 03 feb 1995

Based on the work of
Mr. Pentti Rantala, Effluent Treatment Expert
Mr. Immo Sundholm, Effluent Treatment Technologist
Tampere, FINLAND, 12.06.1995

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OPERATION MANUAL

1
GENERAL

The effluent treatment plant of the Mwanza Tannery was rehabilitated in 1993 - 1995.

The tannery effluent is composed of two main streams. The chrome tanning waters are characterized by high consentration of chrome. The other main effluent stream comes mainly from the beamhouse operations and all other waters are combined into this general effluent flow. The chrome waters are separated inside the tannery and collected separately into the chrome precipitation. The chrome is precipitated with lime and the treated supernatant is discharges into the main effluent treatment plant. The general effluent is collected inside the tannery into the effluent channel and discharged into the main effluent treatment plant.

The total effluent flow is estimated to be at the full production capacity (1000 hides a day) about 200 m^3/d. There are usually six production days a week. The chrome tanning is usually done during five days a week and the amount of chrome waters is 3 - 5 m^3/d.

The main criteria for the effluent treatment plant is to meet the effluent standards set by the authorities. In practical operation the main emphasis should be placed on removing chrome, sulphides, suspended solids and organic material (COD, BOD) as effectively as possible.

The effluent treatment plant is designed to meet the above mentioned criteria. At the moment the rehabilitation of the plant has been implemented and additional improvements may be required in the future.

Good operation and maintenance is very essential in effective operation of the effluent treatment plant. Continuous control of operation, recording and reporting systems are important tools in aiming at improved operation and maintenance practises. This manual is made to assist the staff of the tannery in these efforts.

2
EFFLUENT TREATMENT PROCESS

2.1
General

The effluent treatment process is divided into the chrome precipitation process and main effluent treatment plant. The flow sheet of the effluent treatment system is shown in the figure 1.

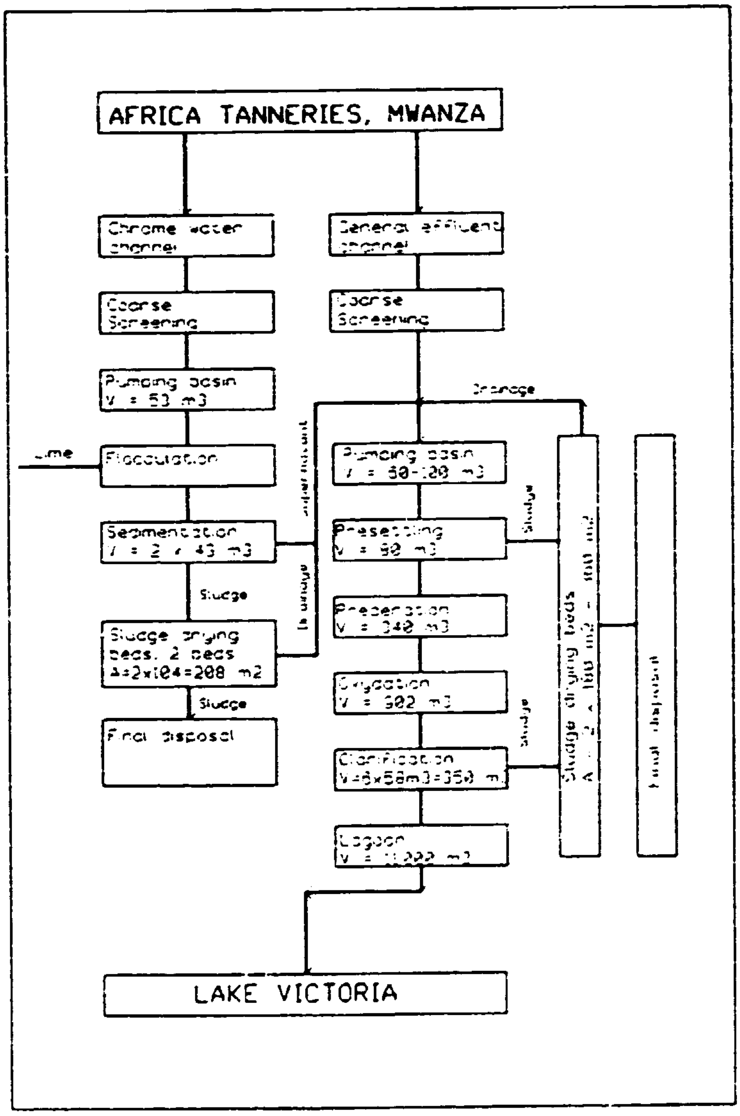

Figure 1.
Effluent treatment process of the Africa Tanneries, Mwanza.

2.2
Chrome Waters

Chrome tanning produces some 20 m^3/week of effluent. These waters are collected and channelled separately from any other type of effluent into the chrome precipitation. The supernatant is released occasionally and it is combined with the general effluent of the tannery and the sludge is discharged into the sludge drying beds. The flow sheet of the chrome water treatment system is shown in figure 2.

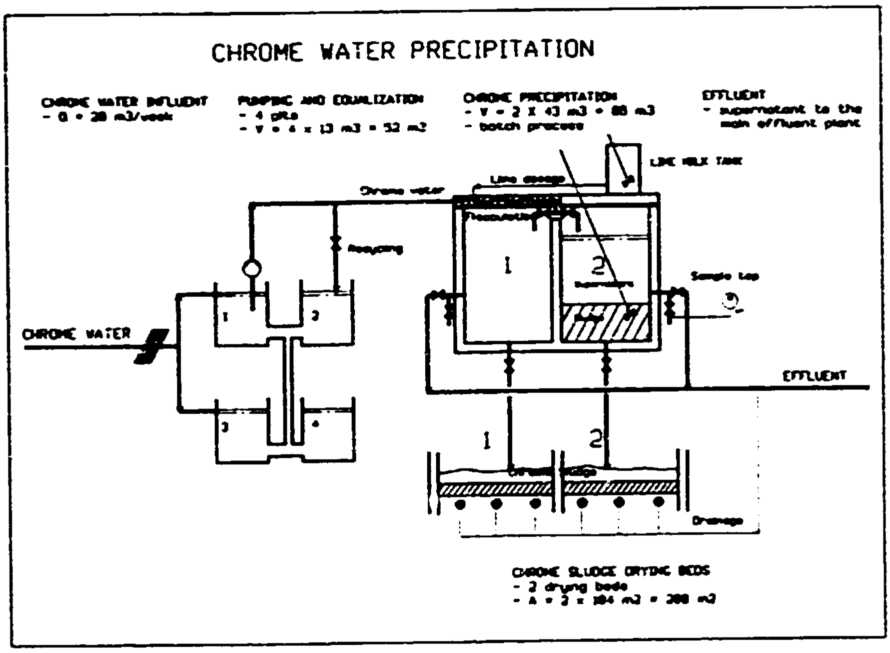

Figure 2.
Treatment process of the chrome waters.

The chrome waters can been separated in the production. The chrome tanning drums have been separated with new walls and through a new channel the chrome waters can flow into the equalization. The effluent is screened in the channel with a coarse manually cleaned screen and then it flows into the equalization and pumping tank. This is an old tank with four compartments and it has been modified for this purpose. The chrome effluent is pumped with a centrifugal pump through mixing into the hydraulic flocculation channel. Then it flows into one of the two settling tanks. The lime is dosed by gravity just before the hydraulic flocculator from a lime milk tank. The pumping can be adjusted by returning part of the flow from the pressure pipe (return pipe with an adjustable valve) back to the equalization tank. Pumping should be even and matching to the lime dosage.

In the chrome precipitation the lime will chemically precipitate the chrome. The lime is mixed with water in a 200 l barrel to form a lime milk which can be dosed by gravity through a pipe with a manually adjustable valve. The required lime dose is about 1000 to 1400 g/m^3 of chrome effluent. The correct dosage must be controlled with a pH measurement.

There are two settling tanks and the flocculated chrome effluent is diverted into one of the tanks with the help of a gate valve at the end of the flocculation channel. Both tanks are 43 m^3 which allow very long settling time.

The hydraulic flocculation is not very effective and therefore it is recommended that the settling tank will be mixed slowly manually for 10 to 15 minutes before settling.

After mixing the pH must be controlled. A sample must be representative. The sample can be taken directly from the tank or from the tap in the supernatant release pipe. The tap must be kept open long enough before taking the sample to guarantee the representativeness of the sample.

The pH must reach 8. In case the sample gives lower value more lime needs to be added. This can be done directly into the tank and mixed manually. After that the pH must be measured again and repeat the procedure as many times as needed to reach pH 8. In case the pH is found to be higher than 8 But less than 9 the settling phase can be started. If the pH is higher than 9 more chrome effluent can be pumped or even in this case the settling can proceed since high pH is not harmful to the chrome precipitation process. Unnecessary high pH in the precipitation will increase the cost since more lime than needed is consumed.

It is recommended that the settling period is 24 hours or at least as long as the supernatant water is clear and the sludge well settled. To control the sludge blanket level it is recommended that a white painted plate with a black cross attached to a stick with length readings will be used to measure the depth of clarified supernatant water above the sludge layer. It is possible to have very long settling periods (up to two weeks) with the existing tanks and with the present production capacity. This will allow flexible operation of the chrome precipitation system.

When the settling is regarded to be completed a sample must be taken from the tap which is in the supernatant release pipe. If there is any sludge in the sample the sludge release valve must be opened to allow some sludge to flow into the sludge drying bed. Only when the sludge blanket is clearly lower than the supernatant release pipe level the supernatant water can be released to flow into the general effluent channel.

It is important that some sludge is released occasionally into the sludge drying beds. This will improve the efficiency of the operation of the settling tank since there will be always enough settling capacity available. The settling tanks will be used by turns.

The two sludge drying beds will be used by turns as well. One bed is expected to be able to receive sludge for about one month and then it is left to dry. During the dry season the sludge will dry in few days after the last sludge has been released on top of the bed. The sludge is well dried when the dry solids content is about 25% to 35%. The sludge cake is then cracked and no water can be pressed by hand from the sludge cake.

For the rainy season it is recommended to construct temporary roof above the sludge drying beds to stop the rain to wet the sludge.

The dried sludge will be removed manually and transported to the safe special chrome sludge disposal site reserved for this purpose outside the tannery area. Some sand will always be removed together with the sludge from the bed surface and this has to be replaced always.

2.3
Main effluent treatment

The main effluent treatment process includes.

- Coarse screening (manually cleaned).
- Equalization and pumping.
- Presettling.
- Sulphide oxidation in stages.
- Clarification.
- Lagooning.

The flow sheet of the main effluent treatment process is shown in the figure 3.

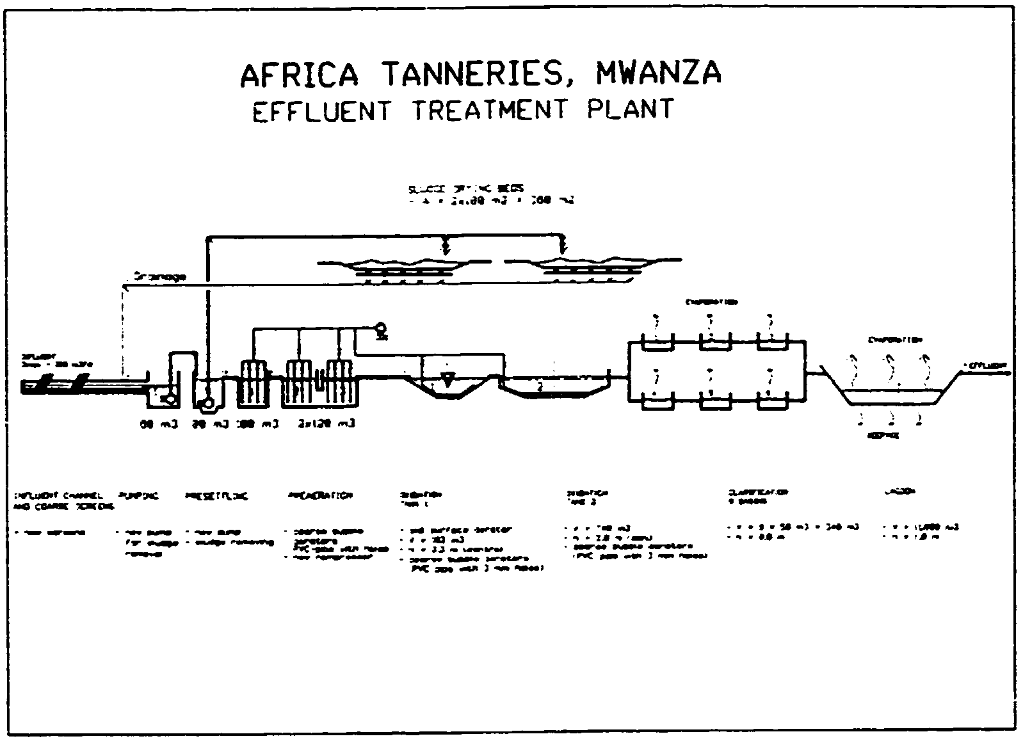

Figure 3.
The main effluent treatment process of the Africa Tanneries, Mwanza.

The main features of the treatment process from operation point of view are the following.

- The screens inside the tannery and in the effluent channels must be cleaned continuously. The bottoms of the channels must be kept clean as well.

- The flow should be equalized as well as possible. A new valve should be installed to the pressure pipe of the main pump. With this new valve it would be possible to adjust the flow better.

Some return flow could be allowed as well (same way as in the chrome effluent pumping). The operator should control the flow during the day and act whenever required.

- The sludge must be removed effectively from the presettling tank by pumping to the sludge drying beds.

- Sludge accumulated into the oxidation tanks must be removed as well. This can be done occasionally. The operators must follow carefully the amount of sludge accumulated and remove it whenever it stars to approach any air distribution pipes by causing clogging.

- One sludge drying bed is used at a time. When one is being filled the other is left drying.

It is very important to try to equalize the effluent flow as much as possible to avoid loading peaks to the system. It is also very important to remove sludge continuously and evenly so that no sludge is accumulated in the plant causing additional internal loading and diminishing tank volumes.

3
MAINTENANCE

3.1
General

All the operation and maintenance manuals of equipment have been delivered by the equipment supplier. These must be carefully followed. Some essential spare parts were included in the supply as well.

Preventive maintenance is very important. Equipment must be greased, oils changed, gaskets checked on a continuous basis etc. The operation of the equipment must be followed up on a daily basis. Any change in the following will be regarded as a sign of possible malfunctioning.

- sound
- vibrations
- leakages
- temperature
- capacity

Any change in the above indicators must lead to immediate action before a major damage can occur.

3.2
Chrome effluent

The chrome precipitation system has fairly small number of equipment. However, the plant needs regular maintenance.

- The chrome effluent pump must be maintained regularly and its operation and condition must be checked every day.

- The joints and valves of the pipelines must be checked every day and in the case of any leakages the pipeline must be repaired immediately. The pipelines may clog and this must be followed carefully as well. The pipelines must be cleaned occasionally and in case there is any drop in the capacity of the pipeline.

- The settling tanks must be cleaned from accumulated sludge. Some sludge will be accumulated in the corners. The cleaning should be done every other month in the beginning. If this proofs to be too seldom the cleaning must be done more frequently.

- The pH meter must be calibrated at least once a week. The reliability of the pH meter should be controlled by comparing the results with another meter every week.

- The operation of the sludge drying beds must be controlled as well. It must be secured that the drainage pipes are not clogged and enough sand is added to the drying beds after removing the dried sludge.

To improve the sludge drying in the rainy season a temporary roof should be constructed. It should be used only when it rains.

3.3
Main effluent treatment plant

The main effluent treatment plant requires constant maintenance and the following are the major maintenance works needed.

- The blower is the key equipment for the plant and it must be maintained according to the manufacturers instructions and additionally the operators must follow up its daily operation and report immediately any change noticed in the operation of the blower.

- The condition of air distribution pipes and valves must be observed daily and any noticed leakage repaired immediately.

- Any clogging of the air distribution system must be recorded and repaired immediately. The clogging in the distribution system may be opened by closing air valves and creating higher pressure on the clogged pipe. If this does not help the system must be lifted up and cleaned.

- The pumps must be maintained according to the manufacturers instructions and additionally the operators must follow up the daily operation of each pump and report immediately any change noticed in the operation of any of the pumps.

- The operation of the sludge drying beds must be controlled as well. It must be secured that the drainage pipes are not clogged and enough sand is added to the drying beds after removing the dried sludge.

4

SELECTED PROPOSALS TO DEVELOP THE EFFICIENCY OF THE PLANT

The rehabilitation of the effluent treatment plant has been implemented. Even with good operation and maintenance practices the plant may have difficulties in performing well especially in temporary overloading situations. Therefore selected proposals are given below to improve the efficiency of the plant.

- A mechanical fine screen would improve the solids separation very much. The screen should be installed into the general effluent channel outside the tannery where all the effluent flows in the same channel. This would ease up the operation of the pumping, presettling and oxidation. This requires a new investment.

- The pumping at the main effluent treatment plant should be rearranged so that the pumping is more constant and stable than presently to enable better balancing of the flow over the day. This could be done by returning some of the pumped water back from the pressure line and reducing the output of the pump by installing a valve to the pressure pipe. This would not require any significant investment.

- The presettling could be improved. This would improve the separation of solids and improve the oxidation efficiency. It is possible to increase the height of the walls of the present presettling tank eg. by 1,5 m.

- At the same time the inflow should be distributed through a cylinder pipe to be placed at the centre of the tank and the outflow should be through overflow weirs to be placed at the edges of the tank. This will require only minor investment and everything can be done locally.

- The oxidation capacity should be increased. Additional blower should be procured. This should be exactly the same type as existing to ease the maintenance. It is also possible to use surface aerators.

These are some examples to improve the operational efficiency of the plant. The proposals presented in the overall rehabilitation plan are valid but this gives indications how to proceed in smaller steps.

5
DIARY

5.1
General

The effluent treatment plant must be operated and maintained 24 hours a day. It can be stopped only when the tannery is stopped. An essential part of the operation control and reporting is the diary of the treatment plant. All actions related to the operation control and maintenance of the treatment plant are recorded into the diary.

The diary must be filled out every day. Monthly, biannual and annual reports are prepared on the basis of the diary. The reports must be filed and kept in logical order. A proposal for the diary is presented in appendix 1.

5.2
Contents of the diary

The diary is divided into three parts.

- General data and tannery production.
- Chrome precipitation data.
- Main effluent treatment plant data.

The person in charge of the operation of the effluent treatment plant will fill out the dairy at least once a day. In case there is any problems or abnormal behaviour of the equipment or process this must be reported in the diary additionally. It is of utmost importance that the actions taken on the basis of abnormal observations are recorded. The dairy should include at least the following information.

A. General data and tannery production

It is important to record data from the tannery and its production because it is possible to understand some of the operational problems only by knowing the production. The following data should be collected.

- date
- time
- weather conditions
- daily production, hides/d
- daily production time, h
- daily operation time of chrome tanning, h
- raw water consumption, m^3/d
- estimated total effluent flow, m^3/d
- estimated chrome effluent flow, m^3/d
- observations

All abnormal situations and observations with actions taken must be recorded with time into the observation column. Actions taken in maintenance of the equipment and process will be recorded here as well as the cleaning of tanks and channels.

B. Chrome precipitation data

This part of the dairy must be filled out every day as well. Even if the chrome precipitation plant is not in use it must be recorded with a reason of stoppage. The following data should be collected.

- date
- time
- chrome effluent flow, m^3/d
- amount of lime used, kg/d
- lime dosage, mg/l
- settling tank number in use
- pH value in the tank
- starting and finishing time of settling
- detention time in settling, h
- chrome concentration in supernatant water, mg/l
- estimated amount of sludge released into sludge beds, m^3
- sludge bed number in use
- starting and finishing date of drying
- sludge drying time, d
- observations

All abnormal situations and observations with actions taken must be recorded with time into the observation column. Actions taken in maintenance of the equipment and process will be recorded here as well as the cleaning of tanks and channels.

C. Main effluent treatment plant data

This part of the dairy must be filled out every day as well. Even if the main effluent treatment plant is not in use it must be recorded with a reason of stoppage. The following data should be collected.

- date
- time
- starting and finishing times of plant influent flow
- estimated influent flow, m^3/d (influent to the pumping)
- starting and finishing times of lagoon influent flow
- starting and finishing times of lagoon effluent flow
- estimated effluent flow, m^3/d (flow to the lake)
- amount of sludge removed, m^3/d (from where)
- quality of the treated effluent (samples from clarifiers), eg. pH, suspended solids, sulphides, chrome etc. according to the analyzing possibilities
- observations

All abnormal situations and observations with actions taken must be recorded with time into the observation column. Actions taken in maintenance of the equipment and process will be recorded here as well as the cleaning of tanks and channels.

Tampere 12.06.1995
Finland

Immo Sundholm
Effluent Treatment
Technologist

AFRICA TANNERIES, MWANZA
EFFLUENT TREATMENT PLANT

DIARY
Page 1(3)

Year ____
Month ____

GENERAL INFORMATION

Date	Time	Weather conditions	Daily production hides/day	Daily production time, h	Daily operation time of chrome tanning, h	Raw water consumption m^3/d	Estimated total effluent flow m^3/d	Estimated chrome effluent flow m^3/d	Observations
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
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AFRICA TANNERIES, MWANZA
EFFLUENT TREATMENT PLANT

DIARY
Page 2(3)

Year ______
Month ______

CHROME PRECIPITATION DATA

Date	Time	Chrome water effl. m^3/h	Lime use kg/d	Lime dosage mg/l	Settling tank in use nr.	pH-value in tank	Detention time in setting / h	Chrome cons. in water mg/l	Amount of sludge released into sludge beds, m3	Sludge bed nr. in use	Starting and finishing date of drying	Drying time d	Observations
1													
2													
3													
4													
5													
6													
7													
8													
9													
10													
11													
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AFRICA TANNERIES, MWANZA
EFFLUENT TREATMENT PLANT

DIARY
Page 3(3)

Year ______
Month ______

MAIN EFFLUENT TREATMENT PLANT DATA

Date	Time	Starting and finishing times of plant influent flow	estimated influent flow m^3/d	Starting and finishing times of lagoon influent flow	Starting and finishing times of lagoon effluent flow	Estimated effluent flow m^3/d	Amount of sludge removed m^3/d	pH-value of effluent	Suspended solids in effluent mg/l	Sulphides in effluent mg/l	Chrome in effluent mg/l	Other analyzes	Observations
1													
2													
3													
4													
5													
6													
7													
8													
9													
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4

UNIDO Contract No. 93/242
Project No. US/URT/91/110
Activity Code: J13104

Annex C

12.06.1995

TECHNICAL PART OF THE REPORT

TABLE OF CONTENTS

LIST AND CHARACTERISTICS OF THE ETP FACILITIES

1

CHROME SEPARATION AND PRECIPITATION PLANT (see annex 1)

Pos.	Description
CH 1	channel in concrete from chrome tanning. depth 500...700 mm. width 500 mm
SC 1	n. 1 coarse screen (not installed yet). slope 60°. space between bars 20...30 mm
TA 1-4	n. 4 equalization and pumping tanks in concrete. dimensions appr. 1.6 x 4.0 x 1.0 H m volume V = 4 x 6.4 m3 = 25.6 m3
PU 1	n. 1 chrome water pump (old) centrifugal type. power appr. 3...5 kW. capacity appr. 0 - 20 m3/h. adjustable by recycling valve
PI 1	pipe between equalization tanks and precipitation. dimension DN 50. Fe37
VA 1	n.1 valve DN 50. recycling contolling valve. manual use
MIX 1	n.1 static mixer in concrete. dimensions appr. 0.5 x 4.4 x 0.1 H m volume appr. V = 0.2 m3
TA 5	n.1 lime milk tank in plastic. volume appr. 200 l
MIX 2	n.1 manual mixer
PI 2	pipe DN20 for lime dosing
VA 2	n.1 valve DN20. for lime dosing. manual adjustable
VA 3,4	n.2 valves DN50. for choosing the precipitation tank
TA 6,7	n.2 precipitation tanks in concrete. dimensions 4.5 x 3.6 x 2.5 H m volume appr. V = 2 x 40 m3 = 80 m3.
MIX 3	n.1 manual mixer

Pos.	Description
PI 3	: pipes DN50, Fe 37
VA 5,6	: n.2 valves DN50
VA 7,8	: n.2 sample valves
ME 1	: portable pH–meter
PI 4	: pipes and hoses DN80
VA 9,10	: n.2 valves DN80
SB 1,2	: n.2 sand drying beds in bricks, dimensions 13 x 8 x 0,6 H m each, surface area A = 2 x 104 m2 = 208 m2 volume V = 2 x 62 m3 = 124 m3

2
MAIN EFFLUENT TREATMENT PLANT
(see annex 2)

Pos.	Description
CH 2,3,4	: channels in concrete, depth 500...800 mm, widths 500...600 mm
SC 2	: n.1 coarse screen after flushing, space dimension appr. 50 mm
SC 3	: n.1 coarse screen, slope 60°, space between bars appr. 30 mm
CH 5	: channel in concrete, depth 500...700 mm, width 600 mm
SC 4,5	: n.2 coarse screens, slope 60°, space between bars appr. 20 and 10 mm
TA 8	: n.1 equalization and pumping tank in concrete, dimensions 5,0 x 6,5 x 3,1 H m max. water level appr. 1,5...1,8 m over the bottom volume appr. V = 50...30 m3

Pos.		Description
PU 2	:	n. 1 wastewater equalization pump submersible type (old). power appr. 3...5 kW. capacity appr. 40...50 m3/h
PI 5	:	pipe DN120 Fe37
TA 9	:	n.1 presettling tank in concrete. dimensions 5.0 x 4.0 x 3.1 H m total water volume appr. V = 60 m3
PU 3	:	n. 1 sludge pump (new) submersible type. Model Sarlin SV024 BH power 1.65 kW. 1413 rpm. 400 V 50 Hz. capacity 6 - 10 l/s at 8 - 6 m water head
PI 6	:	pipe DN80 Fe37
TA	:	n.3 preaeration tanks in concrete. dimensions :
10		5.0 x 6.45 x 3.1 = 100 m3
11		6.0 x 6.45 x 3.1 = 120 m3
12		6.0 x 6.45 x 3.1 = 120 m3
CO 1	:	n.1 air compressor for aeration (Roots model RAI 47) inlet capacity 820 m3/h at 0.48 bar rpm 3000. power 13.2 kW (motor 15.0 kW). 380 V
PI 7	:	preaeration pipes. 50-PEH with 3 mm holes
VA 11-25	:	n.15 valves DN50
PI 8	:	oxidation pipes. 50-PEH. with 3 mm holes
VA 26.27	:	n.2 valves DN50
TA 13	:	n.1 oxidation tank 1 in concrete dimension diameter D = 14 m. depth H = 2.3 m total water volume V = 162 m3 total surface area A = 154 m2
AE 1	:	n.1 surface aerator (repaired old aerator) technical information is not known
PU 4	:	n. 1 sludge pump (new) submersible type. Model Sarlin SV024 BH power 1.65 kW. 1413 rpm. 400 V 50 Hz. capacity 6 - 10 l/s at 8 - 6 m water head

Pos.		Description
TA 14	:	n.1 oxidation tank 2 in concrete dimension diameter D = 18 m, depth H = 3.8 m total water volume V = 740 m3 total surface area A = 254 m2
TA 15–20	:	n.6 clarification basins in concrete dimensions 10 x 10 x 0.9 H m total water volume V = 6 x 58 m3 = 348 m3 total surface area A = 600 m2
LA 1	:	n.1 big maturation lagoon dimensions 60 x 120 x 0.8 H m total water volume appr. V = 5.800 m3 total surface area appr. A = 7.200 m2
SB 3,4	:	n.2 sand drying beds in bricks and concrete, dimensions 15 x 12 x 0.8 H m each, total surface A = 2 x 180 m2 = 360 m2 total volume V = 2 x 180 m3 = 288 m3
VA 28,29	:	n.2 valves DN80
CH 6	:	channel in concrete depth, 500...700 mm, width 500 mm

3

PLANT OPERATIONAL PARAMETERS

3.1

GENERAL

- Processed material max. : 1000 hides a day
- Average actual production in 1994: 43 % of maximum

3.2

CHROME EFFLUENT TREATMENT SYSTEM

- Chrome water effluent flow : Q = 20 m3/week
- Per day : Q = 3-5 m3/d.
- Discharge period : 5 days a week

- Volume of the equalization tanks : 4 x 6.4 m3 = 26 m3
- Retention time in equalization : max. 1 day

- Static mixing channel : V = 0.2 m3
- Amount of lime dosing : 1000...1400 g/m3 of chrome effluent
- Volume of lime milk tank : 200 l

- Principle of precipitation : batch process
- Volume of the precipitation tanks : 2 x 40 m3 = 80 m3
- Average retention time : max. 2 weeks
- pH-level before sedimantation section : between 8...9

- Surface area of drying beds : A = 2 x 104 m2 = 208 m2
- Volume of drying beds : V = 2 x 62 m3 = 124 m3
- Dewatered dry matter : 30...40 % TS
- Capacity of one bed appr.(drying time): 1 month
- The amount of sludge generated approximately : 20...30 m3/month (30...40 %TS)
- Drainage from the bed : back to the effluent treatment plant

Purification level, one analysis was done 28.6.1994, results of analysis are as follows, see also annex 12 :

--	Lime dosing		10 g/l
--	After 30 min	Cr_2O_3	17.7 mg/l
		pH	3.37
--	Final	Cr_2O_3	7.96 mg/l
		pH	3.71
--	Lab. supernatant	Cr_2O_3	2.70 mg/l
		pH	7.43
--	Treatment supernatant	Cr_2O_3	3.80 mg/l
		pH	7.40

3.3
MAIN EFFLUENT TREATMENT PLANT

Flow information

- Effluent flow max. : Q = 200 m3/d
- Effluent flow norm. : Q = 100...150 m3/d
- Discharge period : 6 days a week. 8–10 hrs/day
- Average discharge flow max. : q_{max} = 25 m3/h
- Average discharge flow norm. : q_{norm} = 10...17 m3/h

Screening

- 4 manual coarse screens : bar opening sizes around 50. 30. 20 and 10 mm

(Recommendation : new mechanical fine screen is needed)

Equalization

- Volume of equalization tank : 50...60 m3
- Retention time : 2...5 h
- Equalization pump capacity : appr. 40...50 m3/h
  (Recommendation : new adjustable valve and recycling pipe is needed between equalization and presettling)

Presettling

- Volume of presettling tank : 60 m3
- Surface area : 20 m2
- Retention time : 3...6 h
- Sludge pump capacity : 14...25 m3/h
- Surface load (if smooth pumping) : 0.5...1.2 m/h
  (Recommendation : pumping into the tank should be made adjustable and as smooth as possible. Tank should also be made higher and equipped with inside cylinder for influent and weir for outlet)

Sulphide oxidation (Preaeration stage)

Approximately 60 m3 of air is needed for each m3 of effluent when using catalytic oxidation with manganase ("Tanneries and Environment. A technical guide. UNEP. 1991"). The catalyst concentration should be around 100 mg/l of Mn.

- Total volume of preaeration tanks : 340 m3
- Retention time : 20...34 h
- Aeration capacity needed for sulphide oxidation in Mwanza : 600...1000 Nm3/h
- Blower capacity : 820...1000 Nm3/h
  (Recommendation : start to use manganase as catalyst if sulphides are found in the effluent)

Oxidation

Many tanneries have used surface aerators with inputs around 10...20 W/m3. Retention time should be some 5 to 10 days and then some BOD reuction can be acheived as well.

- Total volume of oxidation tanks : 902 m3
- Retention time : 2...4 d
- Aeration capacity needed for full oxidation of sulphides in Mwanza : around 15...20 kW
- Oxidation capacity now :
  - -- new blower 2...3 kW
  - -- old surface aerator around 2...3 kW

(Recommendation : two new surface aerators should be installed. one 5 kW and another 15 kW for complete oxidation of sulphides and for controlling the BOD7 load interfernce in full production situation)

Clarification
- Six clarifiers in 2 lines. where 3 tanks are in series
- Total surface area : 600 m2
- Total volume : 348 m3
- Retention time : 1...1.5 d
- Surface load of one clarifier : 0.1...0.2 m/h

Lagoon
- Volume : 5800 m3
- Surface area : 7200 m2
- Retention time : 29...50 d

Sludge treatment
- Expected sludge production : 500...750 kgTS/d
- System : sludge drying beds 2 pcs.
- Total surface of the drying beds : A = 2 x 180 m2 = 360 m2
- Total volume of the beds : V = 2 x 144 m3 = 288 m3
- Dewatered dry matter : 30...40 % TS
- Capacity of one bed appr.(drying time): 3...4 weeks
- drainage from the bed : back to the effluent treatment plant

Purification level

The production in Africa Tannery in Mwanza was around 40 % of full capacity from April 8 th till September 6 th. The effluent during that period did not reach the last big lagoon. Up to January 1995 no effluent has reached the lagoon.

For these reason any analyses from main effluent have not been made.

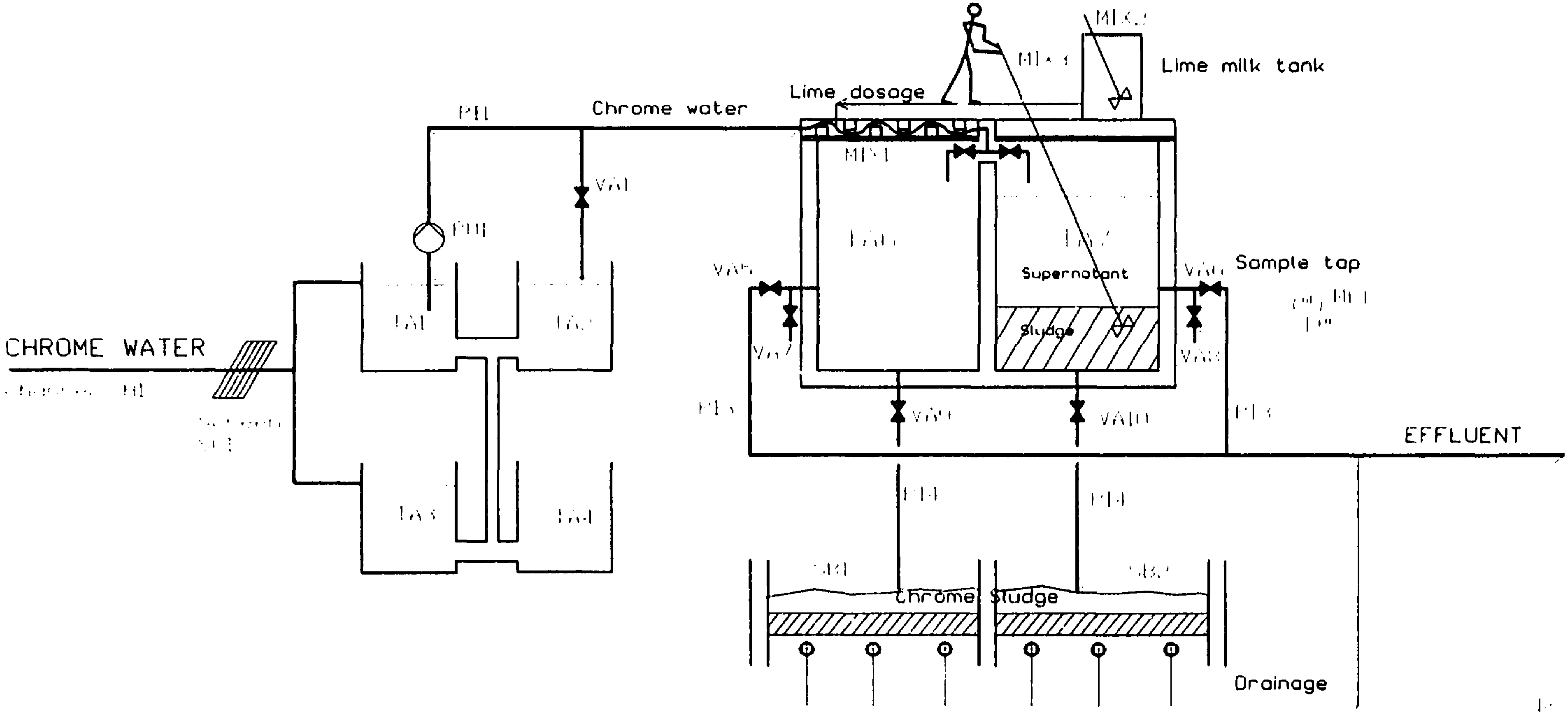
CHROME WATER PRECIPITATION

CHROME WATER INFLUENT
- Q = 20 m3/week

PUMPING AND EQUALIZATION
- 4 pits
- V = 4 x 13 m3 = 52 m3

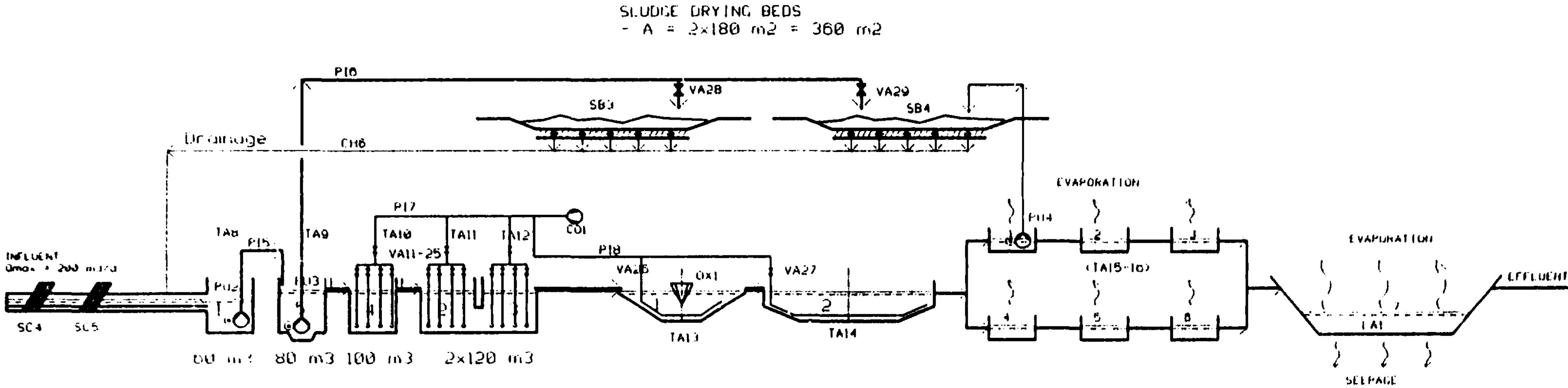
CHROME PRECIPITATION
- V = 2 X 43 m3 = 86 m3
- batch process

EFFLUENT
- supernatant to the main effluent plant



CHROME SLUDGE DRYING BEDS
- 2 drying beds
- A = 2 x 104 m2 = 208 m2
- V = 2 x 104 x 0,6 m2 = 124 m2

AFRICA TANNERIES, MWANZA
EFFLUENT TREATMENT PLANT



INFLUENT CHANNEL AND COARSE SCREENS

- new screens

PUMPING

- new pump for sludge removal

PRESETTLING

- new pump
- sludge removing
- A = 20 m2

PREAERATION

- coarse bubble aerators PVC-pipe with holes
- new compressor
- A = 154 m2

OXIDATION TANK 1

- old surface aerator
- V = 162 m3
- h = 2,3 m (centre)
- coarse bubble aerators (PVC pipe with 3 mm holes)
- A = 254 m2
- d = 14 m

OXIDATION TANK 2

- V = 740 m3
- h = 3,8 m (cen)
- coarse bubble aerators (PVC pipe with 3 mm holes)
- A = 254 m2
- d = 18 m

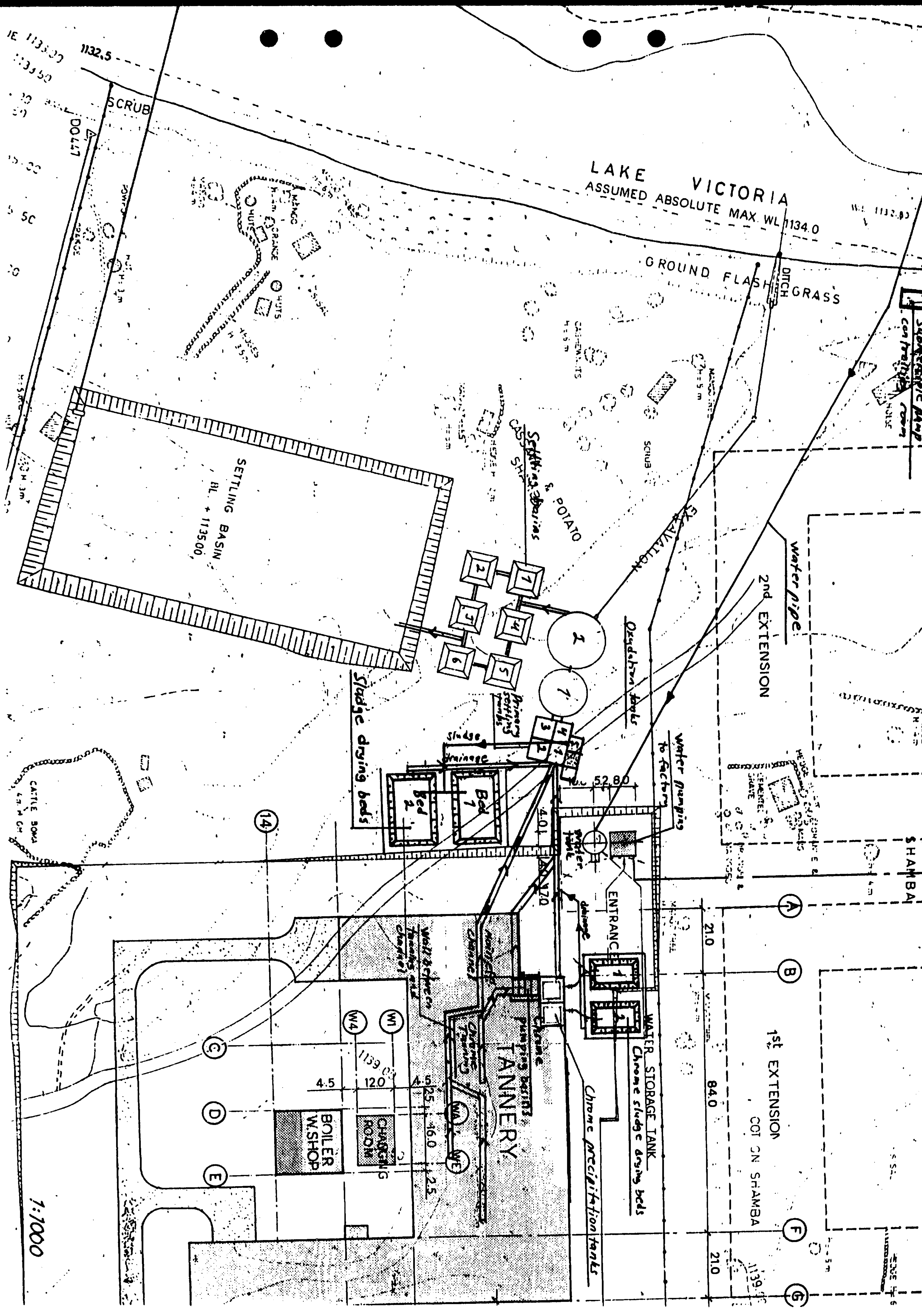
CLARIFICATION 6 BASINS

- V = 6 * 58 m3 = 348 m3
- h = 0,8 m
- A = 6 x (10 x 10 m2)

LAGOON

- V = 5800 m3
- h = 0,8 m
- A = 120 x 60 = 7200 m

ANNEX 2


LAKE VICTORIA
ASSUMED ABSOLUTE MAX WL 1134.0
1132.5
SCRUB
GROUND FLASH
DITCH
GRASS
HUTS
MANGO
ORANGE
SISAL
HEDGES
SETTLING BASIN
BL + 1135.00
Settling basins
& POTATO
EXCAVATION
water pipe
2nd EXTENSION
Oxydation tanks
Primary settling tanks
Sludge
Drainage
Bed 1
Bed 2
Sludge drying beds
water pumping to factory
52.80
4.0
17.0
water tank
ENTRANCE
drainage
WATER STORAGE TANK
Chrome sludge drying beds
Chrome precipitation tanks
Chrome
pumping basins
TANNERY
Chrome tanning
Wall between tanning and chrome channel
BOILER W.SHOP
CHARGING ROOM
W1
W4
WA
WE
1139.0
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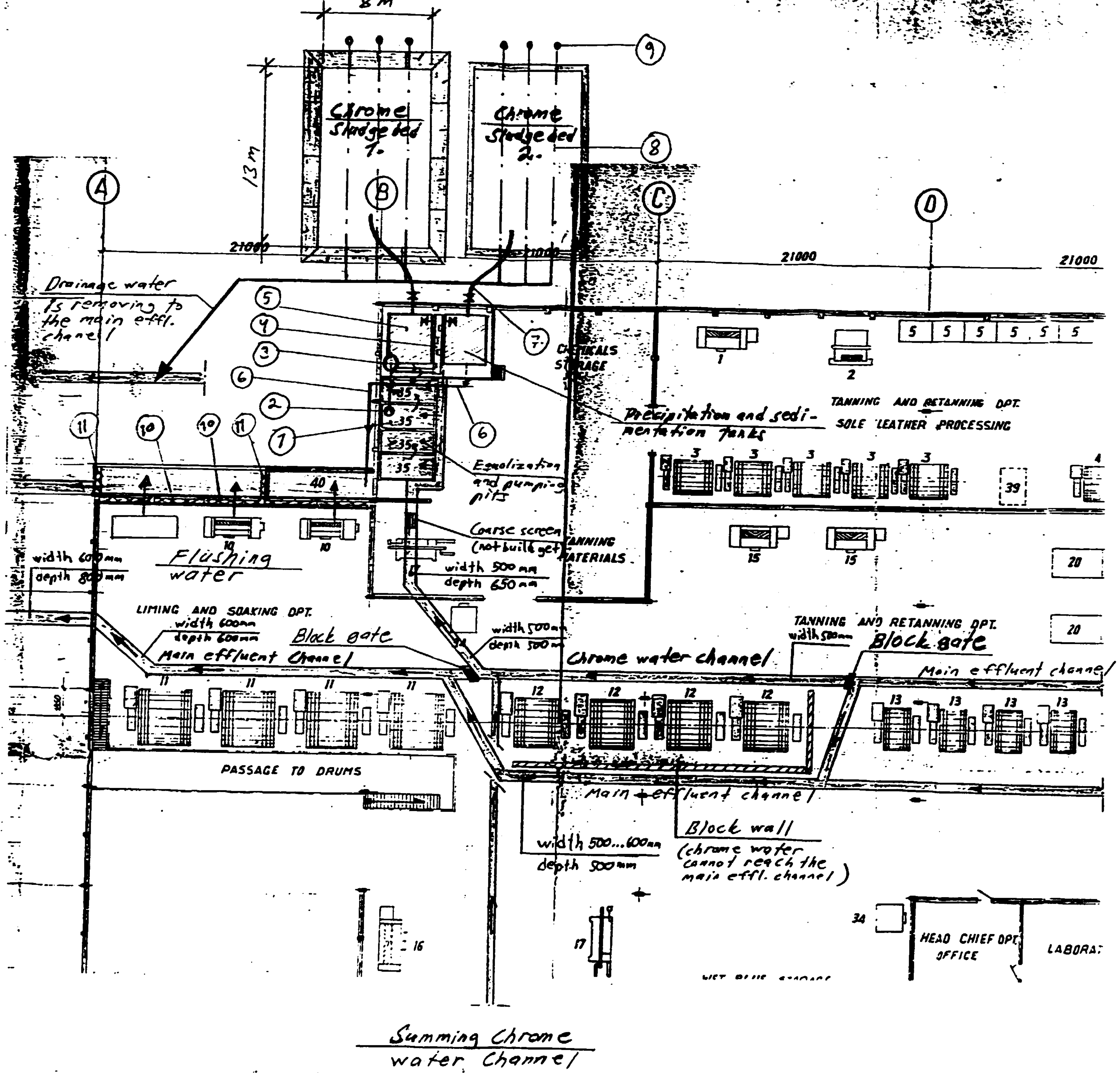
A
B
C
D
E
F
G
21.0
84.0
21.0
1st EXTENSION
COTTON SHAMBA
SHAMBA
CATTLE BOMA
1:1000



1. Chrome equalization and pumping pits.
2. Chrome liquid pump.
3. Lime vessel.
4. Mixing channel (static).
5. Chrome precipitation and sedimentation tank.
6. Supernatant water pipe.
7. Chrome sludge effluent hoses.
8. Drainage water pipes.
9. Flushing pipes.
10. First coarse screen for the flushing water
11. Second coarse screens

Mr. Jmmo Sundholm
Mwan 29 Jan 1995

AIR-IX SUUNNITTELU

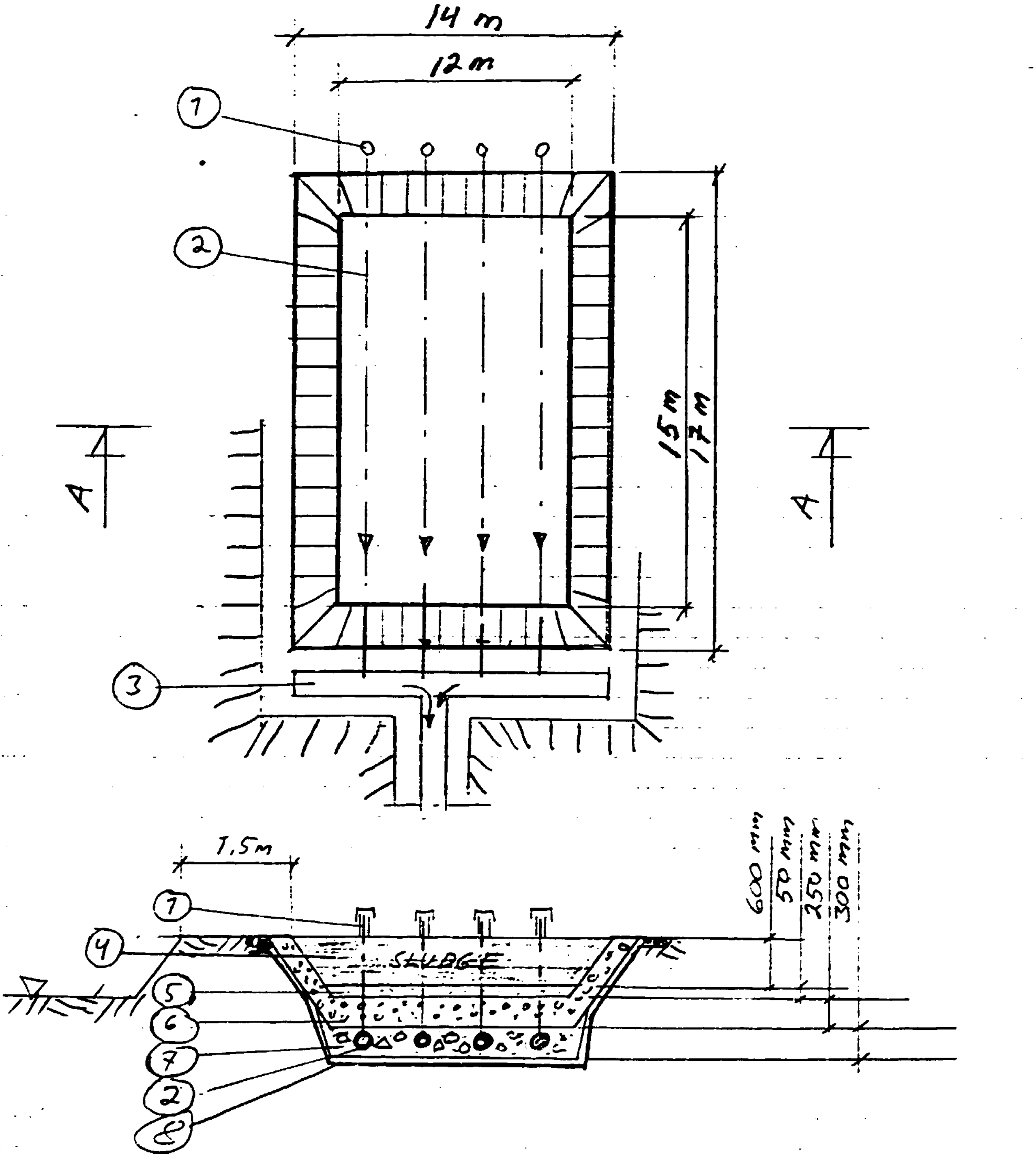
PIIR NIMI: SLUDGE DRYING BEDS AFRICA TANNERY, MWANZA

TYÖ NO: **ANNEX 5.**

LAATIJA: Mr J[illegible]

PVM: 24.7.93

SIVU: --

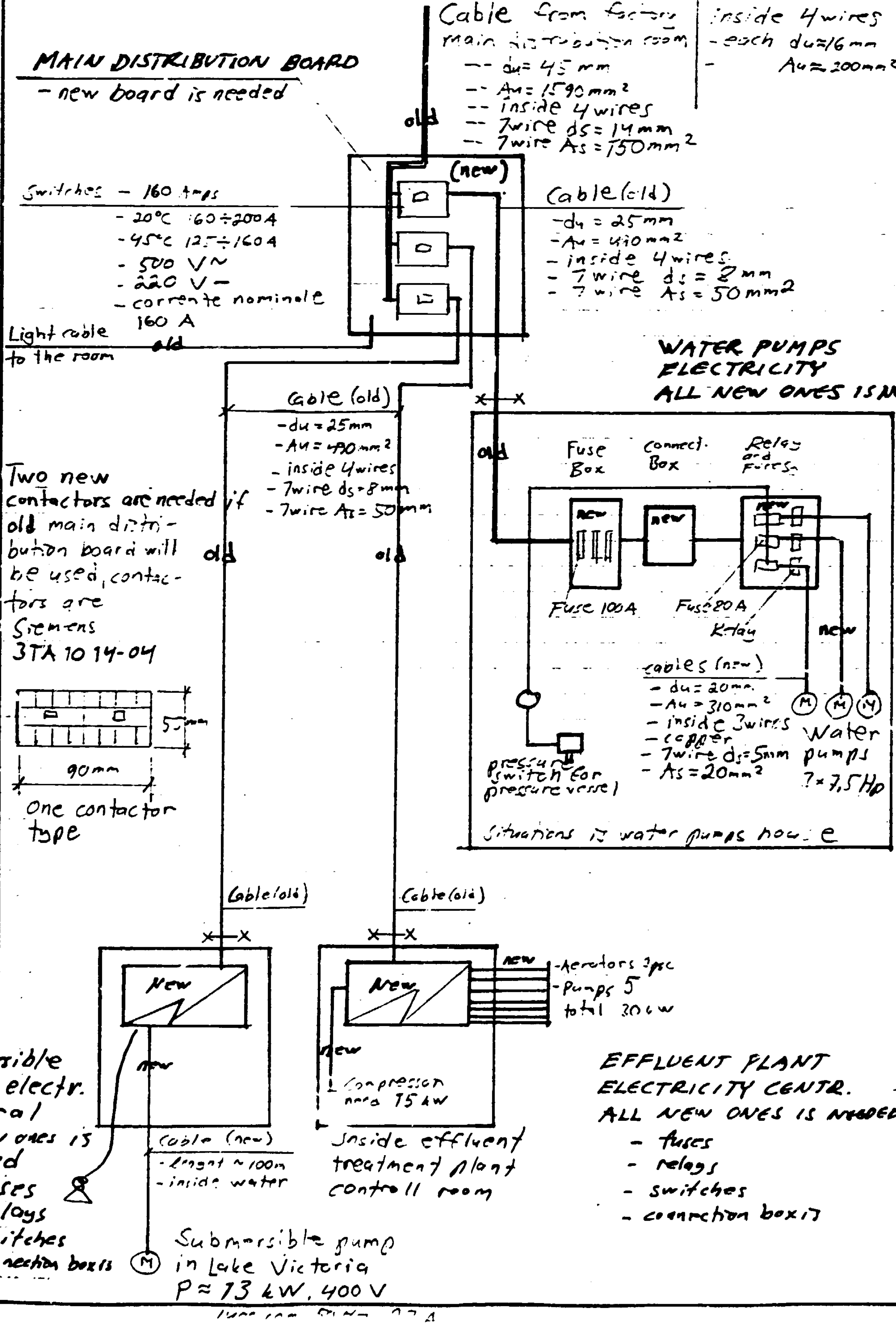


1 Flushing pipes with hats, PVC-pipes de 175 mm
2 Drain pipes, PVC-pipes with holes de 175mm
3 Ditch or channel to the main effluent channel
4 Up to 500mm fresh sludge
5 Fine sand 50 mm, ⌀ about 5mm
6 Gravel 250 mm, ⌀ about 20-30mm
7 Stones 300 mm, ⌀ about 40-60 mm
8 PVC-placktics

ANNEX 6.

AIR-IX
SUUNNITTELU

TYÖN NIMI Mwanza Tannery in Tanzania		TYÖ NO Water and waste-water Electricity
LAATIJA Mr. Jmmo	PVM 24.7.93	SIV 7(2)



AIR-IX SUUNNITTELU

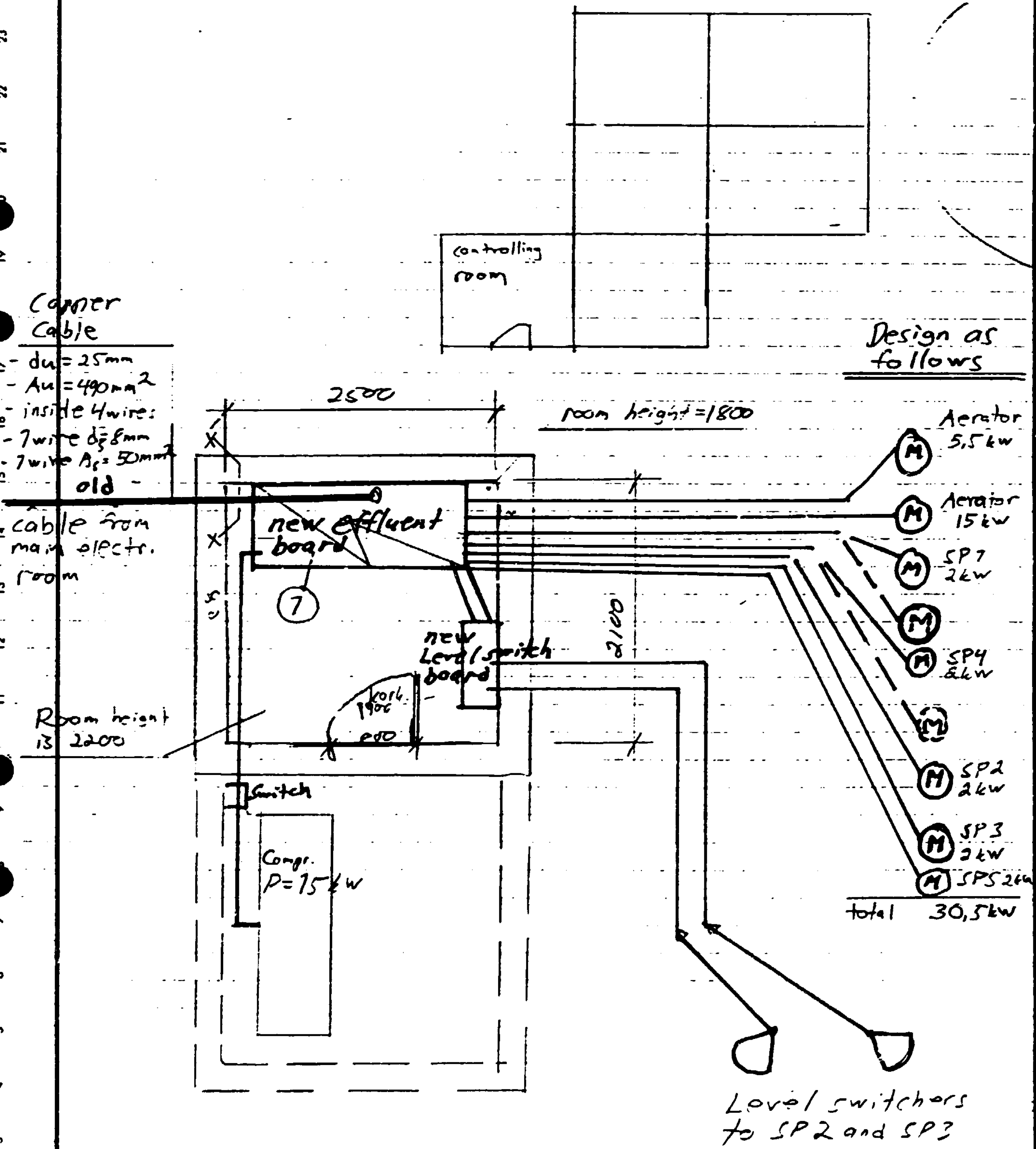
Mwanza Tannery in Tanzania

Water and wastewater electricity

Mr Jmmo

24.7.93

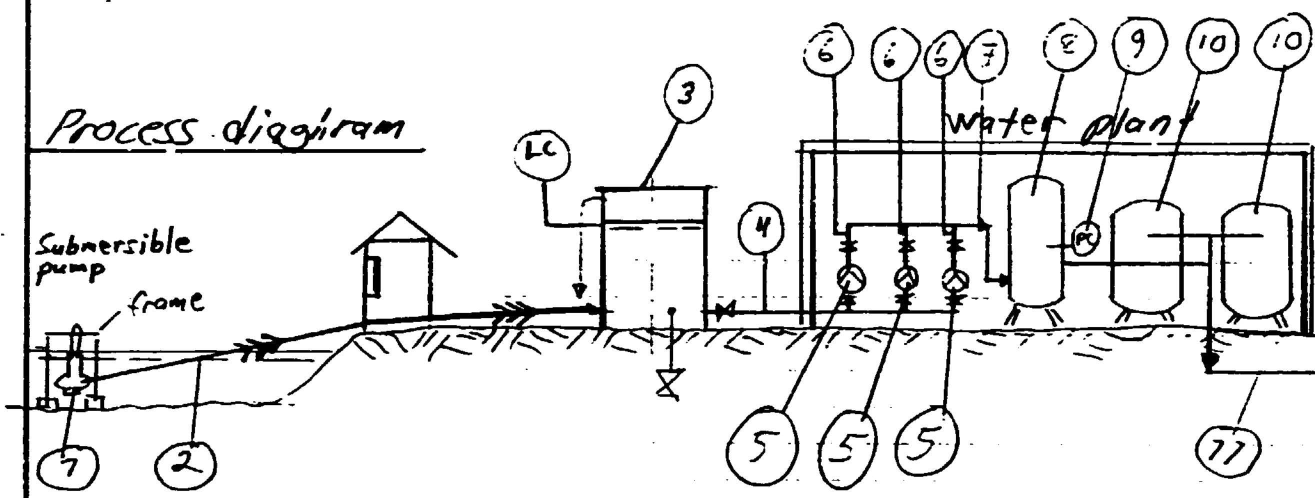
2(2)



Level switchers to SP2 and SP3

AIR-IX SUUNNITTELU	TYÖN NIMI WATER SYSTEM AFRICA TANNERY, MWANZA		TYÖ NO
	LAATIJA Jrmo	PVM 23.7.93	SIVU 7(3)

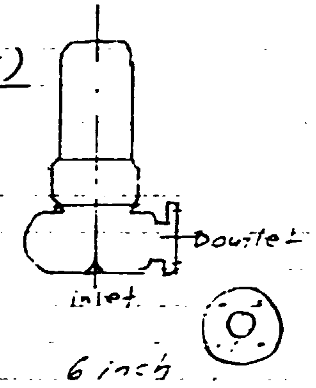
Process diagram



Pos

7. Submersible pump (need 2 pcs of new pumps)

- Flygt pump CP3-151
  - serial numb. 3151 120-46217
  - 3~, 1400 rpm, 50 Hz, 11 kW
  - 400V, 23A, 12,6 kW
  - elevation max. $h_{max} \approx 12\ m$
  - $q_{nominal\ (mean)} = 500 \ldots 1000\ ^{r}/_{eh} \approx 62 \ldots 125\ m^3/h$



6 inch

- pump is connecting to the pipe, and the hole pump is sometimes under the water level, good seeling of the pump is very important

- controlling and switching system is made befor by manually, but in future is needed automatic level control system to control pumping to vessel

2. Water pipe from lake to tannery water vessel

- the lenght of pipe $l \approx 230\ m$
- the dimension of pipe $d = 6''\phi$

- no leaks aren't occured in the pipe

3. Water tank

- height of the tank is $h = 2600\ mm = 2.6\ m$
- dimension —"— $d = 6\ m$
- volume of —"— $V = 80\ m^3$

AIR-IX SUUNNITTELU

TYÖN NIMI: WATER SYSTEM
AFRICA TANNERY, MWANZA
TYÖ NO
KD
LAATIJA Irmo
PVM 23.7.93
SIVU 2(3)

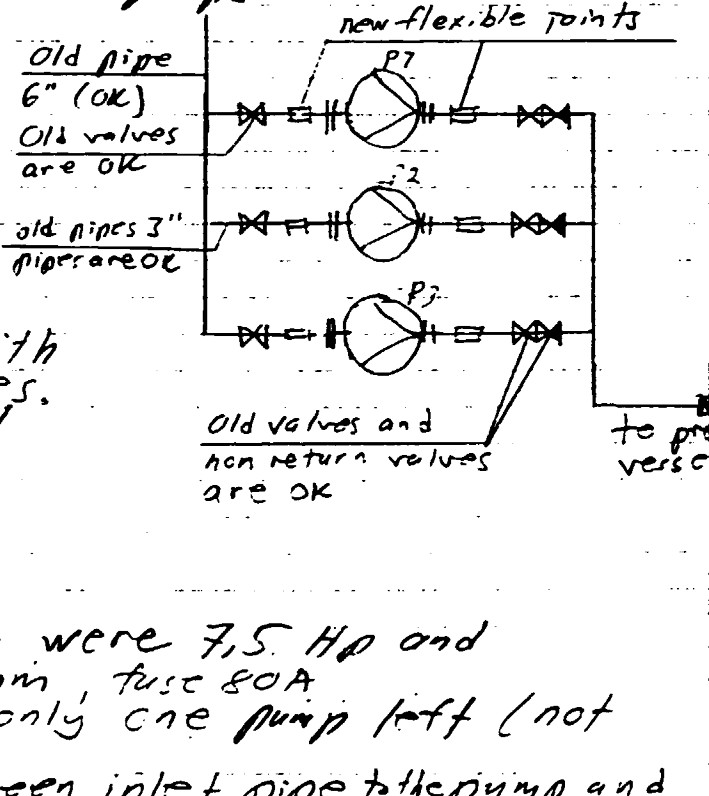
③. Water tank

- level controll are made by manually before, in future automatically if possible
- in the vessel is overflow pipe to the ground

④ Pipe from water vessel to water pumps inside the water plant
- dim = 6 inch
- lenght ≈ 10 m

⑤ Water pumps and pipes
⑥ Places for three pumps, only one old is used now. Three new pumps are needed.

Old pumps
-- 7,5 HP
1400 rpm



Pumps can be joint with flexible points to pipes. New pumps, pipe and joints are needed.

- The old pumps were 7,5 Hp and 380V, 2900 rpm, fuse 80A
- now there is only one pump left (not original pump)
- evalution between inlet pipe to the pump and floor is about 250 mm.
- pipes to pumps are 3" pipes and every joints are now turning points
- controlling has made before by hand controlling. Also there has been those pressure control, which control the pressure level in the pipe of factory

⑦ Pipe for the water pumps to the pressure vessel
- diameter 3"-pipe
- lenght about 5 to 7 m

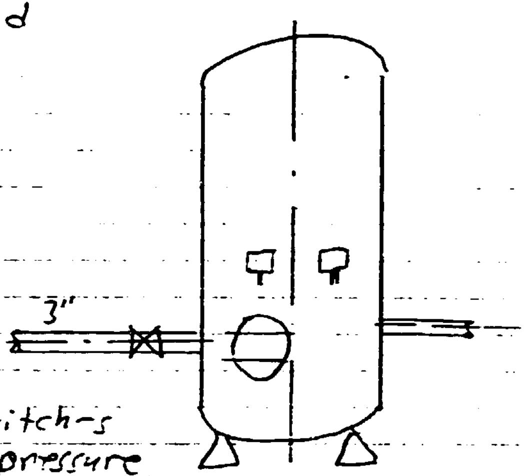
AIR-IX
SUUNNITTELU

TYÖN NIMI	TYÖ NO	KD
WATER SYSTEM AFRICA TANNERY, MWANZA		

LAATIJA	PVM	SIVU
Ar Immo	24.7 93	3(3)

(8) Pressure vessel

Pressure vessel is about 2-3 m height
and about Ø 7 m round

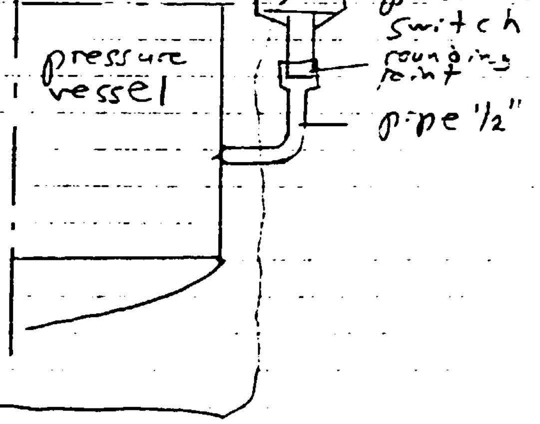


Type of the vessel is
- ICI S.p.A
- Verona
- press 6 kg/cm2
- Lt mod 3000
- Anno 1975, 19521

There are two pressure switches
in tank to controlling pressure,
and switching pumps.

Those pressure switches must
removed for new ones. Information
of pressure switches are
- Squared / Italy
- type HH6-2
- on 5,6, off 7,0
- class 9013

There is also needed new
cable and connection to
the new pump electricity
board (dist. about 70m



ANNEX 8.

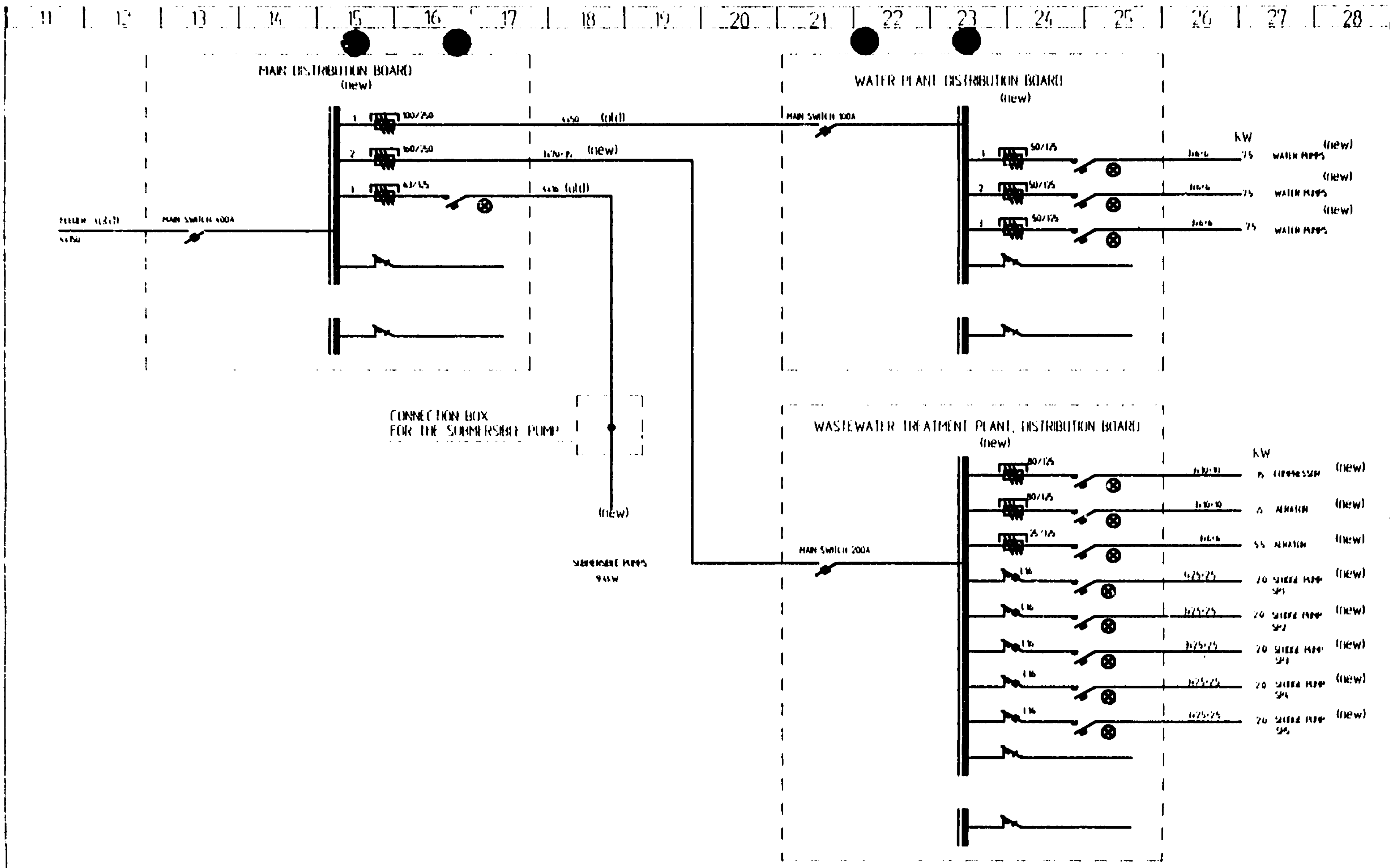
SOIL AND WATER LTD.
Tuomiokirkonatu 34 A
33100 TAMPERE
FINLAND
931-2220 600 tel.
931-2220 366 fax.

DRAWING LIST

Date : 22.04.1994
Revision : 1

MWANZA TANNERY, TANZANIA
ELECTRIC DRAWINGS

No	Date	Revision	Name	Scale
13-200			Main line diagram	
	20.01.94		Main distribution board, layout	1:10
13-201	11.10.93		Main distribution board, block diagram, 2 sheet	
	20.01.94		Water plant, distribution board, layout	1:10
13-202	11.10.93		Water plant, distribution board, block diagram, 2 sheet	
14-302	11.10.93		Water pumps, control circuit diagram	
	26.01.94		Wastewater treatment plant, distribution board, layout	1:10
13-203	24.01.94		Wastewater treatment plant, distribution board, block diagram, 3 sheet	
14-303	24.01.94		Wastewater treatment plant, distribution board, control circuit diagram, 3 sheet	
	11.02.94		Connection box, submersible pump, layout	1:10
14-301	11.10.93		Submersible pump, control circuit diagram	



[illegible]

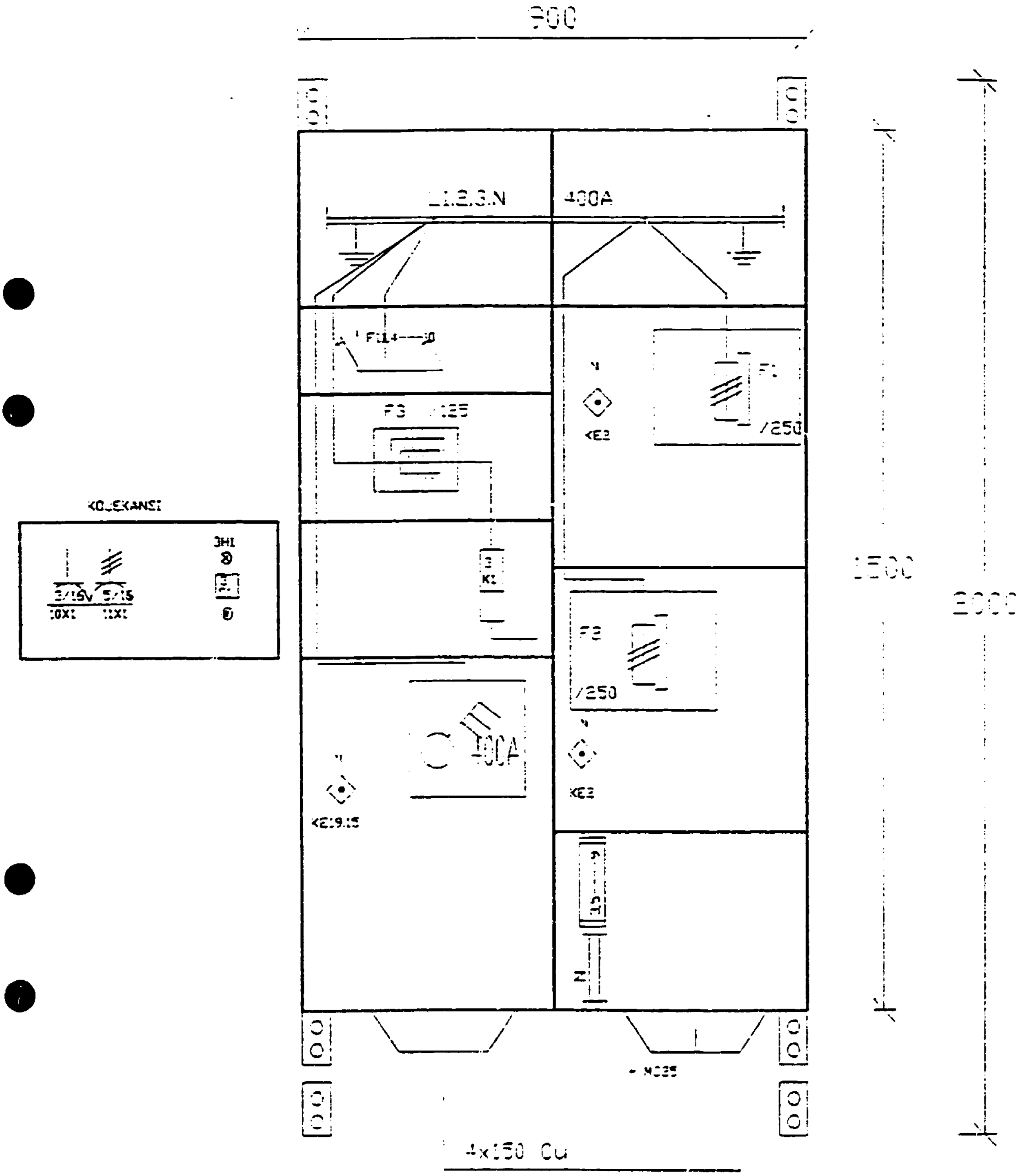
PL 662
FIN-33101 TAMPERE
FINLAND
+358 31 2416 111
+358 31 2416 411

drawn TNi
designed TNi
checked
date 18.04.94

MWANZA TANNERY
MWANZA, TANZANIA

MAIN LINE DIAGRAM

project no 17991-S-201
drawing no 13-200
sheet 1
of sheets 1



Tampereen
KESKUSTEKNIIKKA OY
Hyllilänkatu 15
33730 Tampere
puh. 931-641 111 Fax 931-641 122

TILAAJA [illegible]
MERKKI TANZANIA
KESKUS (PK) MAIN DISTRIBUTION BOARD
NIM JÄNNITE 400/230V
NIM VIRTA 400A
930834

A ELECTRIC DATA

BOARD

1. RATED VOLTAGE U _400_ V

2 FREQUENCY f _50_ Hz

3. RATED CURRENT I _400_ A

4. BUSBAR SYSTEM OR CONDUCTORS
- L1 ☒
- L2 ☒
- L3 ☒
- N ☐
- PE ☐
- PEN ☒

5. CONTROL VOLTAGE U _230_ V
f _50_ Hz

B CONSTRUCTION DATA

1. ENCLOSURE .... IP 34

2. MOUNTING
- SURFASE MOUNTING ☒
- FLUSH MOUNTING ☐

3. TEMPERATURE OF ENVIRONMENT
MIN ...... °C – MAX . 45 °C

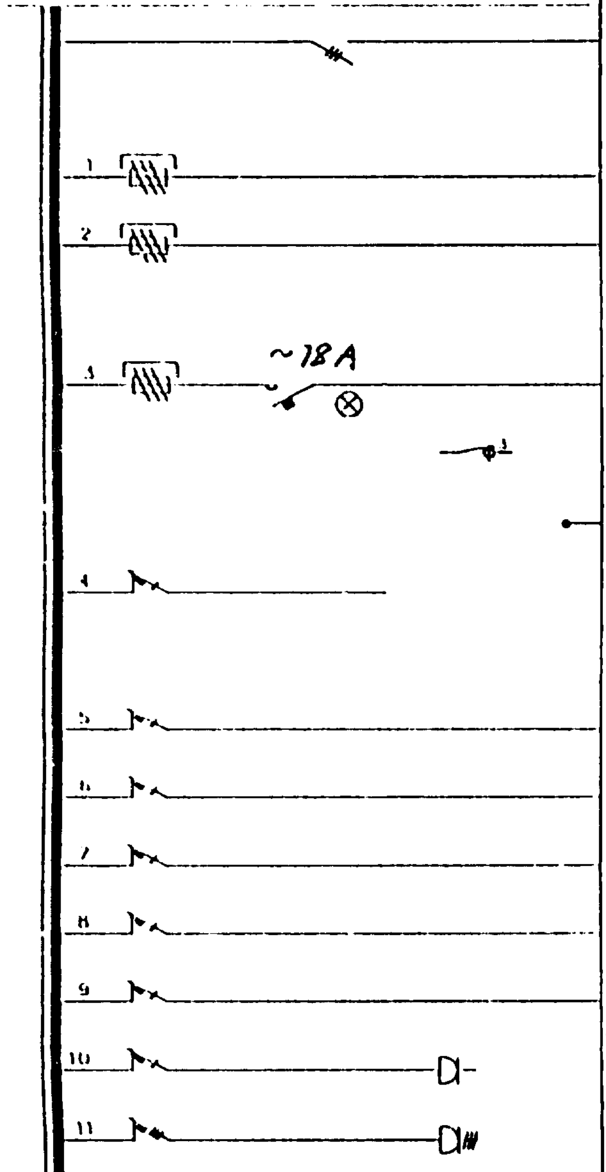
C INSTALLATION DATA

1. DIRECTION OF MAIN CABLES
- DOWN ☒
- UP ☐

2. DIRECTION OF CONTROL CABLES
- DOWN ☒
- UP ☐

3. CONNECTION OF CONTROL WIRES
- APPARATUS ☐
- TERMINAL BLOCK ☒

[illegible] PL 642, FIN 33101 TAMPERE, FINLAND puh. (931) 2416 111 fax (931) 2416 411	NAME AND ADDRESS MWANZA TANNERY MWANZA TANZANIA	MAIN DISTRIBUTION BOARD BLOCK DIAGRAM	DESIGNED JNI DRAWN JNI CHECKED	DATE DATE 11.10.91 DATE	ELECTRIC PROJECT NO. 17991S201	BOARD DRAWING NO. 13-201	SHEET 1/2 REVISION



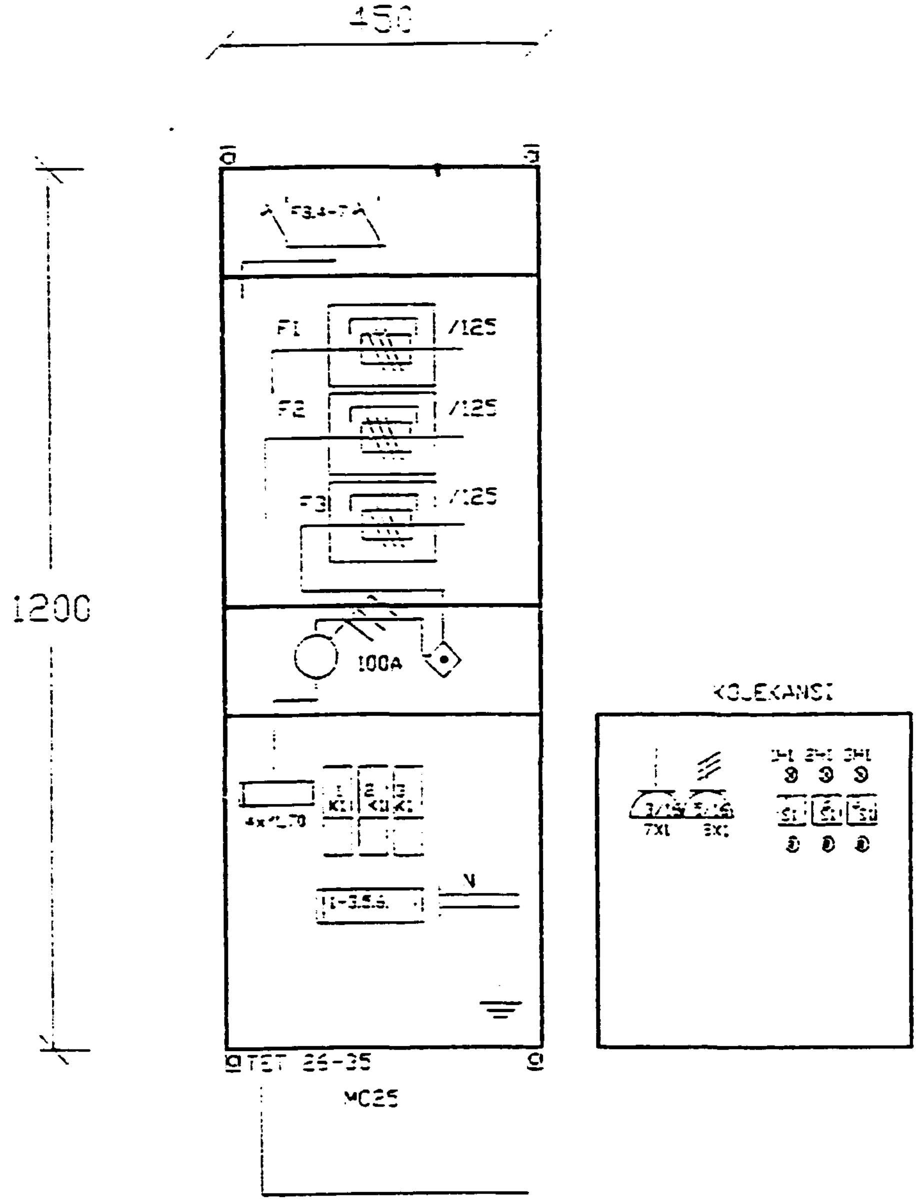
OUTPUT	DIA[illegible]M NU[illegible]R	OBJECT	[illegible]TOR-ÆR P kW	APPARENT POWER [illegible]	CURRENT I A	FUSE-LINK / FUSE A/A	CABLETYPE AND CROSS-SECTION mm²
		FEEDER MAIN SWITCH 400A					4x150
1		WATER PUMPS DISTRIBUTION BOARD				100/250	4x50
2		EFFLUENT PLANT DISTRIBUTION BOARD				160/250	3x70+35
3		SUBMERSIBLE PUMPS	9,4			63/125	4x16
		CONTROL SWITCH LEVEL CONTROL - OFF - TEST					
		CONTROL CABLE FROM LEVEL SWITCH IN WATER TANK					3x2,5+2,5
4	14 301	VOLTAGE OF CONTROL CIRCUIT				I10	
5		RESERVE				U10	
6		RESERVE				U10	
7		RESERVE				U10	
8		RESERVE				U10	
9		RESERVE				U10	
10		SOCKET OUTLET IN THE BOARD				K16	
11		3 PHASE SOCKET OUTLET IN THE BOARD				K16	

[illegible]
PL 642, FIN-33101 TAMPERE, FINLAND
puh. (931) 2416 111 fax. (931) 2416 411

NAME AND ADDRESS
MWANZA TANNERY
MWANZA
TANZANIA

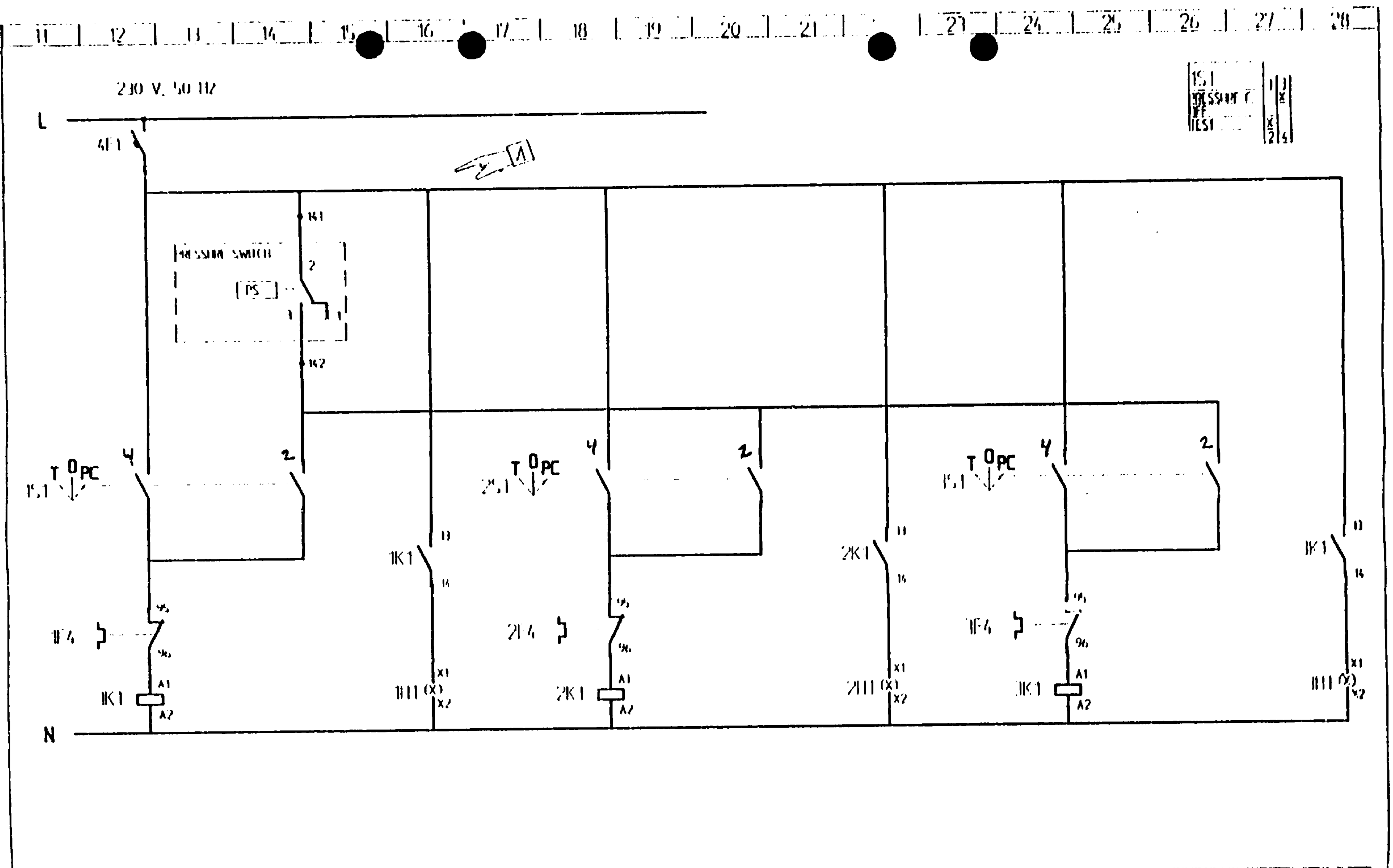
MAIN DISTRIBUTION BOARD
BLOCK DIAGRAM

DESIGNED	DATE		BOARD	SHEET
INI		ELECTRIC		2/2
DRAWN	DATE	PROJECT NO.	DRAWING NO.	REVISION
INI	11.10.93	17991S201	13-201	
CHECKED	DATE			



Tampereen KESKUSTEKNIIKKA OY
Hyllilänkatu 15
33730 Tampere
puh. 931-541 111 Fax 931-541 122

UP-YMPÄRISTÖ
TANZANIA
WATER PLANT DISTRIBUTION BOARD
400/230V
100A
30.1.94 MMJ
10.3.94 TV
43
IP44
930835



[illegible]

drawn	TNi
designed	TNi
checked	
date	111091

MWANZA TANNERY
MWANZA, TANZANIA

WATER PUMPS
CONTROL CIRCUIT DIAGRAM

17991-S-201
14-302

1
1
A

A ELECTRIC DATA

BOARD

1. RATED VOLTAGE U 400 V
2. FREQUENCY f 50 Hz
3. RATED CURRENT I 100 A
4. BUSBAR SYSTEM OR CONDUCTORS
   - L1 ☒
   - L2 ☒
   - L3 ☒
   - N ☒
   - PE ☒
   - PEN ~~☒~~
5. CONTROL VOLTAGE U 230 V
   f 50 Hz

B CONSTRUCTION DATA

1. ENCLOSURE
   IP 34
2. MOUNTING
   - SURFASE MOUNTING ☒
   - FLUSH MOUNTING ☐
3. TEMPERATURE OF ENVIRONMENT
   MIN ____ °C – MAX 45 °C

C INSTALLATION DATA

1. DIRECTION OF MAIN CABLES
   - DOWN ☒
   - UP ☐
2. DIRECTION OF CONTROL CABLES
   - DOWN ☒
   - UP ☐
3. CONNECTION OF CONTROL WIRES
   - APPARATUS ☐
   - TERMINAL BLOCK ☒

[illegible]
PL 642, FIN-33101 TAMPERE, FINLAND
puh. (931) 2416 111 fax (931) 2416 411

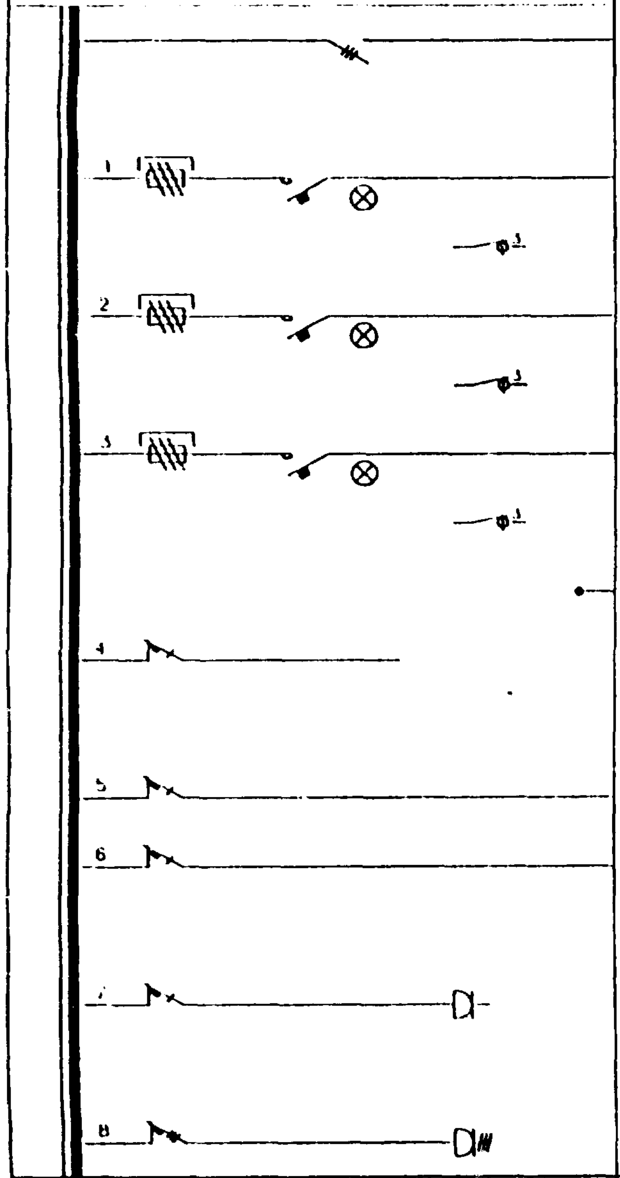
NAME AND ADDRESS
MWANZA TANNERY
MWANZA
TANZANIA

WATER PLANT DISTRIBUTION BOARD
BLOCK DIAGRAM

DESIGNED TH	DATE	ELECTRIC	BOARD
DRAWN TH	DATE 11.10.93	PROJECT NO. 17991S201	DRAWING NO. 13-202
CHECKED	DATE		

SHEET 1/2
REVISION

OUTPUT



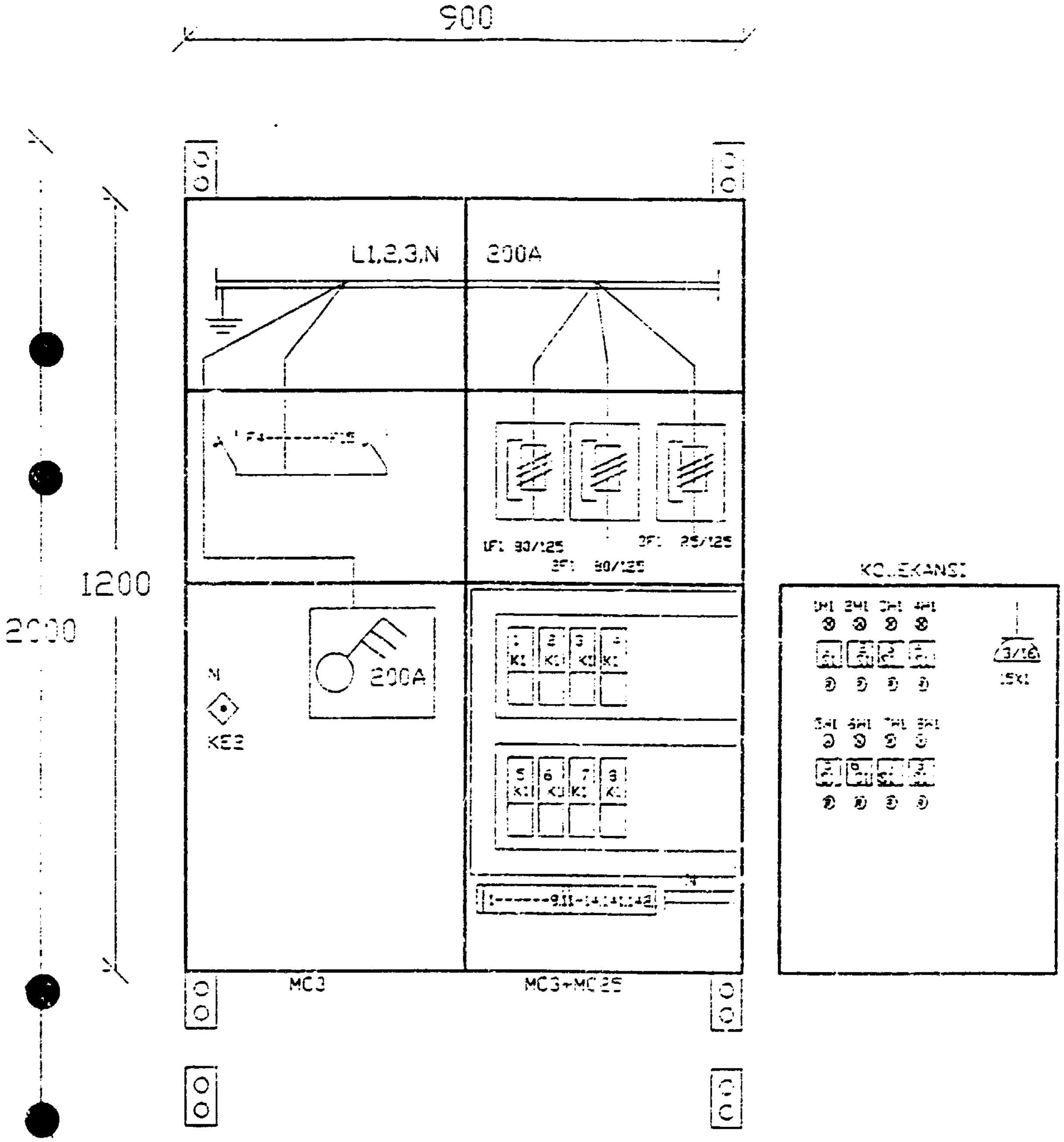
D[illegible]AM N[illegible]BER	OBJECT	[illegible]OTOR- [illegible]OWER P kW	APPARENT [illegible]WER S kVA	CURRENT I A	FUSE-LINK / FUSE A/A	CABLETYPE AND CROSS-SECTION mm²
	FEEDER MAIN SWITCH 100A					4x50
	WATER PUMPS	7,5		15,5	50/125	3x6+6
	CONTROL SWITCH PRESSURE CONTROL OFF - TEST					
	WATER PUMPS	7,5		15,5	50/125	3x6+6
	CONTROL SWITCH PRESSURE CONTROL - OFF - TEST					
	WATER PUMPS	7,5		15,5	50/125	3x6+6
	CONTROL SWITCH PRESSURE CONTROL OFF - TEST					
	CONTROL CABLE FROM PRESSURE SWITCH IN WATER TANK					3x2,5+2,5
14 302	VOLTAGE OF CONTROL CIRCUIT				I10	
	RESERVE				U10	
	RESERVE				U10	
	SOCKET OUTLET IN THE BOARD				K16	
	3 PHASE SOCKET OUTLET IN THE BOARD				K16	

PL 642, FIN-33101 TAMPERE, FINLAND
puh. (931) 2416 111 fax (931) 2416 411

NAME AND ADDRESS
MWANZA TANNERY
MWANZA
TANZANIA

WATER PLANT DISTRIBUTION BOARD
BLOCK DIAGRAM

DESIGNED INI	DATE	ELECTRIC	BOARD	SHEET 2/2
DRAWN INI	DATE 11.10.93	PROJECT NO. 17991S201	DRAWING NO. 13-202	REVISION
CHECKED	DATE			



Tampereen
KESKUSTEKNIIKKA OY
Myllärinkatu 15
33730 Tampere
Puh. 931-641 111 Fax 931-641 122

TILAAJA JP-YMPÄRISTÖ
MERKKI TANSANIA
KESKUS WASTEWATER TREAMENT PLANT, DISTRIBUTION BOARD
NIM. JÄNNITE 400/230V
NIM. VIRTA 200A
SUHDE 1:10
TIS KA
KOTELOINTI IP44
25.1.94MMJ
MUUT.
LEHTI NO 43
TYÖ NO 930636

A ELECTRIC DATA

BOARD

1. RATED VOLTAGE U _400_ V
2. FREQUENCY f _50_ Hz
3. RATED CURRENT I _200_ A
4. BUSBAR SYSTEM OR CONDUCTORS
   - L1 ☒
   - L2 ☒
   - L3 ☒
   - N ☐
   - PE ☐
   - PEN ☒
5. CONTROL VOLTAGE U _230_ V
   f _50_ Hz

B CONSTR[illegible]ON DATA

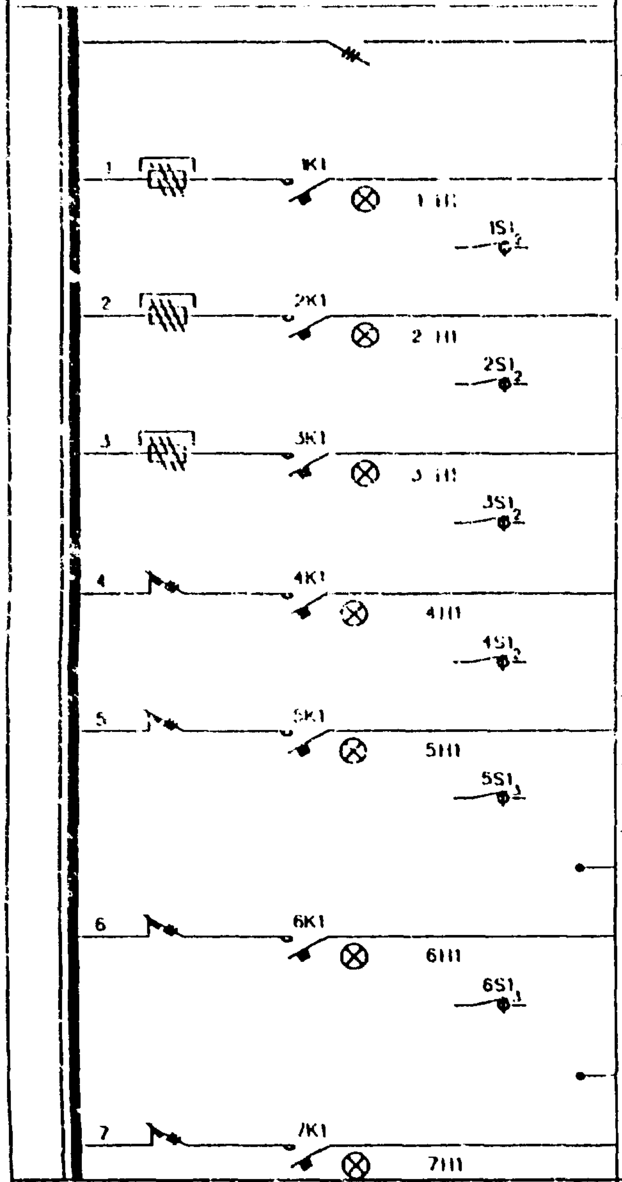
1. ENCLOSURE
   ______IP 34
2. MOUNTING
   - SURFASE MOUNTING ☒
   - FLUSH MOUNTING ☐
3. TEMPERATURE OF ENVIRONMENT
   MIN ____ °C – MAX _45_ °C

C INSTALLATION DA[illegible]

1. DIRECTION OF MAIN CABLES
   - DOWN ☒
   - UP ☐
2. DIRECTION OF CONTROL CABLES
   - DOWN ☒
   - UP ☐
3. CONNECTION OF CONTROL WIRES
   - APPARATUS ☐
   - TERMINAL BLOCK ☒

AAR [illegible] [illegible] 642, FIN-33101 TAMPERE, FINLAND phone (931) 2416 111 fax (931) 2416 411	NAME AND ADDRESS MWANZA TANNERY MWANZA TANZANIA	WASTEWATER TREATMENT PLANT, DISTRIBUTION BOARD BLOCK DIAGRAM	DESIGNED TM DRAWN TM CHECKED	DATE DATE 24.01.94 DATE	ELECTRIC PROJECT NO. 17991S201	BOARD DRAWING NO. 13-203	SHEET 1/3 REVISION

OUTPUT



DIAG[illegible] NU[illegible]ER	OBJECT	[illegible]OR-[illegible]ER P kW	APPARENT [illegible]ER kVA	CURRENT I A	FUSE-LINK / FUSE A/A	CABLETYPE AND CROSS-SECTION mm²
	FEEDER MAIN SWITCH 200A					4x70
14-303	COMPRESSOR	15		30	80/125	3x10+10
14-303	CONTROL SWITCH 0-1					
14-303	AERATOR	15		30	80/125	3x10+10
14-303	CONTROL SWITCH 0-1					
14-303	AERATOR	5,5		11,5	25/125	3x6+6
14-303	CONTROL SWITCH 0-1					
14-303	SLUDGE PUMP SP1		2,0	~4A	1 16	3x2.5+2,5
14-303	CONTROL SWITCH 0-1					
14-303	SLUDGE PUMP SP2		2,0	~4A	1 16	3x2.5+2,5
14-303	CONTROL SWITCH LEVEL CONTROL - OFF - TEST					
14-303	CONTROL CABLE FROM LEVEL SWITCH BOARD					3x2,5+2,5
14-303	SLUDGE PUMP SP3		2,0	~4A	1 16	3x2.5+2,5
14-303	CONTROL SWITCH LEVEL CONTROL - OFF - TEST					
14-303	CONTROL CABLE FROM LEVEL SWITCH BOARD					3x2,5+2,5
14-303	SLUDGE PUMP SP4		2,0	~4A	1 16	3x2.5+2,5

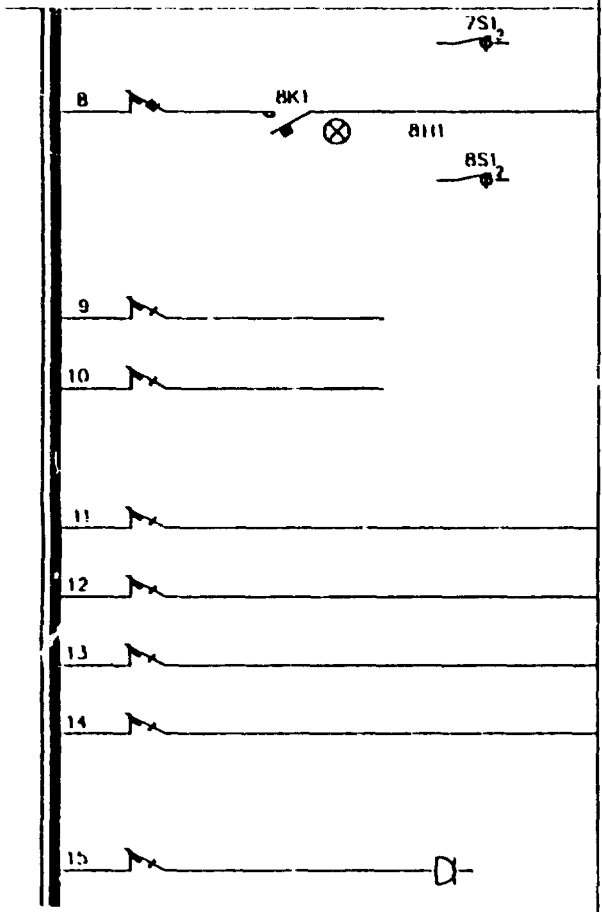
PL 642, FIN-33101 TAMPERE, FINLAND
puh. (931) 2418 111 fax. (931) 2418 411

NAME AND ADDRESS
MWANZA TANNERY
MWANZA
TANZANIA

WASTEWATER TREATMENT PLANT,
DISTRIBUTION BOARD
BLOCK DIAGRAM

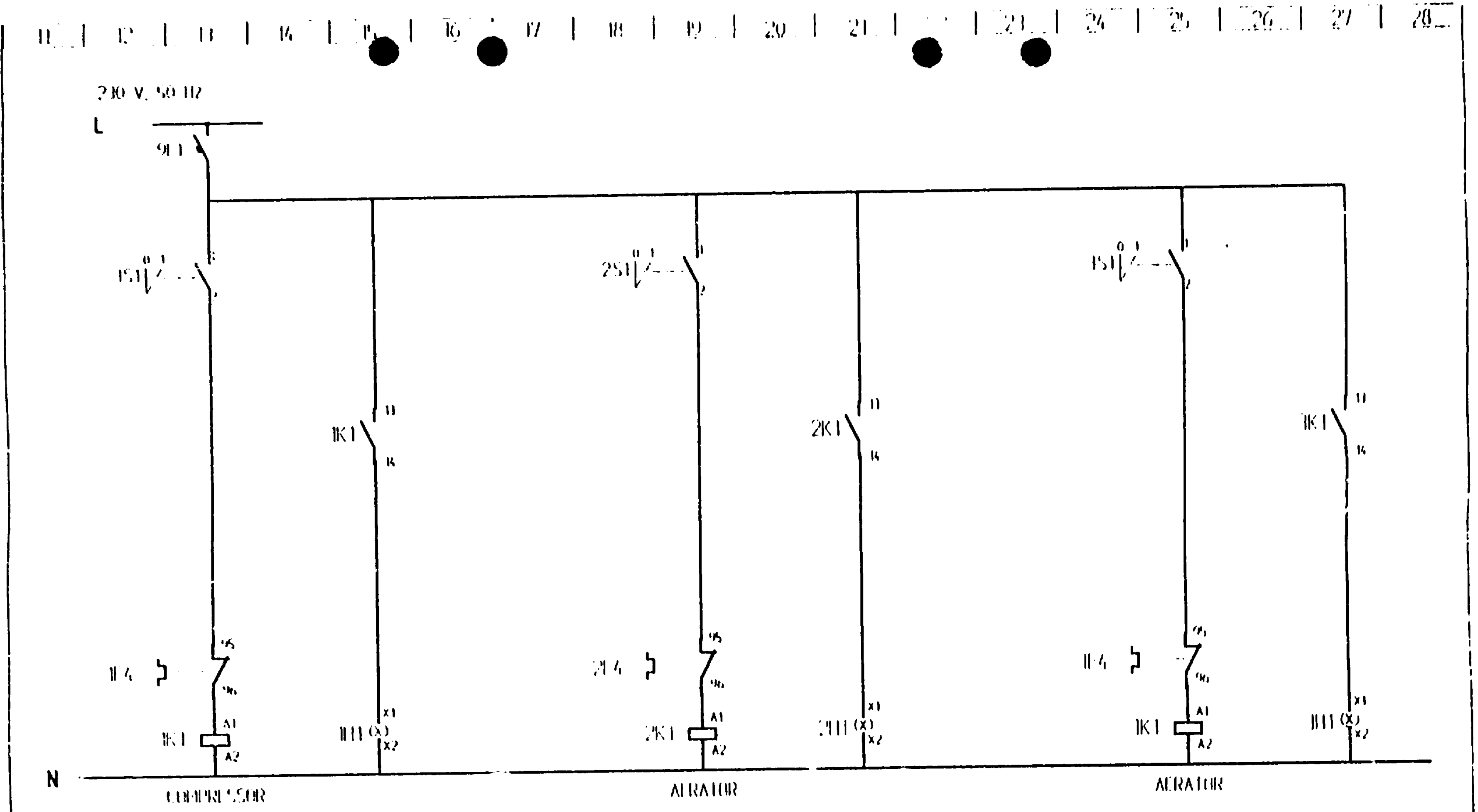
DESIGNED INI	DATE	ELECTRIC	BOARD		SHEET 2/3
DRAWN INI	DATE 21.01.94	PROJECT NO. 17991S201	DRAWING NO. 13-203		REVISION
CHECKED	DATE				

OUTPUT



DIA[illegible] N[illegible]ER	OBJECT	[illegible]OR- [illegible]ER P kW	APPARENT [illegible]ER kVA	CURRENT I A	FUSE-LINK / FUSE A/A	CABLETYPE AND CROSS-SECTION mm²
14-303	CONTROL SWITCH 0-1					
14-303	SLUDGE PUMP SP5		2,0	~4A	U16	3x2,5+2,5
14-303	CONTROL SWITCH 0-1					
14-303	VOLTAGE OF CONTROL CIRCUIT				U10	
14-303	VOLTAGE OF CONTROL CIRCUIT				U10	
	RESERVE				U10	
	RESERVE				U10	
	RESERVE				U10	
	RESERVE				U10	
	SOCKET-OUTLET IN THE BOARD				K16	

MAUNTEKNIIKKA-TECHNIKO PL 642, FIN-33101 TAMPERE, FINLAND puh. (931) 2416 111 fax. (931) 2416 411	NAME AND ADDRESS MWANZA TANNERY MWANZA TANZANIA	WASTEWATER TREATMENT PLANT, DISTRIBUTION BOARD BLOCK DIAGRAM	DESIGNED IHI DATE DRAWN IHI DATE 24.01.94 CHECKED DATE	ELECTRIC PROJECT NO. 17991S201	BOARD DRAWING NO. 13-203	SHEET 3/3 REVISION



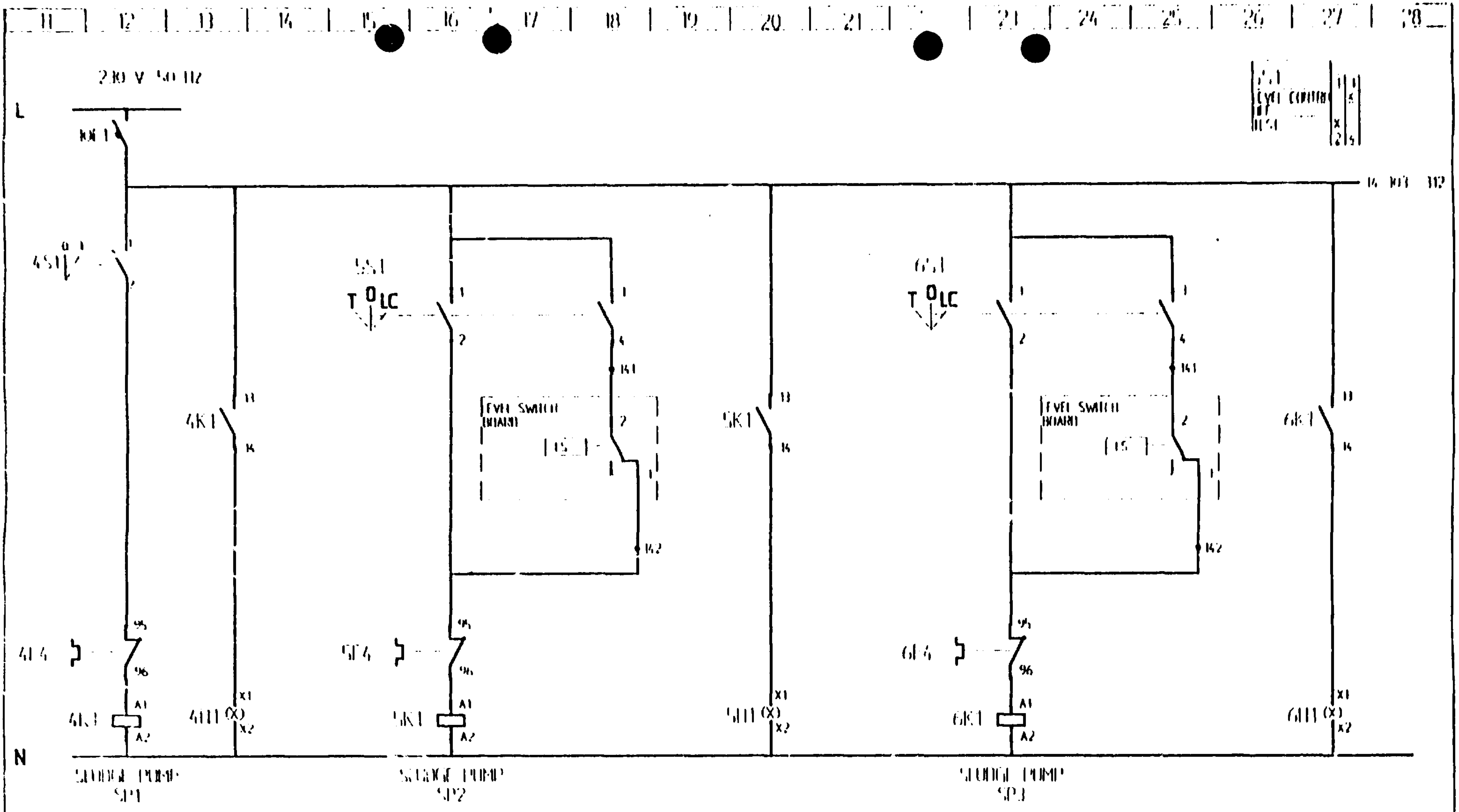
[illegible]	drawn TN	date 24.01.94	
	designed TH		
	checked		

MWANZA TANNERY
MWANZA, TANZANIA

WASTEWATER TREATMENT PLANT,
DISTRIBUTION BOARD
CONTROL CIRCUIT DIAGRAM

17991-S-201
14-303

1
3



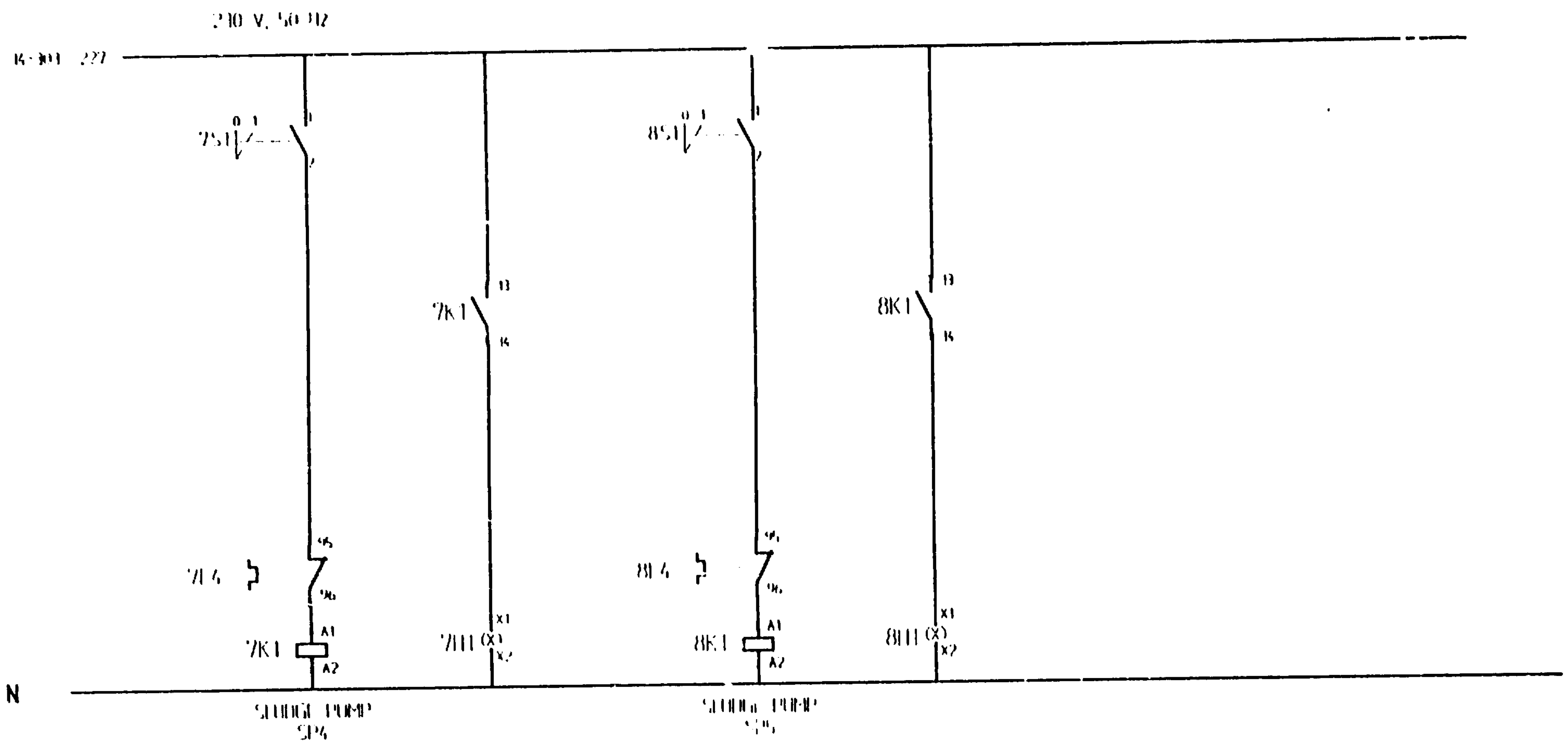
drawn TNi	date 24.01.94	MWANZA TANNERY MWANZA, TANZANIA	WASTEWATER TREATMENT PLANT, DISTRIBUTION BOARD CONTROL CIRCUIT DIAGRAM
designed TNi			
checked			

17991-S 201

14-101

sheet 2

total 3



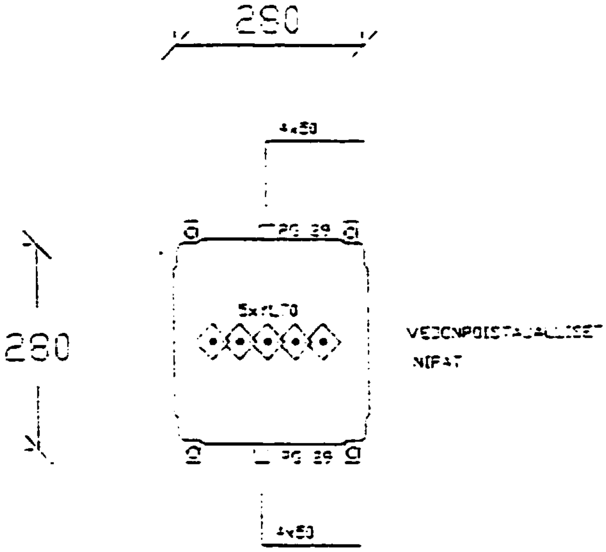
24.01.96

MWANZA TANNERY
MWANZA, TANZANIA

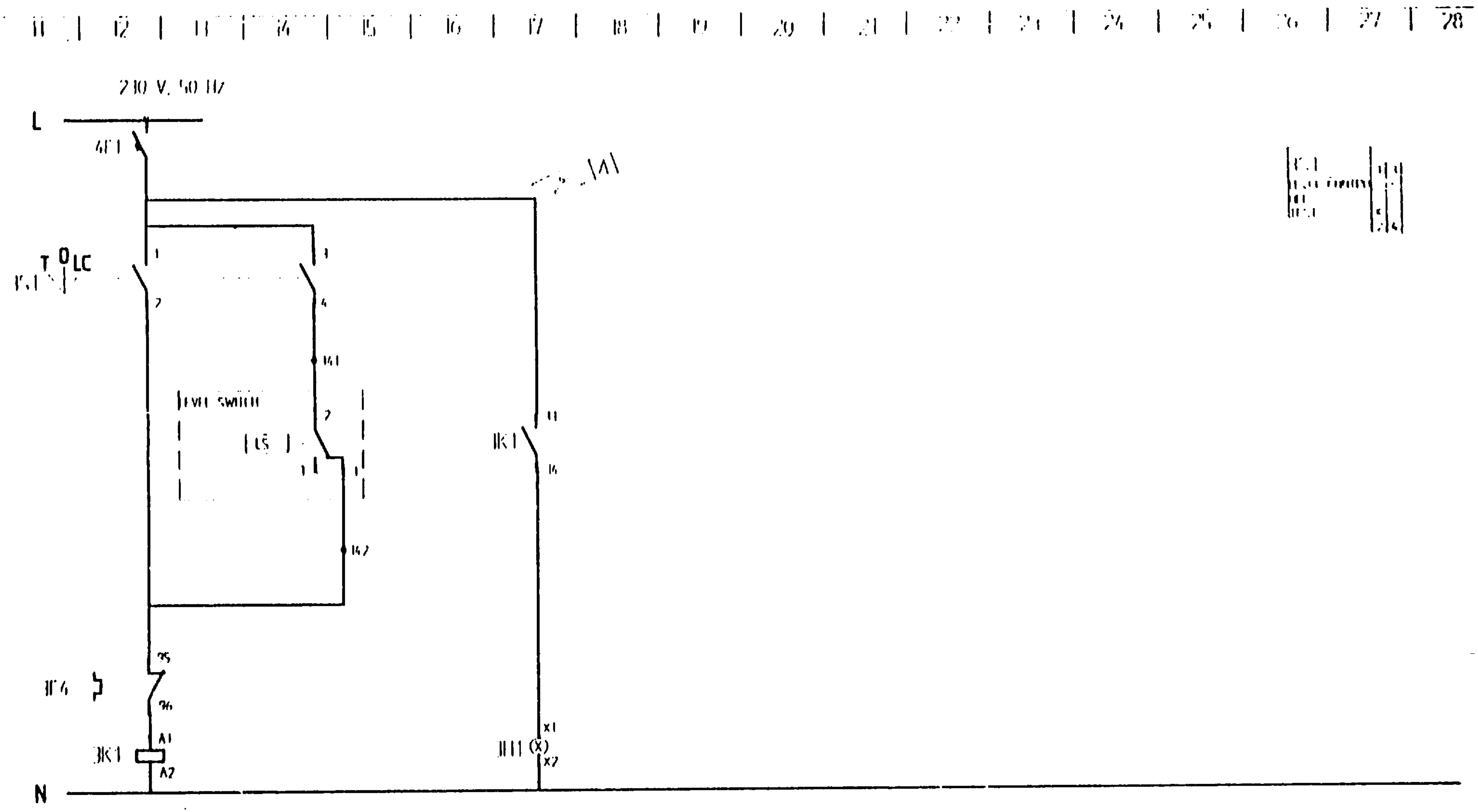
WASTEWATER TREATMENT PLANT,
DISTRIBUTION BOARD
CONTROL CIRCUIT DIAGRAM

1799-5. 201
14 103

1
1



Tampereen KESKUSTEKNIIKKA OY	UP-YMPÄRISTÖ	400/230V	24.1.94MMJ
33720 Tampere	TANSANIA		11.2.94 TV
		1:5	43
	CONNECTION BOX (SUBMERS. PUMP)	1:10	930838



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MWANZA TANNERY
MWANZA, TANZANIA

SUBMERSIBLE PUMP
CONTROL CIRCUIT DIAGRAM

14 301

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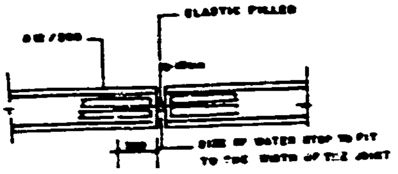
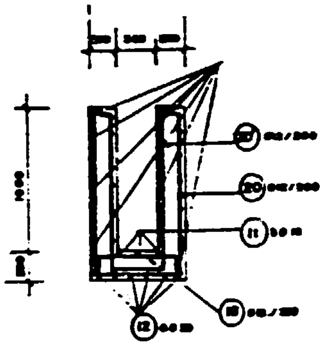
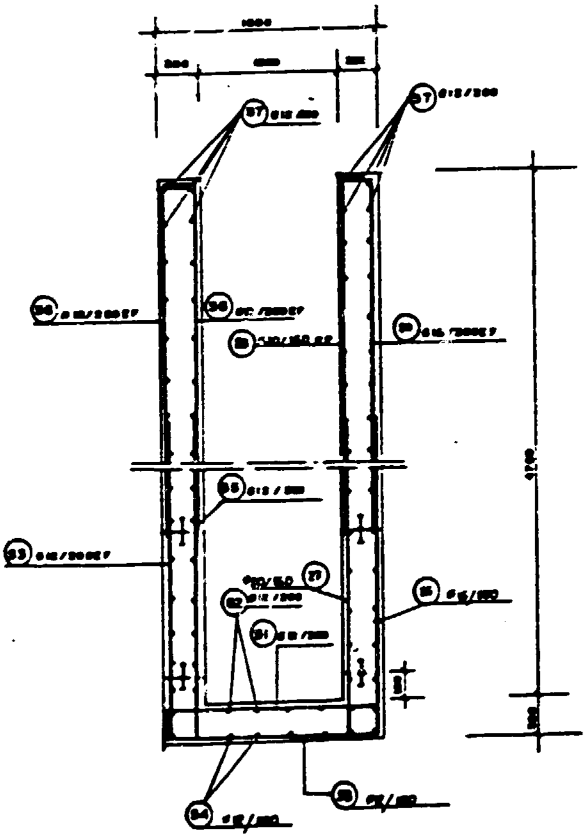
ANNEX 9.

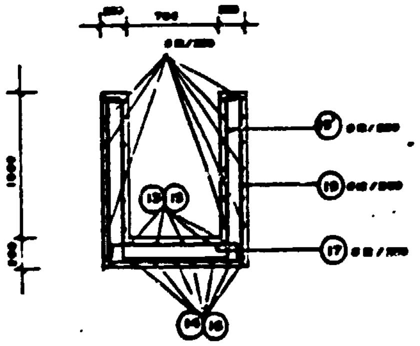


EXPANSION JOINT

NOT TO SCALE







Examples of channel structure. Final design to be based on site survey.

ANNEX 10.

KENYA INDUSTRIAL RESEARCH & DEVELOPMENT INSTITUTE

P.O. Box 30650 NAIROBI

LABORATORY REPORT

Material Chrome Liquors & Wet blue leathers

Laboratory No 61/94 - 66/94 **Sender's No** as shown below

Date received 28/6/94 **Sampled by** Sender

Received from African Tanneries, Box 2200, Mwanza, Tanzania, C/o UNIDO Regional Office, NAIROBI

Invoice No [illegible]

To pay KShs.2,340/-

Results of analysis

Lab. No.	Sender's Ref.	pH	Cr_2O_3
61/94	After 30 min	3.37	17.71 mg/L
62/94	Final	3.71	7.96 mg/L
63/94	S_4 (supernatant)	7.43	2.78 mg/L
64/94	II (supernatant)	7.40	3.80 mg/L
65/94	Calf	3.45	4.82%
66/94	Hide	3.64	5.19%

M C Z MOTURI
for: DIRECTOR

12th July, 1994

African Tanneries
P O Box 2200
MWanza, Tanzania

c/o UNIDO REGIONAL LEATHER OFFICE
P O BOX 30128
NAIROBI

RES/L.8/Vol.3/168

/jo

ANNEX 10.
2(3)

File
water treatment

Note

Nairobi, 15/07/94

To: Mr J. P. Vogtlander, General Manager
Mwanza Tannery, URT

C/o: Messrs. S. Massay and E. Muyinga

From: Nghia Quang Le, Associate Expert
US/RAF/92/200 Regional Leather Project

Subject: Follow-up of recent mission to Mwanza Tannery

1/ First of all, I would like to very much thank you all for your kind assistance and cooperation given to us during our mission 18 -24 June 1994 in Mwanza.

2/ On the basis of the draft Mission Report which was discussed with you before our departure from Mwanza, I have submitted our formal Report to UNIDO Hqs. for further processing.

3/ After my constant follow-up, the complete results of the various samples have just been available today. Please find attached copies of the analysis report as well as invoice for the work done received from the Leather Development Centre.

a/ As regards the cost, Mr B. Chaaker during his recent visit to our office in Nairobi gave Mr J. Muriuki US$ 30 (equivalent Ksh. 1,680, at the UN rate of 1US$ = 56 Ksh) for settlement of these accounts. I will pay the received amount to LDC in my forthcoming visit to LDC. The balance of Ksh.660 may please be taken care of by your Tannery as soon as possible.

b/ Recap of and some comments on the results:

Calf wet blue:	Cr2O3:	4.82 %
Hide wet blue:	Cr2O3:	5.19 %
Original liquor:	Cr2O3:	17.71 g/l
	pH :	3.37
Spent liquor:	Cr2O3:	7.96 g/l
	pH :	3.71
Lab supernatant: (10g lime/litre)	Cr2O3:	2.78 mg/l
	pH :	7.43
Treatment super.:	Cr2O3:	3.80 mg/l
	pH :	7.40

ANNEX 10.

As discussed, until you have a proper required lab facilities and chemicals, these kinds of analysis need to be carried out from time to time with reputable laboratories. The above-mentioned first and initial results should be considered indicative.

On the basis of the above figures, the present chrome exhaustion rate is computed to be 55%. This also means that 45 % of chrome salt used or an amount of 81 kg of chrome salt equivalent to US$ 162 wasted (US$ 2/kg approx.) in very lot of 3,000 kg of pelt weight using 6% of chrome salt as presently the case. This wasteful level is higher considering associated costs for its treatment.

On the other hand, the chrome penetration is achieved is quite high, which is obviously thanks to your tanning techniques including no-float methods and good control of pH levels. According to my limited understanding, the chrome oxide contents should be from 2.5 to 5% as per customers' requirements and the higher levels can cause the leather fibres inflexible and tending to be resistant to finishing chemicals. You may wish to have further analysis done to confirm the figures and or to reduce the chrome oxide contents in the wet blues.

There is room for possible improvements using less percentage of chrome salts to achieve the same or less chrome levels in the wet blues, meaning higher chrome exhaustion and less chrome wasted. I would very much recommend that some experiments in this direction be carried out by your tannery through modifications of different methods of basifying, running time, final temperature etc. considering resultant economic and environmental benefits. I will be glad to follow up with analysis of samples in Nairobi, if so required by you.

As regards the chrome treatment, the results of the supernatant indicate that the dosing of 10 g of lime (solution 10%) per one litre of chrome liquor is better than the present dosing. The chrome contents of 2.78 mg/l will be further diluted and precipitated in the main ETP. If you wish to achieve further purification at chrome treatment process, the dosing of 10g/l can be increased to 12 mg/l or so. As we discussed, the actual operations will always decide.

I look forward to hearing from you soon In the meantime, all the best and regards to you all.

cc. Mr G. Felsner and Ms Aurelia Calabro, BSO, UNIDO, Vienna

5

UNIDO Contract No. 93/242
Project No. US/URT/91/110
Activity Code: J13104

Annex D

12.06.1995

TECHNICAL INFORMATION OF RECOMMENDATIONS AND COST ESTIMATES

TECHNICAL INFORMATION OF RECOMMENDATIONS AND COST ESTIMATES

1

MECHANICAL FINE SCREEN

(see annex 1)

Mechanical fine screen is essential part of the purification system.

Mechanical fine screen should be installed into the general effluent channel just before the effluent treatment plant. It is recommended to construct a shelter over the screen to protect it against the rains.

The type of screen recommended is Step Screen which is self-cleaning and easy to install.

Step Screen will remove approximately 40–50 % of total suspended solids from the raw waste stream. Also some 20–30 % of the organic loading can be removed in the fine screening.

As an example the following fine screen can be recommended to Mwanza.

-	Model Step Screen SSM2200 x 400 x 3 Master	
-	Screen width	400 mm
-	Slot width	3 mm
-	Appr. capacity	10...20 l/s
-	Material	SS2333
-	Power	0,75 kW, 380 V
-	Control and electric panel	

Specification is shown in annex 1.

Cost estimate :

The price, free in Finland, without any handling, packaging and freight costs is approximately 30.000 USD.

Installation is very easy and can be done locally.

2

INCREASING THE PRESETTLING CAPACITY
(see annex 2)

The efficiency of the treatment plant can be improved by balancing the peak flows and equalizing the effluent streams prior to the presettling.

A new recycling pipe with gate valve to adjust the flow between equalization and presettling tanks should be installed. It is important to adjust the flow as stable as possible.

If the influent into the presettling tank in the maximum flow situation (200 m3/d) is stable (continuously around 10 m3/h) the surface load is only 0,5 m/h and the presettling will perform efficiently.

It is also recommended to construct the walls of the presettling tank 1,5 m higher. A new water distribution cylinder and new overflow weirs for effluent should be installed inside the tank as well.

After reconstruction the total volume of the presettling tank is about 80 m3 and the retention time some 8 h giving more hydraulic capacity for presettling.

Sketches are shown in annex 2.

Cost estimate :

All the construction works can be done locally. The investment should be in the order of 1000 USD.

3

INCREASING THE OXIDATION CAPACITY
(see annex 3)

The oxidation capacity should be increased in Mwanza.

Many tanneries have used surface aerators with inputs around 10...20 W/m3. Retention time should be some 5 to 10 days and then some BOD reduction can be acheived as well.

- volume of oxidation tanks : 902 m3

- retention time : 2...4 d

- aeration capacity needed for full oxidation of sulphides in Mwanza :	15...20 kW
- oxidation capacity now	
-- new blower	2...3 kW
-- old surface aerator	2...3 kW

Recommendation :

New aeration capacity of 20 kW for complete oxidation of sulphides to be installed. Installation can be done with two new surface aerators one 5 kW for first oxidation tank and another 10 kW for second oxidation tank. Type and model of the recommendated aerators are Fuchs Spiral Aerators WBL-XV and WBL-V with the following technical data.

- special spiral propeller
- conical coupling
- hollow shaft
- retaining flange
- protective housing
- floating device with
    - -- steel frame
    - -- floats filled with polyuretane
    - -- fixing bar
- motor 5 and 15 kW, 380 V, 1460 rpm
- material :
    - -- wetted parts and frame AISI 316
    - -- floats and protective housing fiber glasss reinforced plastics

Manufacturers typical installation drawings are shown in annex 3.

Cost estimate :

The prices, free in Finland, without any handling, packaging and freight costs are together around 47.000 USD. Additionally some cables and other accessories required for aerators make some 2.000 USD.

Installation is very easy and can be done locally.

STE

Th

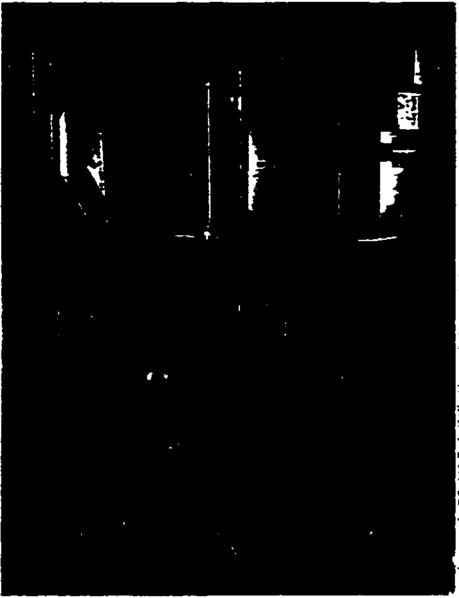
EN MASTER

tion of finescreens

PRESS

When Step Screen was introduced in 1985 it was in several respects a new concept within the processing of screenings. Step Screen proved to fulfil a great demand and soon became a success. As is often the case with successful products it has recently been followed by several copies. We created the original, and therefore it is only natural that it is also we who lead the development in this field and can now present the new generation of Step Screens.

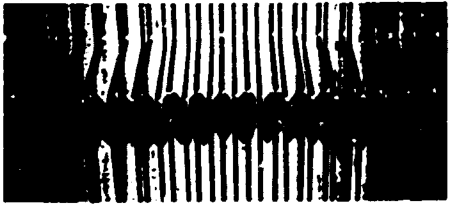
We created the original
We have now made it even better!

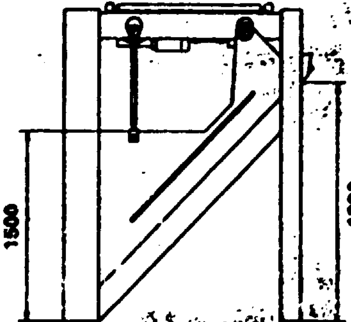


Step Screen Master is a patented design and a further development of the successful basic concept. It has been equipped with a variety of technical and practical features which all together give more effective separation, increased operating reliability, and the improvement of the working environment. We have of course retained all the positive characteristics of the original Step Screen design.

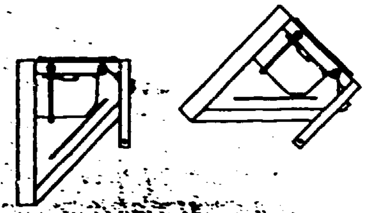
This implies practical innovations for you

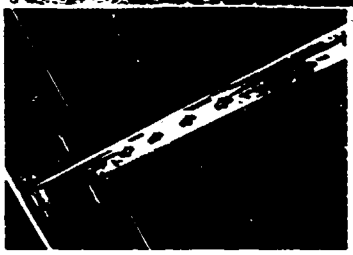
❶ More effective separation thanks to constant slot width over the entire screen area. The completely new bottom step with considerably improved guiding of the laminates has enabled this. In addition, the flow capacity has been much improved by increasing the through flow area.



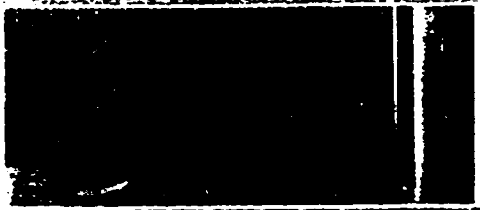


❷ Costs for civil work have been reduced in view of the very small modifications to the channel for the replacement of installations. Step Screen Master provides a discharge height of 1920 mm and a water level of 1500 mm, thus accommodating the conveyor press under the screen. If you require a Step Screen which reaches deeper than the standard dimensions we have alternative solutions.

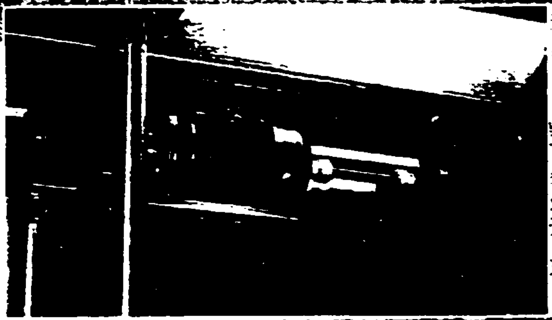




❸ **Superior serviceability,** since Step Screen Master can be tipped up and the step laminate[illegible]ily replaced thanks to their bayonet mounting.



❹ **Reduced sensivity** to sand and gravel as a result of the re-designed bottom step, and the use of low friction material on exposed parts.



❺ **Almost maintenance** free transmission and smoother operation by the use of worm gears with direct drive on each shaft. The entire drive package is placed at a safe distance above the maximum water level.

❻ **Better protection from overload by virtue of electronic sensors with greatly improved sensitivity as standard features.**

❼ **An attractive product** to work with. Even if the technical characteristics are of prime importance, we have taken the trouble to create an attractive and trim exterior. The machine is available with a hood in stainless sheet steel, with easily opened hatches around.

❽ **The result of the optimized design** facilitates more efficient production and therefore lower investment costs for our customers.

We are very proud of our new product, Step Screen Master. But of more importance is the fact that as a customer you will appreciate the improvements we have made. We make every effort to continually develop our concept for the effective handling of screenings, and you can be assured that we will do everything possible to lead the technical developments in this field. Step Screen Master is the proof of this. The new generation of Step Screens with all the built-in experience of previous years.

Worth knowing about Step Screen Master

❶ Step Screen Master is manufactured in several standard sizes.

❷ The slot width can be selected as 1,3 or 6 mm depending on customer requirements.

❸ The screen is self-cleaning via the circular motion of the laminates.

❹ The parts which are in contact with the liquid are manufactured in stainless steel or acid-resistant steel.

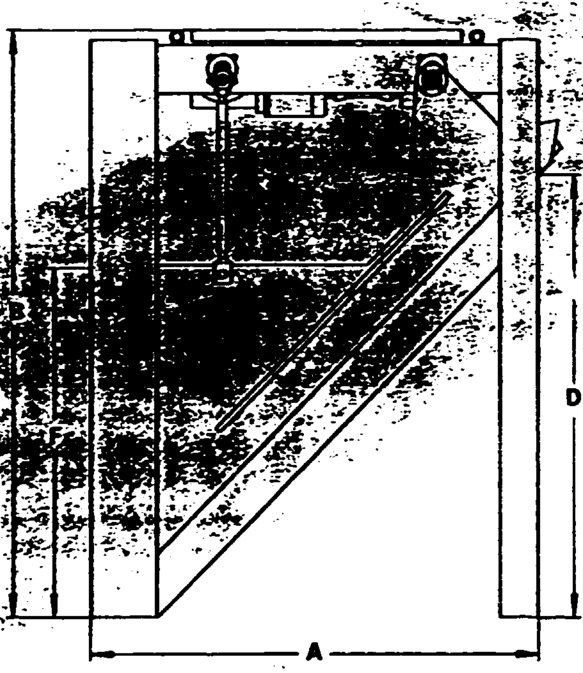
❺ Automatic control equipment is available.

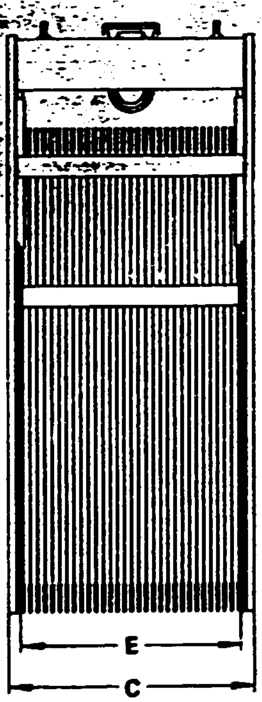
❻ In addition to removing solids from sewage, Step Screen Master can also be used to separate screenings from sludge and industrial process water.

❼ The through flow area is increased upto 25 % depending on slot width.

Technical data

(measurements in mm unless otherwise stated)

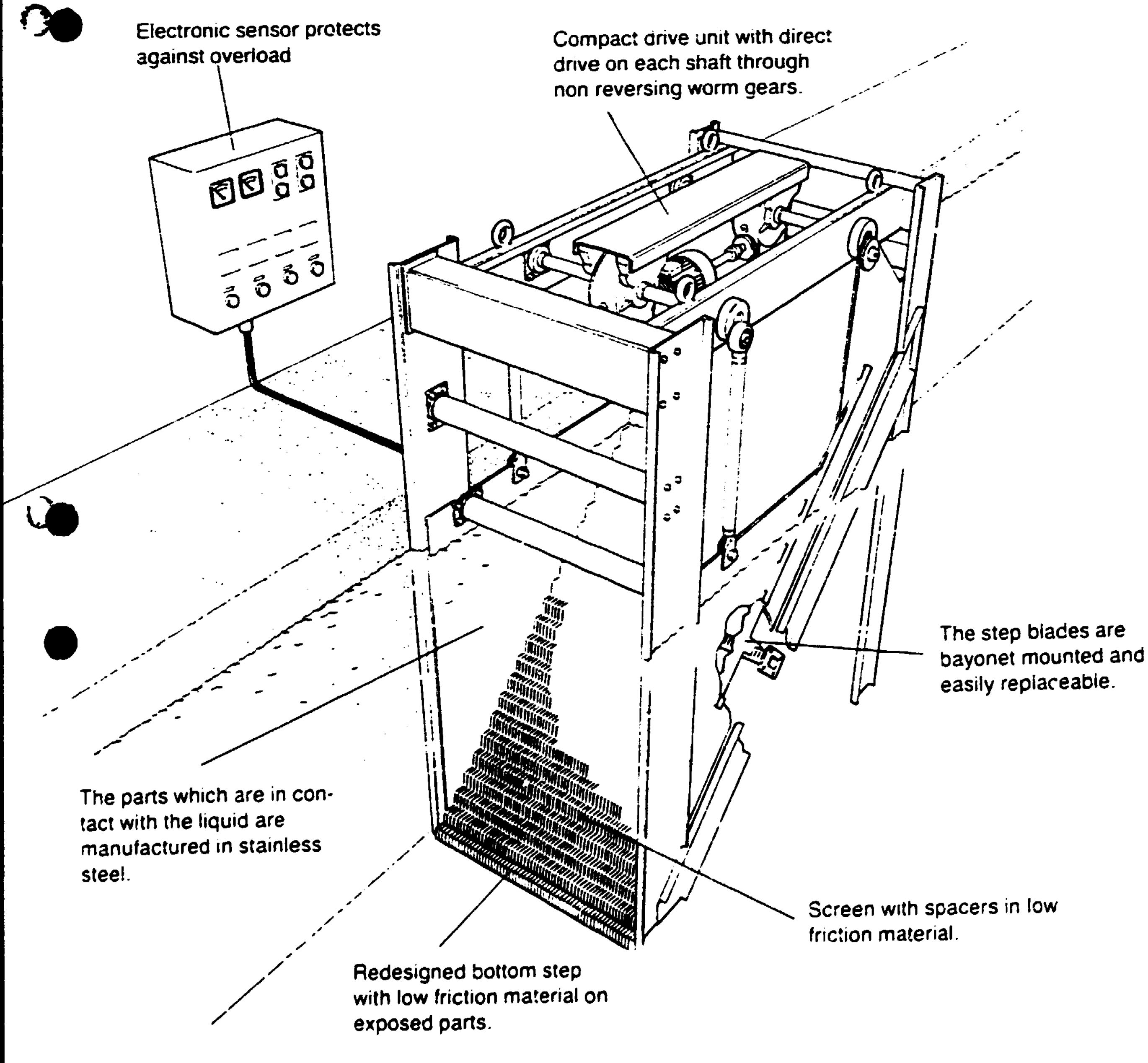


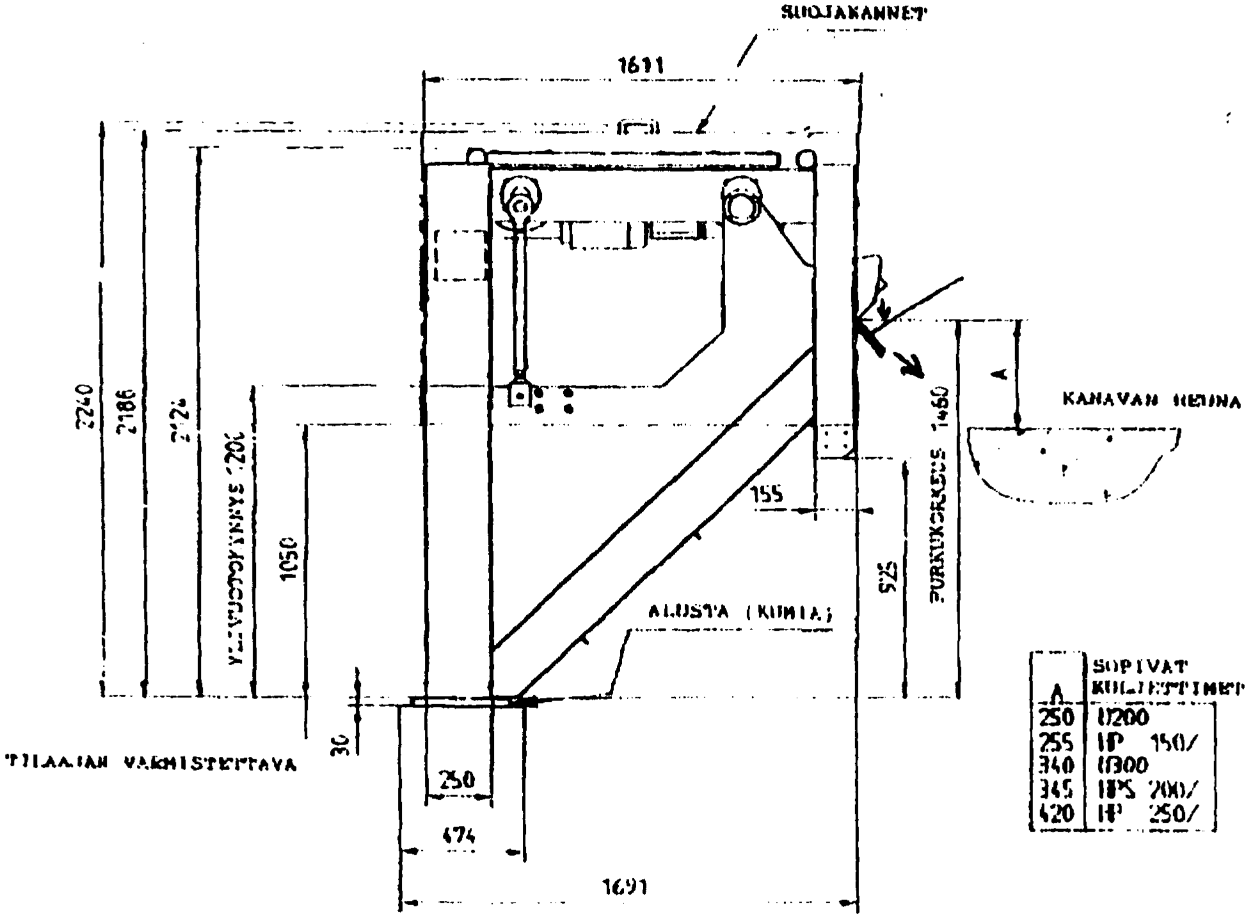


Model	SSM 3000	SSM 2200	SSM 1800	SSM 1200	SSM 900
A) Length	2000	1590	1350	1010	685
B) Height	2560	2125	1810	1535	1200
C) Width	500–1600	500–1600	400–1600	400–1100	390–490
Slot width	1, 3, 6	1, 3, 6	1, 3, 6	1, 3, 6	1, 3, 6
Flow (l/s) max H_1 (clean water) at ΔH=200 mm and 3 mm sloth width	2205	1755	1455	770	225
D) Discharge height	1920	1460	1220	860	565
E) Effective screen width	400–1500	400–1500	300–1500	300–1000	300–400
F) Max water level before the screen (H_1)	1500	1200	1015	860	570

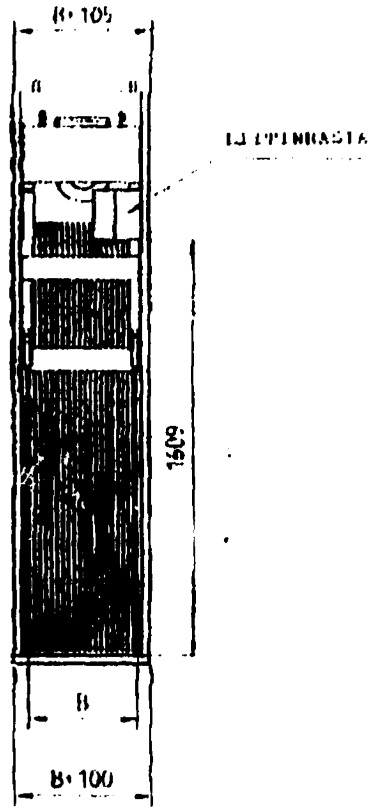
This is how it functions

The unique feature of the Step Screen principle, introduced by Hydropress in 1985, is that the impurities in the liquid actually contribute towards the screening process. The step shaped laminates form a screen on which the fixed particles gather to form a mat. It is the tight mat of screenings which performs the actual screening work. This results in a degree of separation which is many times better than the actual slot width provides. Via the circular movement of the flexible step laminates the screenings are automatically lifted step by step for further transport and handling.





A	SOPIVAT KULJETTIMET
250	U200
255	HP 150/
340	U300
345	HPS 200/
420	HP 250/



B	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500

Oy SILAMEX Ab
PL 20, 00981 HELSINKI
☎ (90) 317 388, TELEFAX (90) 316 490

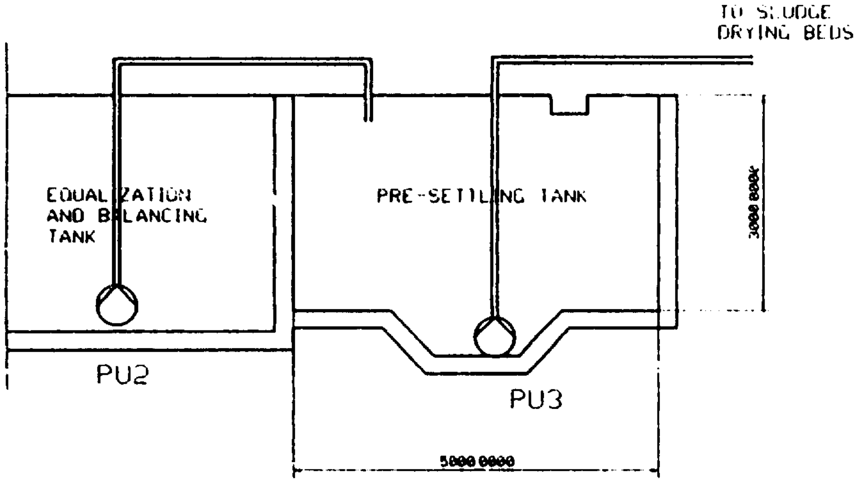
STEP SCREEN SS 2200 MASTER
MITTAPIIRUSTUS

SUHDE		
	PAIV	NIMI

PIIR No
3-427

WATER BALANCING AND PRESETTLING NOW

- NOT WATER ACTUAL BALANCING
- TOO EFFICIENCY PUMPING
- NOT OUTLET WEIRS
- NOT DISTRIBUTION SYLINDER
- RETENTION TIME 3...6 H
- VOLUME AROUND 60 m3
- DIMENSIONS 5 x 4 x 3
- SURFACE LOADING 3...4 m/h



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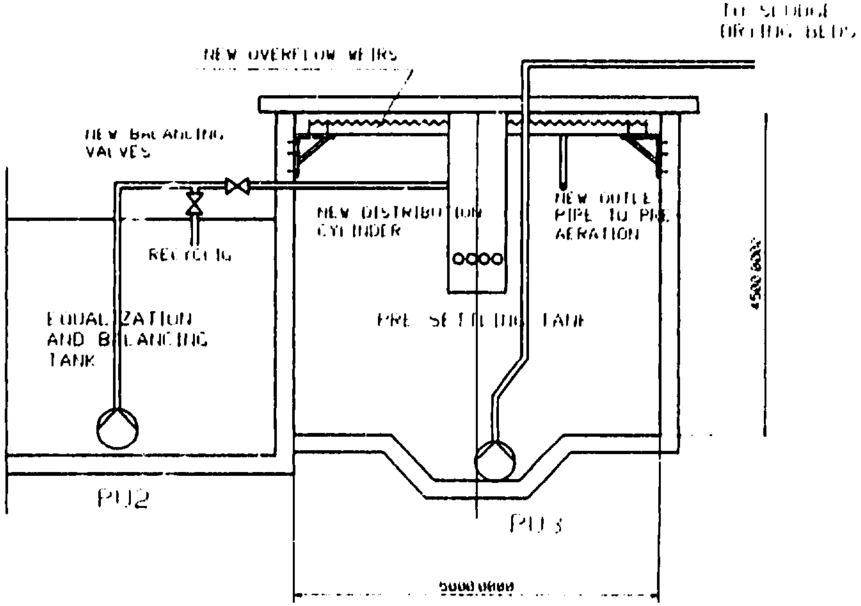
RECOMMENDATION OF WATER BALANCING AND PRESETTLING IN FUTURE

- NEW WATER BALANCING BY TWO VALVES AND RECYCLING
- EFFICIENCY OF PUMPING CAN BE ADJUSTABLE WITH RECYCLING
- NEW OUTLET WEIRS AND PIPE TO PREAERATION
- NEW DISTRIBUTION CYLINDER WITH 50 mm HOLES
- RETENTION TIME 4...8 h
- VOLUME AROUND 80 m3
- DIMENSIONS 5 x 4 x 4,5
- SURFACE LOADING 0,5...1,2 m/h

MODIFICATION WORKS CAN BE DONE BY LOCALLY



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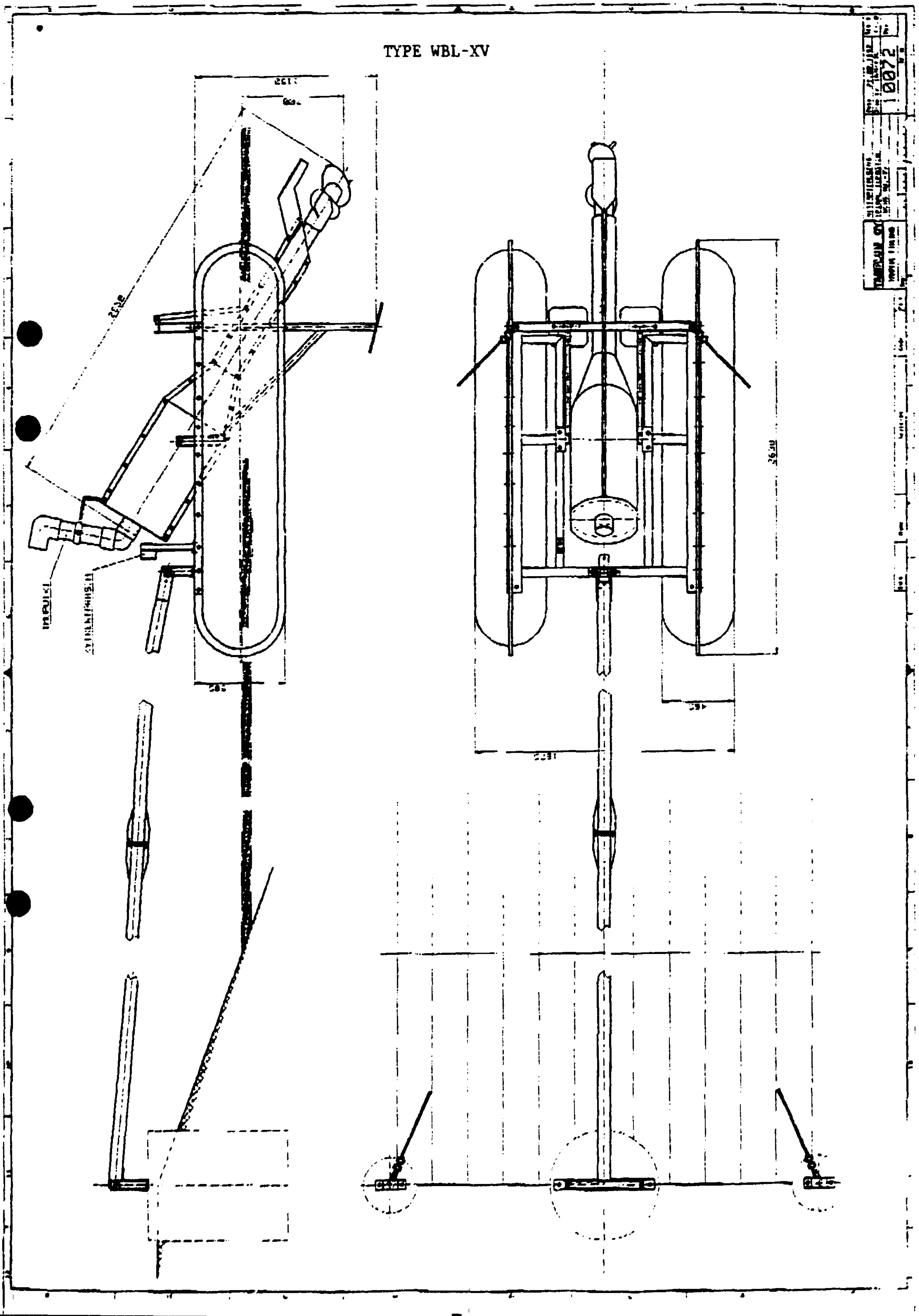
ANNEX 6

TYPE WBL-XV



TAMFLOW OY

TEKNINEN ERITTELY

FUCHS SPIRAL ILMASTIN WBL-XV

Käyttö:

3-vaihe sähkömoottori

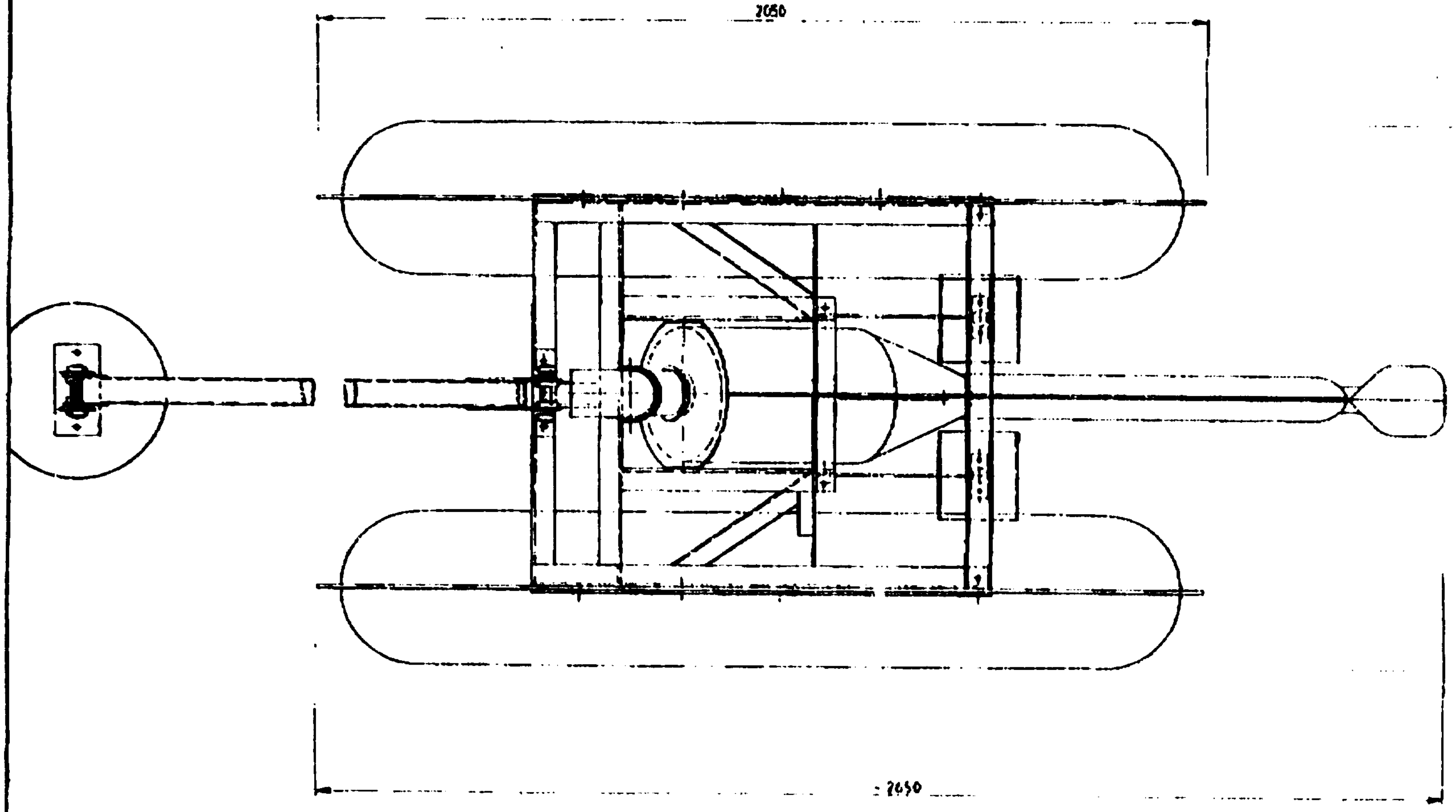
valmistaja:	Siemens
tyyppi:	1 LA 5 166-4 AA 71 Z
nimellisteho:	15,0 kW
jännite:	380 V/660 V
nimellisvirta:	30,0/17,3 A
taajuus:	50 Hz
nimellispyörimisnopeus:	1.460 rpm
IEC-moottorikoko:	160 L
kotelointiluokka:	IP 55
eristysluokka:	F
asennusasento:	B 5/V1
käynnistyskytkentä:	Y-Δ, Δ
laakeri, akselitapin puoli:	6209 DIN 625
laakeri, tuulettimen puoli:	6209 DIN 625

Ilmastin:

kokonaispituus:	2.550 mm
kiinnityslaipan halkaisija:	440 mm
paino:	147,5 kg
ilmanvirtaus:	≥ 310 m^3/h
potkurin upotussyvyys:	0,7 m

FLOATING DEVICE FOR THE SPIRAL AERATOR

TYPE WBL-I-V

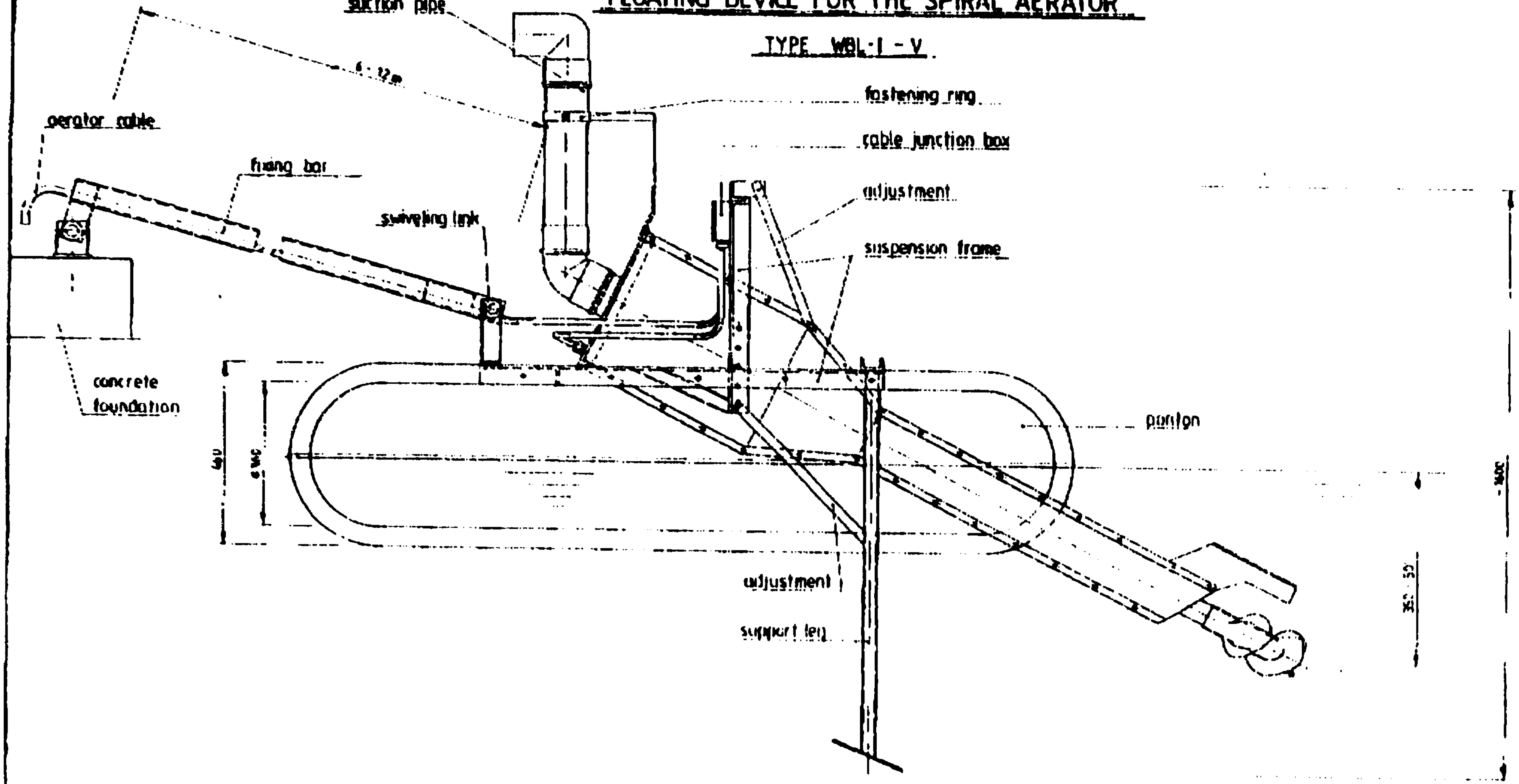


TAMFLOW OY
Hatanpäänvaltatie 34 C
33100 TAMPERE
Puh. 931-129 890
Fax 931-133 239

Fuchs Gas- und Wassertechnik
Im Stocktal 2 PO Box 1362
D 5440 Mayen 1
Telefon (02651) 8004-0 Telex 17 2651814 [illegible]
Telefax [illegible] Telefax (02651) 8004-18

FLOATING DEVICE FOR THE SPIRAL AERATOR

TYPE WBL-I-V



TAMFLOW OY
Hatanpäänvaltatie 34 C
33100 TAMPERE
Puh 931-129 890
Fax 931-133 239

Fuchs Gas- und Wassertechnik
[illegible] PO Box 1357
D 5440 Mayen 1
[illegible]
[illegible]

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19 October 1993

Annex E

TERMS OF REFERENCE

for Sub-contracting the EFFLUENT TREATMENT PLANT for the MWANZA TANNERIES LIMITED in MWANZA for the project US/URT/91/110

A. General Background Information

The Third Consultation on the Leather and Leather Products Industry (Innsbruck, Austria, April 1984) recommended, inter alia, that an integrated programme approach at the national level, with appropriate variations to meet the specific needs of individual developing countries, could provide a relevant framework for international co-operation for the development of the full potential of the raw hides and skins and the leather products industry.

It was also recommended that "Given the objectives of the Industrial Development Decade for Africa and the situation of the leather and leather products industry in that region, the Industrial Development Board should consider the convening of a regional consultation in Africa preceded by the meeting of a group of experts that would identify areas of international co-operation".

Consequently, UNIDO started the project Integrated Development Programme of the Leather and Leather Products Industry in Africa (XA/RAF/85/610) and the terminal report of this project (IPCT.5 of 20/10/86) formed the main background paper for the Regional Meeting on the Leather and Leather Products Industry in Africa, Alexandria, Egypt, January 1987. The Alexandria meeting focussed on the constraints and shortcomings experienced in the African leather industry as a whole and emphasized the need, as a first priority measure, to upgrade the quality of raw hides and skins and to improve the collection systems. As a follow-up the proposed scheme was presented to the First Session of the FAO Intergovernmental Sub-group on Hides and Skins, convened in Rome, 21-23 January 1987, and was as such welcomed and accepted. For the implementation of the integrated sectorial improvement scheme UNIDO was entrusted to seek the required funds. After receiving the approval and support of many African countries, it was agreed that eight East-African and eight West-African countries should be grouped under two regional umbrella projects.

In order to assess the present situation and collect pertinent data for the whole programme, comprising the regional umbrella project and the individual country projects, UNIDO launched a preparatory assistance phase entitled "Preparatory Assistance for Regional Hides and Skins, Leather and Leather Products Improvement Scheme" (UC/RAF/87/069). Two senior experts visited the countries concerned, discussed the assistance needs and the governments' counterpart inputs with the government authorities, trade and industry organizations concerned. The findings and recommendations of these experts were used, by adopting the "system approach", for starting up a Regional Hides and Skins, Leather and Leather Products Improvement Scheme, US/RAF/88/100, with associated country projects including US/URT/88/100, a project which is presently ongoing.

The project documents of the Regional Hides and Skins, Leather and Leather Products Improvement Scheme, US/RAF/88/100 and the national country project US/URT/88/100 have clearly specified that the programme is a pilot exercise which may lead to further assistance activities. During the implementation of US/URT/88/100 new assistance needs were identified. These needs strictly complement, and do not overlap, the activities of project US/URT/88/100 and are considered as a continuation and extension of the assistance provided under the above-mentioned project.

Pollution control has been identified as one of the first priorities in the Tanzanian tanning industry, as it hardly exists in the country.

In the case of the Africa Tannery in Mwanza, the lack of effluent treatment has caused severe problems to the environment.

The Tannery in Mwanza was established in the early -80's as one of the three national tanneries under the Tanzania Leather Associated Industries (TLAI) the tannery has never worked at full capacity and the effluent plant designed for it showed certain deficiencies and did not operate properly. The reasons for the failures in tannery operations were partly the inexperienced management by the TLAI and the unmotivated work force under the para-statal setup.

The main objectives for establishing this tannery were to process raw hides and skins into leather for sale on both domestic and export markets.

The tannery has been recently privatized and taken over by new owners, the African Trade Development (ATD), and re-named as Africa Tannery. The UNIDO projects US/RAF/88/100 and US/URT/88/100 have assisted the new company and provided technical advice to the new owners.

An effluent treatment consultant, Mr. P. Rantala (FIN), was fielded under post US/RAF/88/100/11-10C/J13104 together with the UNIDO tannery machinery engineer Mr. A. Zink to provide advice in solving the effluent problems of the plant.[1] The results of this mission can be summarized as follows:

ATD will be informed that the report meets UNIDO's approval as a technical paper and as a basis for ATD to take the necessary action to start the construction of the civil works and for the purchase of the equipment (with own funds). As soon as ATD has obtained the equipment and finished the civil works they should inform UNIDO of the exact time schedule. UNIDO will then be in the position to negotiate a subcontract for the commissioning and fine-tuning of the plant as well as training of operators in its utilization. The subcontractor's technicians would be fielded after the final confirmation is received from ATD that the plant is ready for installation, commissioning and start up.

B. Immediate Objectives and Project Outputs

The second main objective of the original project document reads as follows:

" This part of the project is designed to assist the selected tannery in Moshi in minimizing the environmental degradation caused by the expanding activities without placing undue economic burden on them; and to reinforce the local and technical capabilities in the area of tannery environmental technology with the aim of improving the service to the Tanzanian tanning industry."

The main output of this objective is the implementation of a :

" Fully operational effluent treatment plant for the selected tannery, with staff trained to operate and maintain the plant independently."

As the foreseen privatization process of the Tanzania Tanneries in Moshi was severely delayed and it is not clear who are to be the new owners it was decided that the tannery selection may be changed[2].

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[1] The report of Mr. Rantala dated 15 May 1993 and the mission report of Mr. Zink (26 April - 5 May 1993) refer.

[2] J. Berg's Tanzania mission report 6-9 December 1992 refers.

C. Responsibility of the contractor; Description of work to be performed.

Given the aims of the second immediate objective of the project and the expected output under the subject project component, as described in the project document, the contractor is expected to:

1. Appraise the situation at Africa Tannery in Mwanza; this will include the scrutiny of the existing plant and the preparation of a detailed installation plan for the existing equipmert and the new equipment ordered;

2. Provide assistance in the adaptation of the civil works and monitor the construction work to be carried out by a local company;

3. Prepare a list of control equipment and chemicals required to monitor and operate the effluent treatment plant.

4. Supervise and assist in assembling the equipment and components supplied and commissioning the Africa Tannery plant (including a trial run);

4. Train the local personnel during the running tests period as required.

5. During the running tests period the sub-contractor team will prepare the draft manual for the waste water for the Mwanza plant and send the final version back to Tanzania after its completion at the home base.

Expertise required during 1993 -94 for field missions and home office work:

	Field Work	Home Office
1 Effluent Treatment Technologist	6 weeks	2 weeks
1 Civil Engineer	1 week	1 week
1 Draughtsman		1 week
1 Typist		1 week

D. General Time Schedule

The final time schedule and the detailed work plan will be prepared as soon as the contractor has been selected. The work plan and the time schedule will be attached to the sub-contract and will be an integral part of the same.

However, a tentative workplan can be drafted as follows:

1. Appraise the situation as per task no. 1	2 weeks
2. Delivery and shipment:	
- Delivery	3 months
- Shipment to Dar-es-Salaam	1 month
- Custom clearance	0.5 month
- Transport Dar-es-Salaam/Moshi	1 month
3. Supervision and assistance during civil-engineering	1 month
6. Installation	0.5 month
7. Commissioning, starting up and training	1 month
8. Preparation of documentation	0.5 month

The inputs are expected to include 3 return trips to Tanzania from the contractors home base.

D. Reporting

Reports are expected to be provided as follows:

1. Preliminary report with final work plan one month after signature of contract.

2. Draft final report one month after completing the field work.

3. Final report one month after approval of draft final report.

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UNIDO Contract No. 93/242
Project No. US/URT/91/110
Activity Code: J13104

Annex F

12.06.1995

LIST OF CONTROL EQUIPMENT AND CHEMICALS REQUIRED TO MONITOR AND OPERATE THE ETP

ANNEX F

LIST OF CONTROL EQUIPMENT AND CHEMICALS

1
GENERAL

In oder to exercise effective day-to-day control over the treatment of wastewater, it is necessary to be able to analyze samples of effluents on a regular basin. Simple analyses should be done in-house.

A useful starting point is a daily check of water concumption. Other basic parameters done on a daily basis could be settieability, pH, conductivity, DO (Dissolved oxygen), COD and SS (Susbended solids).

Parameters done once or twice a week could be e.g. chromium and sulphides.

This paper describes the control equipment and chemiclas required to monitor and operate the ETP. Sampling and analysis should be carried out by the same staff if possible. The results of analyses should be systematically recorded in a diary.

The text gives brief introduction into the topic and more detailed information is given in the Annex 2.

Methods of recommended analyses are as follows :

- Dissolved oxygen (DO), by special electrode
- Settleability, by measuring jar
- pH-value, by special electrode
- Conductivity, by special electrode
- Susbended Solids (SS), vacuum filtration (Standard Methods)
- Chromium, by atomic absorption spectrophotometer method and or higher consentrations, see annex 2
- Sulphide, by determination of sulphide at colorimetric method
- Chemicalo oxygen demand (COD), by closed tube method, oxidation with dichromate

Some other analyses such as BOD_5 and ammonia-nitrogen can be recommended as well.

2
EQUIPMENT

Equipment needed for the above analyses are as follows :

Dissolved oxygen (DO)
- portable DO-meter and electrodes

Settleability
- one liter jar or Imhoff cone

pH-value
- portable pH-meter and electrodes (there is one new meter and 3 old ones in the tannery)
- sample flasks and other accessories

Conductivity
- conductivity meter and electrodes

Susbended solids (SS)
- sample flasks
- special filters, bore size 10 μm, diameter 55 mm
- Büchner funnel, compatible with filters
- vacuum pump and vacuum bottle, compatible with Büchner funnel
- oven for operation at 100 to 105 °C
- precision balance for laboratory use

Chromium analysis
- atomic absorption spectrophotometer with compatible lamps to chromium (357,9 nm)
- special membrane filters of 0,45 μm, for filtration
- filters and > 0,45 μm, for prefiltration
- sample bottles
- flasks 100 ml

Sulphide analysis
- spectrofotometer (absorbance area 670 nm)
- sample bottles (Winkler bottles, V = 130 ml)

COD-analysis
- reaction tubes for boiling (min 10 ml)
- boiling machine, compatible with tubes, temperature around 150 °C
- byrette, accuracy 0,01 ml
- magnetic stirrer with magnets
- pipettes

Additionally a selection of laboratory glasses, flasks, pipettes, byrettes e.g. are needed. Also equipment to produce distiiled water is needed.

As an example a Water Quality Logging System is presented in Annex 1.

3
CHEMICALS

Chemicals needed for the above analyses are as follows :

Dissolved oxygen (DO)
- calibration liquid for the electrode

pH-value
- calibration liquid for the electrode

Conductivity
- calibration liquid for the electrode

Susbended solids (SS)

Chromium
- HNO_3-acid liquid, concentration 7 mol/l
- basic liquid chrome, concentration Cr 1000 mg/l, prepared from $K_2Cr_2O_7$
- working liquid chrome, concentration Cr 10 mg/l
- burning gas asetylene (C_2H_2)
- oxidation gas (N_2O) or air
- washing liquid, 1 % EDTA-salt and 5 % normal laboratory washing liguid
- washing acid, 7 ml strong HNO_3-acid to 1 l with water

Sulphide analysis
- distilled water
- HCl-acid liquid, concentration 6 mol/l
- H_2SO_4-acid liquid, concentration 9 mol/l
- NaOH-liquid, concentration 1 mol/l
- $Zn(CH_3COO)_2$ x $2H_2O$-liquid, concentration 1 mol/l
- absorption-liquid, prepared from Na_2HPO_3 x $2H_2O$, NaOH and $NaHCO_3$
- $(NH_4)_2HPO_4$-liquid
- FeCl3 x 6 H_2O-liquid
- KI (Kaliumjodide)
- $((CH_3)_2NC_6H_4NH_2)_2(COOH)_2$
- Jodometric-indicator liquid
- KIO_3-liquid, concentration 0,003 mol/l

- $Na_2S_2O_3$ x 5 H_2O–liquid, concentration 0.01 mol/l
- Zn–gelatine
- Na_2S x 9 H_2O basic liquid, sulphide concentration 1 g/l
- Na_2S x 9 H_2O working liquid, sulphide concentration 10 mg/l

COD–analysis
- $K_2Cr_2O_7$–liquid, concentration 0.04 mol/l, plus NH_2SO_3H
- $((NH_4)_2Fe(SO_4)_2$ x 6 H_2O
- strong H_2SO_4–liquid
- Ag_2SO_4–liquid
- $HgSO_4$–liquid
- H_2SO_4–liquid, concentration around 4 mol/l
- $KHC_8H_4O_4$–liquid

These are only descriptive lists of equipment and chemicals needed. It is still necessary to train the staff in sampling and analytical procedures. Manuals and handbooks for analyses are available in most countries. More intensive training is available at institutions.

Annex 2 gives also more detailed lists and other information. Annex 2 is a partial copy of the UNIDO Technical report: Manual on laboratory equipment and reagents by Mr. Michel Aloy.

ANNEX 1

The Grant/YSI 3800 Water Quality Logging System

- *Dissolved oxygen*
- *Temperature*
- *Conductivity*
- *pH*
- *Salinity*
- *Ammonia**
- *ORP**
- *Turbidity**
- *Depth**

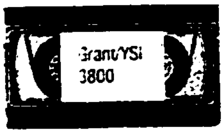
YSI and Grant Instruments have combined their sensor technology and data logging expertise in a new multi-parameter water quality logging system. The Grant/YSI 3800 is easy to use for monitoring or sampling surface water, wastewater effluent and groundwater.

The 3800 system is a complete package for your monitoring needs. The standard unit measures dissolved oxygen, temperature, conductivity, salinity and pH. Depth, turbidity, ammonium, ammonia, ORP and other ISE measurements are optional.

You program the system to record readings on command or to automatically log data at intervals for unattended monitoring. You can assign each monitoring site a unique identification code. Later, you can download the data to your PC or printer.

The new Grant/YSI 3800 system offers these benefits:

- A self-stirring DO probe that uses easy-to-change cap membranes.
- Field-replaceable probes.
- Programmable internal datalogger.
- Complete IBM PC compatibility. Data can also be downloaded directly to a printer.
- An easy-to-read backlit display.
- A field carrier with a sonde storage area.
- A mV/mA/count input compatible with other equipment such as flow meters.
- Detachable cables available in lengths from 10 to 200 feet.
- Easy DO calibration in air with automatic temperature and barometric pressure compensation.
- Memory capability to log 80,000 individual readings.
- An optional external power supply provides line power for lab work.
- An optional flow-through cell for groundwater measurement.
- And like all YSI water quality meters, the Grant/YSI 3800 Logger has a 2-year warranty.



Free Video
Ask for our video illustrating the benefits of the Grant/YSI 3800.

For information, call the YSI dealer in your area listed on the inside back cover.

*Optional sensors

General Specifications

Medium: Fresh, sea or polluted water
Temperature: -5 to +45°C
Depth: 0 to 200 feet
Sonde size: 3.5" dia. 12" long, 3.66 lbs
Computer interface: 3-wire RS232C, 4800 baud
Printer interface: Centronics compatible, parallel
Software: Recorded data can be downloaded to a PC using the communications software included
Inter[illegible] logging memory: 80,000 readings
Power: 6 D cells or optional external supply
Battery life: 30 days at 15-minute logg[illegible] intervals at 25°C

Grant/YSI 3800
Includes logger, sonde, field carrier, DO, conductivity, pH and temperature probes. Order sonde to logger cable separately.

The Grant/YSI 3800 is easy to use for sampling surface water.

*Performance Specifications**

Probe	**Range**	**Resolution**	**Accuracy**	**Comments**
DO–% saturation	0 to 200% saturation	0.1% saturation	±0.2%	Automatic temperature compensation
DO–mg/L	0 to 20 mg/L	0.01 mg/L	±0.03 mg/L	Automatic temperature & salinity compensation
Conductivity	0 to 100 mS/cm	2 µS/cm, 0-2 mS/cm 10 µS/cm, 2-20 mS/cm 50 µS/cm, 20-100 mS/cm	At 25°C (77°F) ±3%, 0-20 mS/cm; ±4%, 20-100 mS/cm	Automatic temperature compensation to 25°C (77°F). Optional
pH	0 to 14 pH	0.01 pH	±0.04 pH	Automatic temperature compensation to 25°C
Temperature	-5-+50°C (23-122°F)	0.1°C (0.2°F)	Total: ±0.4°C (±0.7°F)	Select °C or °F
Salinity	0 to 50‰	0.1‰	Total: ±4.5%full scale	Calculated from conductivity, temperature
Depth	0 to 200 feet (60 m)	1 foot (0.3 m)	Total: ±1.5 feet (±0.5 m)	Compensation for density, barometric pressure
Turbidity	0 to 1,000 NTU	1 NTU	±2 lsd, 0 to 25 NTU; ±6% of reading, 25 to 1,000 NTU	
Ammonium NH$_4$-N	0 to 100 mg/L	0.1 mg/L, 0-10 mg/L 1 mg/L, 10-100 mg/L	10% or 2 mg/L, whichever is larger, at calibration temperature when salinity is below 0.5‰	Automatic temperature compensation
Ammonia NH$_3$-N	0 to 100 mg/L	0.1 mg/L, 0-10 mg/L 1 mg/L, 10-100 mg/L	20% or 4 mg/L, whichever is larger, for pH above 8 at calibrated temperature	Automatic temperature compensation
ORP	-2,000 to +2,000 mV	1 mV	±5 mV	
Air Pressure	50 to 110 kPa	0.1 kPa	±2%	

*Accuracy specifications for the Grant/YSI 3800 relate to laboratory measurements taken soon after calibration and at calibration temperature. Dissolved oxygen accuracy was determined with the probe in known gas mixtures after calibration in water-saturated air. Please contact YSI for insight into field accuracy which can be expected under the specific conditions of your application.

6. METHODS OF ANALYSING WASTE WATER

To monitor and check the satisfactory operation of a purification plant, it is essential to carry out water analyses at the inlet and outlet points of the treatment installations, since visual assessment alone is not sufficient to determine the effectiveness of the various treatment stages. While the outlet analytical values provide evidence for the authorities of the quality of effluent discharged into the environment, the values obtained at the plant's inlet show the effectiveness of the clean technologies installed at the tannery and make it possible to evaluate purification performance.

Most of the analytical methods presented in this document are taken from the eighteenth edition of Standard Methods for the Examination of Water and Wastewater published by A.P.H.A., A.W.W.A, and W.E.F. (Water Environment Federation), American Public Health Association, 1015 15th Street NW, Washington, DC 2005, U.S.A.. Other methods have been adapted for tannery effluent analysis by the Centre Technique Cuir Chaussure Maroquinerie (CTC) and are described in the manual Techniques d'analyse des eaux résiduaires industrielles published by CTC, 4 rue Hermann Frenkel, 69367 Lyon, France.

6.1 Sampling methods

It is indispensable to obtain representative samples of the element to be analysed. The sampling bottles must be clean and rinsed with the water that is to be examined.

- Grab sampling

This is the most commonly used sampling technique, by which it is possible to determine under satisfactory conditions the analytical parameters of a solution that contains no suspended solids. However, it provides only limited data if the sampled discharge is likely to vary in quality and quantity over time.

- Composite sampling

If an average value over two or 24 hours is sought, it is necessary to undertake sampling proportional to the flow rate by means of an automatic sampling apparatus. It is often possible to ascertain the variations in effluent characteristics during the day by analysing the different hourly-sampled segments. Samples must be kept at 4° C to prevent their undergoing changes. Nevertheless, despite these precautions, the characteristics of certain parameters begin to change after 24 hours' storage. Promptness in commencing the analyses is thus a guarantee of their accuracy.

6.2 Measuring pH

The pH measurement indicates whether a solution is acidic (pH values between 0 and 7) or alkaline (pH values between 7 and 14). It is possible in some cases to use indicator paper, but such measurement is inaccurate and liable to risks of interference (light, suspended solids, chlorinated products).

The electrochemical method is the most commonly employed and the most accurate. It involves immersing a glass electrode and a reference electrode (calomel) into the solution to be analysed. The difference in potential between the two electrodes is directly related to the pH of the solution.

This procedure requires a measuring apparatus, i.e. a pH-meter with a glass electrode and a calomel (KCl) electrode, and also glass beakers, a stirrer and comparison solutions with a pH of 4, 7 and 10.

6.3 Measuring effluent settleability

The volume of settleable solids present in waste water can be checked by putting the water sample into a graduated measuring cylinder (preferably conical). It is then possible to monitor the effluent settling rate by noting the volume of sludge formed over time. The settleable matter is the matter deposited during a period conventionally fixed at two hours.

The only equipment required for this determination is an Imhoff cone or a one-litre measuring jar.

6.4 Measuring chemical oxygen demand (COD) (standard method 5220 C)

COD is the quantity of oxygen consumed by organic and inorganic matter susceptible to oxidation in defined conditions:

- Presence of an excess of potassium bichromate;
- Concentrated sulphuric acid medium;
- Boiling for two hours;
- Catalysts: sulphate of mercury and sulphate of silver.

The excess bichromate is titrated with a solution of Mohr's salt (iron II and ammonium sulphate).

This measuring operation requires the use of the following equipment:

- One precision balance (capable of weighing to 1/10 mg);
- Six 500-ml flasks with ground-glass necks;
- Six water or air coolers;
- Precision pipettes;
- One 25-ml precision burette;
- Six electric flask heaters.

The quantitative analysis requires the following chemical reagents:

- Mercury II sulphate, $HgSO_4$, in powder form;
- Silver sulphate, Ag_2SO_4, in powder form;
- Concentrated sulphuric acid (d 20°: 1.83);
- Mohr's salt, $FeSO_4.(NH_4)_2SO_4.6H_2O$;
- Potassium bichromate, $K_2Cr_2O_7$;

- 1,1 o-phenanthroline;
- Ferrous sulphate, $FeSO_4.7H_2O$.

6.5 Chromium analysis

Chromium occurs in two stable oxidation states: one hexavalent and the other trivalent. (In solution, trivalent chromium is green and hexavalent chromium is orange.)

It is possible to determine the hexavalent chromium content by analysis using the colorimetric method or the Mohr's salt method, and the total chromium content following conversion to hexavalent chromium by oxidation. The trivalent chromium content is calculated by taking the difference. The detection limit is approximately 25 mg/l.

Oxidation to hexavalent chromium is obtained, at boiling heat, by a mixture of sulphuric, perchloric and nitric acids. Three main analytical methods can then be used:

- Colorimetric analysis using diphenylcarbazide in a slightly acidic medium, which produces a pink-violet coloration that can be measured at 540 nm (standard method 3500-Cr D);
- Analysis by reduction of chromium VI to chromium III using Mohr's salt (or double iron and ammonium sulphate) in the presence of ferroin (standard method for COD);
- Analysis by the iodometric method using potassium iodide, the liberated iodine being titrated with sodium thiosulphate.

For measuring low concentrations, it is necessary to use the atomic absorption spectrometric method, by which it is possible to detect a minimum chromium concentration of 50 ug/l. In view of the cost of the apparatus, that method will not be described or evaluated in this manual.

The equipment required for the standard analytical procedures is as follows:

For the oxidation phase:

- One gas or electric heater;
- One precision balance capable of weighing to 1/10 mg;
- Precision pipettes;
- Six 250-ml volumetric flasks;
- Six 250-ml Erlenmeyer flasks;
- Glass beads.

For colorimetric analysis:

- One spectrocolorimeter;

- Six 50-ml volumetric flasks;
- Precision pipettes;
- One filter-holder with paper filters.

For analysis using Mohr's salt:

- One 25-ml precision burette;
- Precision pipettes;
- Six 250-ml beakers.

For iodometric analysis:

- One 25-ml precision burette;
- Six 250-ml Erlenmeyer flasks;
- Precision pipettes.

The chemical reagents required for the oxidation phase and the different analytical procedures are as follows:

- Oxidation:
    - Perchloric acid, $HClO_4$ (d 20°: 1.615);
    - Sulphuric acid, H_2SO_4 (d 20°: 1.83);
    - Nitric acid, HNO_3 (d 20°: 1.33);
- Spectrocolorimetric analysis:
    - Diphenylcarbazide;
    - Phthalic anhydride;
    - Ethyl alcohol, 95°;
    - Potassium chromate, K_2CrO_4, for calibration of the colorimeter.
- Analysis using Mohr's salt:
    - Concentrated sulphuric acid (d 20°: 1.83);
    - Mohr's salt, $FeSO_4.(NH_4)_2SO_4.6H_2O$;
    - Potassium bichromate, $K_2Cr_2O_7$;
    - 1,1 o-phenanthroline;
    - Ferrous sulphate, $FeSO_4.7H_2O$.

- Iodometric analysis:
  - Phosphoric acid, H_3PO_4 (d 20°: 1.71);
  - Potassium iodide, KI;
  - Thiodene in powder form;
  - Sodium thiosulphate, $Na_2S_2O_3.5H_2O$;
  - Potassium bichromate, $K_2Cr_2O_7$.

6.6 Suspended solids (standard method 2540 D)

Essentially, two laboratory methods are used:

- Vacuum filtration through a glass-fibre filter;
- Centrifugation in the case of highly-clogging samples.

After weighing, the filter disk is placed on a vacuum filtering support, and a specific quantity of liquid is filtered. The filter is dried at 105° C and weighed.

In cases where filtration is difficult, the sample is centrifuged, the supernatant is removed, and the residue is dried at 105° C and then weighed.

The equipment required for measuring suspended solids by filtration is as follows:

- One glass filter pump or vacuum pump;
- One vacuum filtration apparatus (one-litre flask, support and joint);
- 100 calibrated glass-fibre filters;
- Ten silica dishes;
- One oven for operation at 100 to 105° C;
- One precision balance capable of weighing to 1/10 mg;
- Precision pipettes;
- One desiccator.

If the inorganic substances present in the suspended solids are also to be determined, a furnace is necessary:

- One muffle furnace that can be heated to between 600 and 650° C.

To measure suspended solids by centrifugation, a centrifuge is also required:

- One centrifuge capable of an average acceleration of 3,000 rpm and equipped with bowls of at least 200 ml (if possible 500 ml).

6.7 Total solids (dry solids) (standard method 2540 B)

In this operation, the total dry solids present in a sample for analysis are calculated by evaporation. At 100-105° C, only water and some organic solvents are removed. At 600-650° C, solely the inorganic substances remain, although some are partly decomposed.

The apparatus required is as follows:

- Ten silica dishes;

- One oven for operation at 100 to 105° C;

- One precision balance capable of weighing to 1/10 mg;

- Laboratory glassware (precision pipettes, desiccator);

and, if applicable, for inorganic substances:

- One muffle furnace that can be heated to between 600 and 650° C.

6.8 Sodium sulphide analysis

In concentrations of 4 mg/1 or higher, sodium sulphide is extremely toxic to living organisms. Two measuring methods are possible:

- An electrochemical method based on the use of a selective electrode, which is highly reliable but requires the use of special equipment;

- Volumetric analysis using potassium ferricyanide.

- Potentiometric method (CTC method - Rodier techniques)

The sulphides are converted to sulphide of silver by the addition of silver nitrate. The variation in potential at the end-point is recorded by the apparatus, with a detection limit of 2 mg/l.

The analysis equipment required is as follows:

- One potentiometric analysis apparatus;

- One calomel electrode with K_2SO_4 filler;

- One sulphide-selective electrode;

- Precision pipettes;

- One 50-ml measuring cylinder;

- 250-ml beakers;

- One magnetic stirrer.

The chemical reagents used for the analysis are as follows:

- Silver nitrate, $AgNO_3$;

- Ammonia, NH_4OH (d 20°: 0.9);
- Ammonium chloride, NH_4Cl;
- 1,2 cyclohexylenediamine tetraacetic acid (CDTA).

- Volumetric method

The sulphides are analysed by means of potassium ferricyanide in the presence of a ferrous dimethylglyoxime ammonia complex. They are oxidized in sulphur, and the sulphites, which may cause interference, are precipitated with barium chloride. The method detection limit is 3 mg/l.

The analysis equipment required is as follows:

- One 25-ml burette;
- One magnetic stirrer;
- One 25C-ml beaker;
- Precision pipettes;
- One precision balance capable of weighing to 1/10 mg.

The chemical reagents used for the analysis are as follows:

- Potassium ferricyanide, $K_3Fe(CN)_6$;
- Ammonium chloride, NH_4Cl;
- Ammonia, NH_4OH (d 20°: 0.9);
- Barium chloride, $BaCl_2$;
- Iron II sulphate, $FeSO_4$;
- Ethanol, 95%;
- Dimethylglyoxime;
- Sulphuric acid, H_2SC_4 (d 20°: 1.84).

6.9 Dissolved oxygen

Levels of dissolved oxygen are related to biological activity in water. The respiratory activities of water fauna and flora require sizeable quantities of it. Certain physico-chemical parameters also condition the dissolved oxygen content (temperature, atmospheric pressure, salinity, etc.).

There are two determination techniques:

- Volumetric analysis based on the oxidizing property of dissolved oxygen: the Winkler method (standard method 4500-O B);
- Electrochemical analysis using a polarographic electrode (standard method 450C-O G)

Since the volumetric method is a delicate process that is liable to interference and involves a lengthy measuring operation, only the electrochemical method will be included.

The measuring apparatus required is as follows:

- One magnetic stirrer;
- One polarographic measuring probe;
- One thermometer;
- One oxygen analyser graduated in ppm, mg/l or % oxygen;
- Twenty 100-ml bottles.

6.10 Mohlman index (standard method 2710 D)

The Mohlman index shows the volume in ml occupied by 1 g of suspended solids after settling for 30 minutes. It enables the efficiency of biological treatment to be checked. It is directly related to the settleability of biological sludge.

The measuring apparatus required is as follows:

- One oven regulated at 105° C;
- One Imhoff cone or 1-litre measuring jar;
- Five silica dishes;
- One precision balance capable of weighing to 1/10 mg;
- 50-ml precision pipettes.

6.11 Total Kjeldahl nitrogen (TKN) analysis (standard method 4500-Norg B & 4500-Norg C)

Total Kjeldahl nitrogen corresponds to the sum of ammonia nitrogen and organic nitrogen. If the oxidized forms of nitrogen - nitrites and nitrates - are added, the total nitrogen is obtained.

By oxidative digestion in an acidic medium, organic nitrogen (protein, peptides, amino acids, etc.) is converted to ammonia nitrogen without any degradation of the oxidized compounds of nitrogen (nitrites, nitrates, hydrazine, oximes, etc.). The ammonia is then displaced by distillation in an alkaline medium and analysed by acidimetry. The method detection limit is approximately 2 mg/l.

The analysis equipment required is as follows:

- One distillation apparatus comprising:
  - 1,000-ml distilling flasks;
  - One ground-glass reducing joint;
  - One three-way ground-glass adaptor;

- One separating funnel;
- One straight-sided condenser;
- One curved extension piece;
- One gas heater (Bunsen burner);
- Support rods;
- Clamps;

or an automatic distillation apparatus;

- One digestion rack (gas- or electrically-heated with hood);
- 500-ml Erlenmeyer flasks;
- One burette;
- One magnetic stirrer;
- Silicon grease.

The chemical reagents used for the analysis are as follows:

- Sulphuric acid, H_2SO_4 (d 20°: 1.84);
- Potassium sulphate, K_2SO_4;
- Selenium catalyst;
- Sodium hydroxide, NaOH;
- Boric acid, H_3BO_3;
- Methyl red;
- Bromocresol green;
- Ethanol, 95%.

6.12 Biochemical oxygen demand (BOD_5) (standard method 5210 B)

Five-day biochemical oxygen demand, or BOD_5, is the amount of oxygen consumed under test conditions (incubation for five days at 20° C in darkness) by certain substances present in water in the course of their biological degradation.

Despite its limitations, the BOD_5 test is the analytical technique that most faithfully mimics the metabolic action of organic pollutants in watercourses.

However, four phenomena may interfere with BOD_5:

- The presence of highly-reducing substances that account for a high oxygen demand during the first 10 hours (sulphides, sulphites, etc.);

- Photochemical activity, which leads to the production of oxygen within the sample itself and is inhibited by incubating the samples in the dark;

- The presence of toxins, which can inhibit biological reactions entirely or for a specific period;

- The action of bacteria in the nitrogen cycle (nitrification), which can alter the oxygen balance of the medium to a considerable degree, particularly in the final stage of the test.

The test procedure consists of preparing several dilutions of the sample using dilution water saturated with oxygen and seeded. The quantity of dissolved oxygen in each dilution is measured before and after incubation for five days at 20° C in the dark. Oxygen consumption should be between 40 and 60 per cent of the initial sample content.

It is also possible to use a manometric method, by which it is possible to monitor changes in oxygen consumption throughout the five-day period. The shape of the oxygen consumption curve plotted gives a good indication of the presence of any toxic substances in the analysis sample.

The equipment required for the manometric method consists of a multi-position respirometer, which gives a reading of the oxygen consumption in the sample by means of a manometer or by a continuous recording. The equipment must be heat-insulated at 20 ± 1° C or placed in an incubator thermostatically controlled at 20 ± 1° C.

The equipment required for dilution analysis of biochemical oxygen demand is as follows:

- One incubator thermoregulated at 20 ± 1° C;

- 250-ml incubation bottles with ground-glass stoppers;

- Precision pipettes;

- Volumetric flasks of the following volumes: 2,000, 1,000, 500, 250, 150 and 100 ml;

- Equipment for measuring dissolved oxygen by polarographic probe;

- An aeration device to saturate the dilution water.

The reagents required for measuring BOD_5 are as follows:

- Dihydrated sodium monohydrogenophosphate, $Na_2HPO_4.2H_2O$, or dodecahydrated sodium monohydrogenophosphate, $Na_2HPO_4.12H_2O$;

- Potassium dihydrogenophosphate, KH_2PO_4;

- Magnesium sulphate, $MgSO_4.7H_2O$;

- Calcium chloride, $CaCl_2$;

- Ferric chloride, $FeCl_3$;

- Ammonium chloride, NH_4Cl;
- Biological treatment sludge or sewage water for the seed source;
- Sulphuric acid, H_2SO_4 (d 20°: 1.84);
- Potassium bichromate, $K_2Cr_2O_7$.

6.13 Calcium analysis

Calcium is a predominant element of water hardness and may thus constitute a drawback in some leather processing operations, such as dyeing. It is also one of the components of unhairing and liming liquor. There are two methods of analysis by complexometry with disodium salt of ethylenediamine tetraacetic acid (EDTA):

- A volumetric method using a colour indicator specific to calcium;
- A potentiometric method,' by which it is also possible to analyse magnesium in addition to calcium.

Calcium analysis by volumetry (Rodier techniques)

The calcium is complexed by a solution of EDTA in an alkaline medium (pH between 12 and 13) in the presence of a colour indicator (eriochrome blue). The detection limit is 5 mg/l.

The analysis equipment required is as follows:

- One 25-ml burette;
- One magnetic stirrer;
- Precision pipettes;
- 150-ml beakers;
- One precision balance capable of weighing to 1/10 mg.

The reagents required for the analysis are as follows:

- Sodium hydroxide NaOH;
- Eriochrome blue;
- EDTA.

Calcium analysis by potentiometry (standard method 3500-Ca D)

First, all the calcium and magnesium ions are analysed by complexometry with EDTA in a medium buffered to a pH of 10.2 ± 0.1. The magnesium ion is then eliminated as hydroxide in a medium buffered to a pH of 12 ± 0.1 and just the calcium is analysed by complexometry with EDTA. The reactions are monitored by potentiometry.

The analysis equipment required is as follows:

- One potentiometric titration apparatus;
- One calomel reference electrode;
- One mercury silver amalgam electrode;
- One magnetic stirrer;
- One precision balance capable of weighing to 1/10 mg;
- 150-ml beakers;
- Precision pipettes.

The reagents required for the analysis are as follows:

- Nitric acid, HNO_3;
- Purified mercury;
- Triethanolamine;
- Ethanolamine;
- EDTA;
- Mercury (II) sulphate, $HgCl_2$;
- Calcium carbonate, $CaCO_3$;
- Sodium hydroxide, NaOH.

6.14 Chloride analysis (standard method 4500-Cl^- D)

In a nitric acid medium, chlorides are converted to their silver salts in the presence of silver nitrate. For this analysis, a potentiometric method is used. The method detection limit is 5 mg/l.

The analysis equipment required is as follows:

- One potentiometric titration apparatus;
- One silver electrode;
- One reference electrode filled with saturated K_2SO_4;
- 250-ml beakers;
- One magnetic stirrer;
- Precision pipettes.

The reagents required for the analysis are as follows:

- Silver nitrate, $AgNO_3$;

- Concentrated nitric acid, HNO_3 (d 20°: 1.33);
- Hydrochloric acid, HCl;
- Sulphuric acid, H_2SO_4.

6.15 Phenol analysis (standard method 5530 D)

In an alkaline medium, a number of phenolic compounds react with aminoantipyrine in the presence of potassium ferricyanide to produce an orange-red coloration that can be analysed colorimetrically in a chloroform phase.

However, not all phenols react (in particular the para-substituted phenols). Some phenols produce different coloration intensities. For this reason, the term "phenol index" is used rather than phenol determination.

The analysis equipment required is as follows:

- One precision balance capable of weighing to 1/10 mg;
- One set of twelve 25-ml volumetric flasks;
- Four 100-ml volumetric flasks;
- Two 1,000-ml volumetric flasks;
- One pH-meter;
- One spectrocolorimeter;
- One set of twelve 250-ml separating funnels;
- One set of twelve 200-ml volumetric flasks;
- Precision pipettes;
- One set of twelve 150-ml beakers;
- One all-glass distillation apparatus with ground joints, comprising:
  - . One 500-ml three-necked flask;
  - . One thistle funnel to fit the flask;
  - . One condenser;
  - . Two curved extension pieces.

The reagents required for the analysis are as follows:

- Ammonium chloride, NH_4Cl;
- Double potassium and sodium tartrate, $KNaC_4H_4O_6.4H_2O$;
- Ammonia, NH_4OH;

- 4-aminoantipyrine (1-phenyl-2-3-dimethyl-4-amino-pyrazolone-5);
- Potassium ferricyanide, $K_3Fe(CN)_6$;
- Phosphoric acid, H_3PO_4;
- Chloroform, $CHCl_3$;
- Sodium chloride, NaCl;
- Phenol, C_6H_5OH.

6.16 Sulphate analysis (standard method 4500-SO_4^{--} E)

In a hydrochloric acid medium, sulphates precipitate in the presence of barium chloride. The barium sulphate precipitate is stabilized, by means of solution of Tween 20, in order to allow nephelometric measuring by spectrometer. The method detection limit is between 1 and 2 mg/l.

The analysis equipment required is as follows:

- One spectrocolorimeter regulated at 650 nm;
- One set of twelve 50-ml volumetric flasks with stoppers;
- Precision pipettes;
- One precision balance capable of weighing to 1/10 mg;
- Two 1,000-ml volumetric flasks;
- Two 100-ml volumetric flasks.

The reagents required for the analysis are as follows:

- Sodium sulphate, Na_2SO_4;
- Hydrochloric acid, HCl;
- Tween 20;
- Stabilized barium chloride, $BaCl_2$.

6.17 Aluminium analysis

EDTA is used, there being a donor-acceptor bond between the metallic io Al^{3+} and the lone nitrogen pair. The complex obtained with the aluminium is negatively charged.

Two methods are employed:

- A potentiometric titration method; and
- A manual volumetric method.

Potentiometric analysis (CTC method)

Since the reaction between EDTA and aluminium is very slow, direct titration cannot be carried out; reverse analysis is therefore undertaken. A precisely-measured excess quantity of EDTA is added, the solution is then adjusted to a pH of 4.5, and the reaction is accelerated by heating. The excess EDTA is then titrated by a titrated solution of zinc sulphate with a pH of between 5 and 6. The method detection limit is 25 mg/l.

The analysis apparatus required is as follows:

- A potentiometric analysis apparatus with a magnetic stirrer;
- Five 150-ml beakers;
- Precision pipettes;
- One heating rack;
- One precision balance capable of weighing to 1/10 mg;
- One calomel reference electrode;
- One mercury silver amalgam electrode.

The reagents required for the analysis are as follows:

- EDTA;
- Methyl red;
- Ethyl alcohol;
- Sodium hydroxide, NaOH;
- Hexamethylenetetramine;
- Xylenol orange;
- Zinc sulphate, $ZnSO_4$;
- Concentrated nitric acid, HNO_3;
- Ethanolamine;
- Mercury (II) sulphate, $HgSO_4$.

Manual volumetric analysis

The aluminium is analysed directly by EDTA, hot, in the presence of copper complexonate and a colour indicator.

The analysis equipment required is as follows:

- One precision balance capable of weighing to 1/10 mg;
- One 25-ml burette;

- One gas heater point;
- Five 250-ml wide-necked Erlenmeyer flasks;
- Precision pipettes;
- One magnetic stirrer.

The reagents required for the analysis are as follows:

- EDTA;
- Aluminium comparison solution;
- Pan-indicator;
- Copper sulphate, $CuSO_4$.

6.18 <u>Iron analysis</u> (standard method 3500-Fe D)

In a buffered medium, iron II reacts with phenanthroline to form a red complex that can be measured colorimetrically at 510 nm. The method detection limit is 0.01 mg/l. For total iron analysis, iron III has to be converted to iron II.

This analysis is subject to several interferences:

. Copper, cobalt, chromium and zinc interfere if present in concentrations equal to ten times that of the iron, and cyanides and nickel in concentrations equal to or higher than 2 mg/l. These interferences are avoided by working with a pH of between 3.5 and 5.5;

. Cadmium, mercury, bismuth and silver interfere by reacting with phenanthroline;

. Phosphates react if their concentration is equal to ten times that of the iron.

. In the case of industrial waste water, calcination at 600 to 650° C and dissolution of the ash are necessary prior to analysis.

The analysis equipment required is as follows:

- One spectrocolorimeter regulated at 510 nm;
- One set of twelve 100-ml volumetric flasks;
- Precision pipettes;
- One precision balance capable of weighing to 1/10 mg.

The reagents required for the analysis are as follows:

- Concentrated hydrochloric acid, HCl;
- Concentrated nitric acid, HNO_3;

- Concentrated sulphuric acid, H_2SO_4;
- Potassium peroxodisulphate, $K_2S_2O_8$;
- Hydroxylamine hydrochloride, $NH_2OH.HCl$;
- Ammonium acetate, CH_3COONH_4;
- Crystallizable acetic acid, CH_3COOH;
- 1,10 phenanthroline hydrochloride, $C_{12}H_9ClN_2.H_2O$;
- Non-oxidized iron wire.

6.19 Analysis of phosphorus and its compounds

The methods described make it possible to analyse the phosphorus present in water in various forms:

- Orthophosphate analysis;
- Polyphosphate analysis following hydrolysis;
- Total phosphorus analysis following oxidative digestion.

The detection limit for all these methods is 0.01 mg/l. All the results are expressed in mg/l of phosphorus (P).

Orthophosphate analysis (Rodier techniques)

In an acidic medium in the presence of ammonium molybdate, orthophosphates form a phosphomolybdic complex, which, when reduced by ascorbic acid, produces a blue coloration that can be analysed colorimetrically.

The analysis equipment required is as follows:

- One spectrocolorimeter;
- Precision pipettes;
- One set of twelve 50-ml volumetric flasks;
- One precision balance capable of weighing to 1/10 mg;
- One laboratory balance capable of weighing to 1/100 g;
- One pH-meter;
- Three 500-ml volumetric flasks;
- Five 1,000-ml volumetric flasks.

The reagents required for the analysis are as follows:

- Ascorbic acid, $C_6H_8O_6$;
- Sulphuric acid, H_2SO_4;

- Sodium hydroxide, $NaOH$;
- Antimony potassium tartrate, $K(SbO)C_4H_4O_6.0.5H_2O$;
- Ammonium molybdate, $(NH_4)_6Mo_7O_{24}.4H_2O$;
- Potassium dihydrogenophosphate, KH_2PO_4.

Polyphosphate analysis (Rodier techniques)

Polyphosphates are converted to orthophosphates by hot hydrolysis in an acidic medium.

Colorimetric analysis carried out after such hydrolysis shows the total content, expressed in mg/l of phosphorus (P), of the orthophosphates initially present and of the polyphosphates. The hydrolysable polyphosphate or phosphate content will be obtained by the difference between that total value and the values of the orthophosphates to be analysed separately.

In addition to the equipment already described for orthophosphate analysis, the following apparatus is required:

- Five 250-ml glass flasks;
- One heating rack;
- Five 100-ml volumetric flasks.

The chemical reagents used are the same as for orthophosphate analysis.

Total phosphorus analysis (Rodier techniques)

All the phosphorus, regardless of its state, is digested in a hot acidic medium in the presence of sodium persulphate. The orthophosphates obtained are then analysed colorimetrically.

In addition to the equipment required for orthophosphate analysis, the following apparatus is needed:

- One digestion rack comprising:
  - . Five 250-ml long-necked flasks (Kjeldahl type);
  - . One heating rack;
- Five 200-ml volumetric flasks;
- Five 250-ml beakers;
- One fume hood.

In addition to the reagents required for orthophosphate analysis, the following is also necessary:

- Sodium peroxodisulphate, $Na_2S_2O_8$.

6.20 Colour analysis (standard method 2120 B)

The procedure is based on visual comparison of the analysis sample with a reference coloration range such as the platinum-cobalt scale. This measuring technique is used only in the case of water whose colour characteristics are close to the reference scale.

The analysis equipment required is as follows:

- One set of twenty 50-ml flat-bottomed colorimetric tubes;
- One precision balance capable of weighing to 1/10 mg;
- One 1,000-ml volumetric flask;
- One 100-ml graduated measuring cylinder;
- One set of fifteen 50-ml volumetric flasks;
- One vacuum filtration apparatus with glass-fibre filters.

The chemicals required for the analysis are as follows:

- Hexahydrated cobalt (II) chloride, $CoCl_2.6H_2O$;
- Potassium chloroplatinate, K_2PtCl_6;
- Hydrochloric acid, HCl (d 20°: 1.19).

6.21 Effluent toxicity determination

Toxicity is a very complex concept: it encompasses the action of very many elements in highly varied forms (complexed, ionized, oxidized, etc.). Toxicity is measured by means of a test using a biological reagent: fish, daphnia, bacteria, algae, etc. This highly sophisticated measuring operation is reserved for specialized laboratories.

7. IDENTIFICATION OF FOUR LABORATORY SIZES

With a view to undertaking a quantitative and qualitative assessment of the equipment and chemicals required for a tannery laboratory, in the management of a physico-chemical and biological treatment plant, and for the implementation of clean in-house technologies, the following scale has been adopted:

Level 1

The laboratory is attached to a small tannery that handles less than 5 tons of salted raw bovine hides per day or processes less than 1,000 sheepskins or goatskins per day. The maximum values may be higher if the tannery carries out only part of the production operation, for example from raw to wet-blue hides or from crust to finished leather. The quantity of waste water will generally be less than 150 to 200 m^3 per day.

Level 2

This level corresponds to a tannery handling between 5 and 15 tons of salted raw bovine hides per day or between 1,000 and 3,000 skins per day. The quantity of waste water will be between 200 and 500 m^3 per day.

Level 3

The tannery capacity will be between 15 and 30 tons of bovine hides per day or between 3,000 and 6,000 sheepskins or goatskins per day, with a waste-water volume of less than 1,000 m^3 per day.

Level 4

This last level corresponds to a bovine tannery with a capacity exceeding 30 tons of salted hides per day or a tannery handling more than 6,000 skins per day. The volume of effluent discharge will generally be in excess of 1,000 m^3 per day.

8. NUMBER OF ANALYSES CONDUCTED PER WEEK AT EACH LEVEL

The weekly number of analyses for each determination can be seen from the table below:

Parameter	Level 1	Level 2	Level 3	Level 4
pH	15	30	60	90
Settleability	5	5	10	10
COD	2	5	10	10
Chromium	5	10	20	30
SS		5	10	10
Total solids		5	10	10
Sulphides		5	10	10
Dissolved oxygen		5	10	15
Mohlman index			5	5
TKN			2	5
BOD_5			5	10
Calcium			5	10
Chlorides			2	5
Phenols				2
Sulphates				2
Aluminium				5
Iron				2
Phosphorus				1
Colour				1

These values are of course only quantitative indications that are liable to variation in specific situations, such as tanneries linked to a joint industrial effluent treatment plant.

9. LEVEL 1 LABORATORY: EQUIPMENT REQUIRED

Such a laboratory will thus carry out the following determinations:

- pH, settleability, COD and chromium.

The laboratory equipment required is as follows:

- One laboratory pH-meter;
- One glass electrode and one calomel electrode (KCl);
- Twelve 250-ml glass beakers;
- One magnetic heating stirrer with five Teflon-coated bars;
- One 1-litre graduated Imhoff cone with one support;
- One precision balance (capable of weighing to 1/10 mg);
- Six 500-ml flasks with ground-glass necks;
- Six water or air coolers;
- Four precision pipettes of each of the following volumes: 1, 5, 10, 20, 25 and 50 ml;
- Two 25-ml precision burettes;
- One burette support with double clamp;
- Six electric flask heaters;
- Six 250-ml volumetric flasks with stoppers;
- Six 250-ml Erlenmeyer flasks;
- Glass beads;
- One 3-kW distilled water apparatus with a capacity of 4 litres per hour;
- One 20-litre storage container;
- 50 metres of clear PVC tubing with an inside diameter of 10 mm;
- One refrigerator with a capacity of approximately 250 litres.

These equipment items require a laboratory work surface 6 m long and 0.85 m wide, with one sink, two cold-water taps, one hot-water tap, four single-phase power sockets and one three-phase power socket. The laboratory, which will have a total floor area of 18 m^2, will also contain a storage cabinet for equipment and chemicals, and an air extractor hood.

10. LEVEL 1 LABORATORY: CHEMICALS

The chemicals have been determined on the basis of a one-year period of normal laboratory operation. They thus correspond to:

- 750 pH measurements;
- 250 settleability tests;
- 100 COD tests;
- 250 chromium analyses using the Mohr's salt method.

The chemicals required are as follows:

- 12 solutions buffered to a pH of 4;
- 12 solutions buffered to a pH of 7;
- 12 solutions buffered to a pH of 10;
- 100 g of mercury II sulphate, $HgSO_4$, in powder form;
- 50 g of silver sulphate, Ag_2SO_4, in powder form;
- 15 litres of concentrated sulphuric acid (d 20°: 1.83);
- 2 kg of Mohr's salt, $FeSO_4.(NH_4)_2SO_4.6H_2O$;
- 250 g of potassium bichromate, $K_2Cr_2O_7$;
- 300 ml of ferroin indicator (o-phenanthroline and $FeSO_4.7H_2O$);
- 3 litres of perchloric acid, $HClO_4$ (d 20°: 1.615);
- 2 litres of nitric acid, HNO_3 (d 20°: 1.33).

11. LEVEL 2 LABORATORY: EQUIPMENT REQUIRED

Such a laboratory will carry out the following determinations:

- pH, settleability, COD, chromium, suspended solids, dry solids, sulphide and dissolved oxygen.

The laboratory equipment required is as follows:

- One automatic sampler;
- One laboratory pH-meter;
- One glass electrode and one calomel electrode (KCl);
- Twelve 250-ml glass beakers;
- One magnetic heating stirrer with five Teflon-coated bars;

- One 1-litre graduated Imhoff cone with one support;
- One precision balance (capable of weighing to 1/10 mg);
- Six 500-ml flasks with ground-glass necks;
- Six water or air coolers;
- Four precision pipettes of each of the following volumes: 1, 5, 10, 20, 25 and 50 ml;
- Two 25-ml precision burettes;
- One burette support with double clamp;
- Six electric flask heaters;
- Six 250-ml volumetric flasks with stoppers;
- Six 250-ml Erlenmeyer flasks;
- Glass beads;
- One 3-kW distilled water apparatus with a capacity of 4 litres per hour;
- One 20-litre storage container;
- 50 metres of clear PVC tubing with an inside diameter of 10 mm;
- One refrigerator with a capacity of approximately 250 litres;
- One stainless vacuum pump with 10 metres of 6 x 18 mm vacuum tubing;
- One vacuum filtration apparatus (1-litre flask, support and joint);
- Ten 50-ml silica dishes;
- Ten 190-ml silica dishes;
- One 55-litre oven for operation at 100 to 105° C;
- One desiccator with a diameter of 200 mm;
- One 5-litre muffle furnace capable of being heated to 850° C;
- One potentiometric analysis apparatus;
- One calomel electrode with K_2SO_4 filler;
- One sulphide-selective electrode;
- Two 50-ml measuring cylinders;
- One polarographic measuring probe;

- One precision thermometer;
- One oxygen analyser graduated in ppm, mg/l or % oxygen;
- Twenty 100-ml glass bottles.

These equipment items require a laboratory work surface 10 m long and 0.85 m wide, with one sink, three cold-water taps, one hot-water tap, six single-phase power sockets and one three-phase power socket. The laboratory, which will have a total floor area of 30 m², will also contain two storage cabinets for equipment and chemicals.

12. LEVEL 2 LABORATORY: CHEMICALS

The chemicals have been determined on the basis of a one-year period of normal laboratory operation. They thus correspond to:

- 1,500 pH measurements;
- 250 settleability tests;
- 250 COD tests;
- 500 chromium analyses using the Mohr's salt method;
- 250 suspended solids analyses;
- 250 total solids analyses;
- 250 sulphide analyses using the potentiometric method;
- 250 dissolved oxygen tests.

The chemicals required are as follows:

- 24 solutions buffered to a pH of 4;
- 24 solutions buffered to a pH of 7;
- 24 solutions buffered to a pH of 10;
- 250 g of mercury II sulphate, $HgSO_4$, in powder form;
- 100 g of silver sulphate, Ag_2SO_4, in powder form;
- 35 litres of concentrated sulphuric acid (d 20°: 1.83);
- 5 kg of Mohr's salt, $FeSO_4.(NH_4)_2SO_4.6H_2O$;
- 500 g of potassium bichromate, $K_2Cr_2O_7$;
- 700 ml of ferroin indicator (o-phenanthroline and $FeSO_4.7H_2O$);
- 6 litres of perchloric acid, $HClO_4$ (d 20°: 1.615);
- 3 litres of nitric acid, HNO_3 (d 20°: 1.33);

- 300 calibrated glass-fibre filters with a diameter of 47 mm;
- 150 g of silver nitrate, $AgNO_3$;
- 5 litres of ammonia, NH_4OH (d 20°: 0.9);
- 1 kg of ammonium chloride, NH_4Cl;
- 150 g of 1,2 CDTA.

13. LEVEL 3 LABORATORY: EQUIPMENT REQUIRED

Such a laboratory will carry out the following determinations:

- pH, settleability, COD, chromium, suspended solids, dry solids, sulphide, dissolved oxygen, Mohlman index, TKN, BOD_5, calcium and chloride.

The laboratory equipment required is as follows:

- One automatic sampler;
- One flow meter and recorder;
- One laboratory pH-meter;
- One glass electrode and one calomel electrode (KCl);
- Twelve 250-ml glass beakers;
- One magnetic heating stirrer with five Teflon-coated bars;
- One 1-litre graduated Imhoff cone with one support;
- One precision balance (capable of weighing to 1/10 mg);
- Six 500-ml flasks with ground-glass necks;
- Six water or air coolers;
- Four precision pipettes of each of the following volumes: 1, 5, 10, 20, 25 and 50 ml;
- Two 25-ml precision burettes;
- One burette support with double clamp;
- Six electric flask heaters;
- Six 250-ml volumetric flasks with stoppers;
- Six 250-ml Erlenmeyer flasks;
- Glass beads;

- One 3-kW distilled water apparatus with a capacity of 4 litres per hour;
- One 20-litre storage container;
- 50 metres of clear PVC tubing with an inside diameter of 10 mm;
- One refrigerator with a capacity of approximately 250 litres;
- One stainless vacuum pump with 10 metres of 6 x 18 mm vacuum tubing;
- One vacuum filtration apparatus (1-litre flask, support and joint);
- Ten 50-ml silica dishes;
- Ten 190-ml silica dishes;
- One 55-litre oven for operation at 100 to 105° C;
- One desiccator with a diameter of 200 mm;
- One 5-litre muffle furnace capable of being heated to 850° C;
- One potentiometric analysis apparatus;
- One calomel electrode with K_2SO_4 filler;
- One sulphide-selective electrode;
- Two 50-ml measuring cylinders;
- One polarographic measuring probe;
- One precision thermometer;
- One oxygen analyser graduated in ppm, mg/l or % oxygen;
- Twenty 100-ml glass bottles;
- One automatic Kjeldahl nitrogen distillation apparatus;
- Ten 300-ml balloon flasks;
- One electrically heated six-position digestion rack;
- Ten 500-ml Erlenmeyer flasks;
- Silicon grease;
- One incubator thermostatically controlled at 20 ± 1° C for BOD_5;
- One hundred 250-ml incubation bottles with ground-glass stoppers;
- Volumetric flasks: 2 x 2,000 ml, 5 x 1,000 ml, 6 x 500 ml and 10 x 100 ml;

- One 12-W membrane compressor (capacity: 9 litres per minute) to saturate the dilution water;
- One mercury silver amalgam electrode;
- Twelve 150-ml beakers;
- One silver electrode.

These equipment items require a laboratory work surface 16 m long and 0.85 m wide, with two sinks, four cold-water taps, two hot-water taps, 10 single-phase power sockets and 2 three-phase power sockets. The laboratory, which will have a total floor area of 40 m^2, will also contain storage units beneath the work surface for equipment and chemicals.

14. LEVEL 3 LABORATORY: CHEMICALS

The chemicals have been determined on the basis of a six-month period of normal laboratory operation. They thus correspond to:

- 1,500 pH measurements;
- 250 settleability tests;
- 250 COD tests;
- 500 chromium analyses using the Mohr's salt method;
- 250 suspended solids analyses;
- 250 total solids analyses;
- 250 sulphide analyses using the potentiometric method;
- 250 dissolved oxygen tests;
- 125 Mohlman index measurements;
- 50 TKN analyses;
- 125 BOD_5 tests;
- 125 calcium analyses using the potentiometric method;
- 50 chloride analyses.

The chemicals required are as follows:

- 24 solutions buffered to a pH of 4;
- 24 solutions buffered to a pH of 7;
- 24 solutions buffered to a pH of 10;
- 300 g of mercury II sulphate, $HgSO_4$, in powder form;

- 100 g of silver sulphate, Ag_2SO_4, in powder form;
- 50 litres of concentrated sulphuric acid (d 20°: 1.83);
- 5 kg of Mohr's salt, $FeSO_4.(NH_4)_2SO_4.6H_2O$;
- 2 kg of potassium bichromate, $K_2Cr_2O_7$;
- 700 ml of ferroin indicator (o-phenanthroline and $FeSO_4.7H_2O$);
- 6 litres of perchloric acid, $HClO_4$ (d 20°: 1.615);
- 10 litres of nitric acid, HNO_3 (d 20°: 1.33);
- 300 calibrated glass-fibre filters with a diameter of 47 mm;
- 200 g of silver nitrate, $AgNO_3$;
- 5 litres of ammonia, NH_4OH (d 20°: 0.9)
- 2 kg of ammonium chloride, NH_4Cl;
- 150 g of CDTA;
- 1 kg of potassium sulphate, K_2SO_4;
- 50 g of selenium catalyst;
- 3 kg of sodium hydroxide, NaOH;
- 500 g of boric acid, H_3BO_3;
- 100 g of methyl red;
- 25 g of bromocresol green;
- 1 litre of ethanol, 95%;
- 1 kg of dihydrated sodium monohydrogenophosphate, $Na_2HPO_4.2H_2O$;
- 1 kg of potassium dihydrogenophosphate, KH_2PO_4;
- 1 kg of magnesium sulphate, $MgSO_4.7H_2O$;
- 1 kg of calcium chloride, $CaCl_2$;
- 1 litre of ferric chloride, $FeCl_3$, 27.5%;
- 250 g of purified mercury;
- 1 litre of triethanolamine;
- 1 litre of ethanolamine;
- 100 g of EDTA;

- 250 g of calcium carbonate, $CaCO_3$;
- 1 litre of hydrochloric acid, HCl.

15. LEVEL 4 LABORATORY: EQUIPMENT REQUIRED

Such a laboratory will carry out the following determinations:

- pH, settleability, COD, chromium, suspended solids, dry solids, sulphide, dissolved oxygen, Mohlman index, TKN, BOD_5, calcium, chloride, phenols, sulphates, aluminium, iron, phosphorus and colour.

The laboratory equipment required is as follows:

- One automatic sampler;
- One flow meter and recorder;
- One laboratory pH-meter;
- One glass electrode and one calomel electrode (KCl);
- Twelve 250-ml glass beakers;
- One magnetic heating stirrer with 5 Teflon-coated bars;
- One 1-litre graduated Imhoff cone with one support;
- One precision balance (capable of weighing to 1/10 mg);
- Six 500-ml flasks with ground-glass necks;
- Six water or air coolers;
- Four precision pipettes of each of the following volumes: 1, 5, 10, 20, 25 and 50 ml;
- Two 100-ml precision pipettes;
- Two 25-ml precision burettes;
- One burette support with double clamp;
- Six electric flask heaters;
- Six 250-ml volumetric flasks with stoppers;
- Six 250-ml Erlenmeyer flasks;
- Glass beads;
- One 3-kW distilled water apparatus with a capacity of 4 litres per hour;
- One 20-litre storage container;

- 50 metres of clear PVC tubing with an inside diameter of 10 mm;
- One refrigerator with a capacity of approximately 250 litres;
- One stainless vacuum pump with 10 metres of 6 x 18 mm vacuum tubing;
- One vacuum filtration apparatus (1-litre flask, support and joint);
- Ten 50-ml silica dishes;
- Ten 190-ml silica dishes;
- One 55-litre oven for operation at 100 to 105° C;
- One desiccator with a diameter of 200 mm;
- One 5-litre muffle furnace capable of being heated to 850° C;
- One potentiometric analysis apparatus;
- One calomel electrode with K_2SO_4 filler;
- One sulphide-selective electrode;
- Two 50-ml measuring cylinders;
- One polarographic measuring probe;
- One precision thermometer;
- One oxygen analyser graduated in ppm, mg/1 or % oxygen;
- Twenty 100-ml glass bottles;
- One automatic Kjeldahl nitrogen distillation apparatus;
- Ten 300-ml balloon flasks;
- One electrically heated six-position digestion rack;
- Ten 500-ml Erlenmeyer flasks;
- Silicon grease;
- One incubator thermostatically controlled at 20 ± 1° C for BOD_5;
- One hundred 250-ml incubation bottles with ground-glass stoppers;
- Volumetric flasks: 2 x 2,000 ml, 5 x 1,000 ml, 6 x 500 ml and 10 x 100 ml;
- One 12-W membrane compressor (capacity: 9 litres per minute) to saturate the dilution water;
- One mercury silver amalgam electrode;

- Twelve 150-ml beakers;
- One silver electrode;
- One set of twelve 25-ml volumetric flasks;
- One spectrocolorimeter with accessories;
- One set of twelve 250-ml separating funnels;
- One set of twelve 200-ml volumetric flasks;
- One all-glass distillation apparatus with ground joints, comprising:
  - . One 500-ml three-necked flask;
  - . One thistle funnel to fit the flask;
  - . One condenser;
  - . Two curved extension pieces;
- One set of twenty 50-ml volumetric flasks with stoppers;
- One laboratory balance capable of weighing to 1/100 g;
- Five 250-ml glass flasks with ground necks;
- One set of twenty 50-ml flat-bottomed colorimetric tubes;
- Two 100-ml graduated measuring cylinders.

These equipment items require a laboratory work surface 24 m long and 0.85 m wide, with two sinks, four cold-water taps, two hot-water taps, 16 single-phase power sockets and 2 three-phase power sockets. The laboratory, which will have a total floor area of 60 m^2, will also contain storage units beneath the work surface for equipment and chemicals.

16. LEVEL 4 LABORATORY: CHEMICALS

The chemicals have been determined on the basis of a six-month period of normal laboratory operation. They thus correspond to:

- 2,250 pH measurements;
- 250 settleability tests;
- 250 COD tests;
- 750 chromium analyses using the Mohr's salt method;
- 250 suspended solids analyses;
- 250 total solids analyses;
- 250 sulphide analyses using the potentiometric method;

- 375 dissolved oxygen tests;
- 125 Mohlman index measurements;
- 125 TKN analyses;
- 250 BOD_5 tests;
- 250 calcium analyses using the potentiometric method;
- 125 chloride analyses;
- 50 phenol index measurements;
- 50 sulphate analyses;
- 125 aluminium analyses;
- 50 iron analyses;
- 50 phosphorus analyses;
- 25 colour measurements.

The chemicals required are as follows:

- 36 solutions buffered to a pH of 4;
- 36 solutions buffered to a pH of 7;
- 36 solutions buffered to a pH of 10;
- 300 g of mercury II sulphate, $HgSO_4$, in powder form;
- 100 g of silver sulphate, Ag_2SO_4, in powder form;
- 60 litres of concentrated sulphuric acid (d 20°: 1.83);
- 6 kg of Mohr's salt, $FeSO_4.(NH_4)_2SO_4.6H_2O$;
- 2 kg of potassium bichromate, $K_2Cr_2O_7$;
- 800 ml of ferroin indicator (o-phenanthroline and $FeSO_4.7H_2O$);
- 9 litres of perchloric acid, $HClO_4$ (d 20°: 1.615);
- 13 litres of nitric acid, HNO_3 (d 20°: 1.33);
- 300 calibrated glass-fibre filters with a diameter of 47 mm;
- 200 g of silver nitrate, $AgNO_3$;
- 6 litres of ammonia, NH_4OH (d 20°: 0.9);
- 2 kg of ammonium chloride, NH_4Cl;

- 150 g of CDTA;
- 1 kg of potassium sulphate, K_2SO_4;
- 100 g of selenium catalyst;
- 5 kg of sodium hydroxide, NaOH;
- 1 kg of boric acid, H_3BO_3;
- 200 g of methyl red;
- 25 g of bromocresol green;
- 1 litre of ethanol, 95%;
- 1 kg of dihydrated sodium monohydrogenophosphate, $Na_2HPO_4.2H_2O$;
- 1 kg of potassium dihydrogenophosphate, KH_2PO_4;
- 1 kg of magnesium sulphate, $MgSO_4.7H_2O$;
- 1 kg of calcium chloride, $CaCl_2$;
- 1 litre of ferric chloride, $FeCl_3$, 27.5%;
- 500 g of purified mercury;
- 1 litre of triethanolamine;
- 1 litre of ethanolamine;
- 200 g of EDTA;
- 250 g of calcium carbonate, $CaCO_3$;
- 2 litres of hydrochloric acid, HCl;
- 1 kg of double potassium sodium tartrate, $KNaC_4H_4O_6.4H_2O$;
- 10 g of 4-aminoantipyrine (1-phenyl-2-3-dimethyl-4-amino-pyrazolone-5);
- 250 g of potassium ferricyanide, $K_3Fe(CN)_6$;
- 1 litre of phosphoric acid, H_3PO_4;
- 2 litres of chloroform, $CHCl_3$;
- 3 kg of sodium chloride, NaCl;
- 1 kg of phenol, C_6H_5OH;
- 1 kg of sodium sulphate, Na_2SO_4;
- 1 litre of Tween 20;

- 1 kg of stabilized barium chloride, $BaCl_2$;
- 1 kg of hexamethylenetetramine;
- 100 g of xylenol orange;
- 250 g of zinc sulphate, $ZnSO_4.7H_2O$;
- 100 g of potassium peroxodisulphate, $K_2S_2O_8$;
- 250 g of hydroxylamine hydrochloride, $NH_2OH.HCl$;
- 1 kg of ammonium acetate, CH_3COONH_4;
- 1 litre of crystallizable acetic acid, CH_3COOH;
- 15 g of 1,10 phenanthroline hydrochloride, $C_{12}H_9ClN_2.H_2O$;
- 250 g of non-oxidized iron wire;
- 250 g of ascorbic acid, $C_6H_8O_6$;
- 500 g of antimony potassium tartrate, $K(SbO)C_4H_4O_6.0.5H_2O$;
- 100 g of ammonium heptamolybdate, $(NH_4)_6Mo_7O_{24}.4H_2O$;
- 250 g of sodium peroxodisulphate, $Na_2S_2O_8$;
- 100 g of hexahydrated cobalt (II) chloride, $CoCl_2.6H_2O$;
- 1 g of potassium chloroplatinate, K_2PtCl_6.

17. ASSESSMENT OF NECESSARY EQUIPMENT AND CHEMICALS

An example of a standard laboratory layout is shown in annex 3.

The evaluations given below are based on equipment and chemicals available in Europe. The prices are indicated in United States dollars befor tax (export sales).

Level 1

. Equipment evaluation:	\$ 8 500
. Chemicals:	\$ 1 200
Total	\$ 9 700

Level 2

. Equipment evaluation:	\$19 700
. Chemicals:	\$ 4 100
Total	\$23 800

Level 3

. Equipment evaluation:	\$36 800
. Chemicals:	\$ 5 600
Total	\$42 400

Level 4

. Equipment evaluation:	$44 800
. Chemicals:	$ 7 800
Total	$52 600

18. ASSESSMENT OF PERSONNEL REQUIREMENTS

Taking into account the analyses to be carried out, the laboratory personnel requirements may be evaluated as follows:

Level 1: 1 part-time employee

Level 2: 1 full-time employee

Level 3: 1 full-time and 1 part-time employee

Level 4: 2 full-time employees.

The personnel skills required correspond to a laboratory technician's diploma, i.e. a technical vocational level of education.

Annex 1

LABORATORY EQUIPMENT SPECIFICATIONS

Burette support

- 3-kg cast-iron base
- Nickel-plated steel rod measuring 800 x 12 mm
- Two-burette clamp for 12-mm rod
- With sighting device to prevent parallax errors

Colorimetric tubes, 50 ml

- Borosilicate glass
- Flat-bottomed
- Approximate dimensions: 22 x 200 mm
- PTFE screw cap and joint
- 20-hole (2 x 10) stand for 25-mm tubes

Desiccator

- Diameter: 200 mm
- Borosilicate glass
- Flat 24/29 ground-glass lid with tap
- Enamelled porcelain disk 185 mm in diameter
- 1 kg of silica gel

Dissolved oxygen analyser

- Portable equipment supplied in a carrying-case
- Measuring range: 0 to 60 mg/l or 0 to 600% saturation
- Accuracy: 1%
- Automatic temperature compensation from 0 to 50° C
- Automatic pressure compensation from 800 to 1,080 mbar
- Automatic salinity compensation from 0 to 40%
- Recorder output: 10 mV per mg/l of dissolved oxygen
- Independence of operation: up to 250 hours

Electric digestion rack

- Six positions
- Independent regulator for each position
- For 300-ml balloon flasks
- Wattage: 300 and 600 W
- With fume hood and support

Electric flask heaters

- Six-position electric heating rack
- Flask capacity: 500 ml
- Independent regulation of all six positions
- Temperature adjustment up to 450° C
- Wattage: 1,200 W
- Current and temperature indicator lights
- Acid splash protection
- Interchangeable heating caps
- Six support rods 12.5 mm in diameter

Electrode, glass

- Standard bulb electrode 10 mm in diameter
- Length: 120 mm
- Measuring range: 0 to 14 pH
- Cable length: 1 m

Electrode, reference

- Calomel reference electrode (saturated KCl)
- Length: 120 mm
- Measuring range: 0 to 14 pH
- Operating temperature: 0 to 60° C
- Cable length: 1 m
- 250 ml of saturated KCl solution

Electrode, silver

- Screw head
- Silver rod cap 4 mm in diameter
- Tubular body 10 mm in diameter and 120 mm long
- 1.5 metres of connecting cable

Electrode, sulphide-selective

- pH range: 11 to 14
- Silver sulphide monocrystal
- Response range: 1 to 10^{-10} M

Erlenmeyer flasks, 250 ml

- Borosilicate glass
- Wide aperture, without spout, 45 mm diameter
- Approximate height: 140 mm

Erlenmeyer flasks, 500 ml

- Borosilicate glass
- Wide aperture, without spout, 45 mm diameter
- Approximate height: 175 mm

Extension pieces for distiller, curved

- Borosilicate glass
- 105° angle bend
- 19/26 ground-glass cone and socket joints

Flasks with ground-glass necks, 250 ml

- Round-bottomed
- Short-necked
- Standard 24/29 ground glass
- Pyrex borosilicate glass

Flasks with ground-glass necks, 500 ml

- Round-bottomed
- Short-necked

- Standard 24/29 ground glass
- Pyrex borosilicate glass

Glass beads

- Diameter: 4 mm
- Weight: 1 kg approximately

Glass beakers, 150 ml

- Heavy-duty Pyrex glass
- Low-sided, diameter approximately 57 mm
- Reinforced flanged rims
- Double graduation scale

Glass beakers, 250 ml

- Heavy-duty Pyrex glass
- Low-sided, diameter approximately 68 mm
- Reinforced flanged rims
- Double graduation scale

Glass bottles, 100 ml

- Borosilicate glass
- Phenolic-plastic screw cap
- PTFE watertight joint

Heating oven

- Internal volume: 55 litres
- Temperature range: ambient + 5° C to 220° C
- Continuous control between 60 and 220° C with safety thermostat
- Accuracy: < ± 1%
- Wattage: 600 W
- Stainless-steel inner chamber
- Reinforced insulation
- Remote thermometer (40 to 220° C)

- Maximum number of shelves: 4
- Natural hot-air convection

Heating stirrer, magnetic

- Stirring capacity: 5 litres
- Temperature adjustment
- Continuous speed control from 300 to 1,000 rpm
- Plate diameter: 110 mm
- Maximum temperature: 350° C
- Wattage: 350 W
- Five PTFE-coated magnetized bars measuring 45 x 9 mm

Imhoff cones

- Quantity: 2
- Useful unit volume: 1 litre
- Clear acrylonitrile polystyrene
- Rigid methyl polymethacrylate support for 2 cones

Incubation bottles, 250 ml

- White laboratory glass
- Wide-necked (60 mm)
- Ground-glass cap stopper

Incubator for BOD_5 test, thermostatically controlled

- Useful volume: 260 litres
- Temperature adjustable in 1° C stages from 4 to 40° C
- Temperature read-out: liquid-crystal display (accuracy: ± 1° C)
- Radial ventilation: 100 m^3 per hour
- Internal power sockets
- ABS interior
- 4 shelves

Kjeldahl balloon flasks, 300 ml

- Borosilicate glass
- Neck diameter 28 mm and length 300 mm
- Round-bottomed

Kjeldahl nitrogen distillation equipment

- Semi-automatic model
- Distillation time programmable up to 20 minutes
- Detection limit: 0.5 mg of nitrogen
- Distilled water feed
- Push-button soda dispenser
- Compatible with all tube types
- Reproducibility: 1%
- Wattage: 1,800 W

Laboratory balance, electronic

- Weighing range: 0 to 2,100 g
- Subtractive taring range: 0 to 2,100 g
- Read-out accuracy: 0.01 g
- Linearity: ± 0.02 g
- Electrical protection: IP54
- Calibration menu
- Stabilization detector
- Vibration adaptor

Laboratory pH-meter

- Measuring range: 0 to 14 ± 0.01 pH; 0 to 100 ± 0.4° C
- Automatic and manual temperature compensation
- 3 memorized buffer solutions: pH 4, 7 and 10
- Automatic calibration
- Numerical liquid crystal display

- Control keyboard with watertight keys
- With combined pH electrode and temperature probe

Measuring cylinders, 50 ml

- Borosilicate glass
- Enamelled graduation markings in 1-ml divisions
- Approximate height: 200 mm
- Hexagonal base and pouring spout

Measuring cylinders, 100 ml

- Borosilicate glass
- Enamelled graduation markings in 1-ml divisions
- Approximate height: 260 mm
- Hexagonal base and pouring spout

Membrane compressor

- For oil-free air
- Maximum flow rate: 9 litres per minute
- Operating pressure: 0.4 bar
- Wattage: 12 W
- Neoprene membrane
- Replacement membrane and valves

Muffle furnace

- Loading capacity: 5 litres
- Maximum temperature: 900° C
- Continuous temperature control
- Accuracy: < ± 0.5%
- Wattage: 1,800 W
- Ceramic-fibre insulation
- Safety device (heater cutting out when door is opened)
- 1 intermediate ceramic tray

- Fume evacuation flue
- 1 replacement heating element

Polarographic measuring probe

- With three spare membranes
- Electrolyte and anode cleaning solution
- 1.5 m of cable
- Response time: 90% of the value in less than 10 seconds

Portable flow meter and recorder

- Bubbling probe measuring system
- Fitting all waste outlet types
- Watertight polyester carrying-case
- Battery with built-in charger (2 weeks' independence of operation)
- Three-curve recorder
- Additional inlets for a further 2 parameters (pH and temperature)
- Possible connection to a sampler
- PC-retrievable data

Portable sampler, programmable

- Sampling volume adustable from 5 to 100 ml (accuracy: ± 0.5 ml)
- Sampling rate adjustable by timer or flow-meter control (sampling proportional to time or volume)
- Twenty-four 1-litre polyethylene bottles
- Vacuum-pump sampling, with pre-sampling pressurized flushing
- Delayed start-up possible for 24 hours
- Battery with built-in charger (independence of operation for 1,000 sampling operations)
- Spare parts kit
- Replacement battery
- Set of spare bottles

Potentiometric analysis equipment

- Millivolt range: -1.600.0 to +1,600.0
- Relative millivolt range: -1,999.9 to +1,999.9
- Resolution: 0.1 mV
- Relative error: ± 0.2 mV
- Automatic calibration on 5 buffer solutions
- Five pH calibration and concentration points
- RS 232 outlet
- Two electrode inlets
- Automatic temperature compensation
- Digital display

Precision balance, electronic

- Weighing range: 0 to 109 g
- Accuracy: 0.1 mg
- Subtractive taring range: 0 to 109 g
- Stabilization time: 5 seconds
- Enclosed weighing chamber accessible from both sides and from above
- Wattage: 10 W

Precision burette, 25 ml

- Divisions: 0.05 ml
- High-temperature-enamelled graduation markings
- Error: < 0.05 ml
- Scale interval: > 1 mm
- PTFE stopcock

Precision pipettes

- Single-scale graduated pipettes
- Borosilicate glass
- Volumes: 1, 5, 10, 20, 25, 50 and 100 ml
- Pipetting bulb: model for 3.5- to 10-mm-diameter pipettes

Precision thermometer

- Measuring range: -2 to +80° C
- Divisions: 0.2° C
- Approximate length: 400 mm

PVC tubing, clear

- Length: 50 m
- Inside diameter: 10 mm

Refrigerator, 250 litres

- Household type
- Stainless inner liner
- 5 storage levels

Separating funnels, 250 ml

- Borosilicate glass
- Pear-shaped
- PTFE stopcock
- 24/29 ground-glass stopper
- Supporting platform for two funnels, orifices: 65 mm, distance between axes: 200 mm
- With stainless boss for 12-mm rod

Silica dishes

- Translucent silica
- Useful volume: 50 and 190 ml
- Spherical, with pouring spout and flat bottom

Spectrocolorimeter

- Monochromator with grid
- Wavelength range: 330 to 900 nm
- Accuracy: ± 2 nm
- Pass-band: ± 7 nm
- Numerical display

- Resolution: 0.001 optical density
- Automatic zero
- Light source: tungsten halogen lamp
- One replacement lamp
- Photocell detection
- Absorbance, transmittance, concentration and kinetic modes
- 10-mm cell-holder
- 6 glass cells with 2 polished planes, 10-mm window, 45 mm high, with 10-mm (± 0.01 mm) light path

Storage container, 20 litres

- Low-density polyethylene
- Wide aperture
- Polypropylene screw cap for 100-mm threaded neck
- Two carrying-handles

Thistle funnel

- Borosilicate glass
- Cylindrical
- Volume: 100 ml
- 19/26 ground-glass cone base joint

Three-necked flask, 00 ml

- Borosilicate glass
- Two 19/26 ground-glass side necks angled at 30°
- Central 29/32 ground-glass neck
- Round-bottomed

Vacuum filtration equipment

- 300-ml filter funnel
- Filtration support for filter paper having a diameter of 47 mm
- Seven rubber support joints
- 1-litre vacuum filtration flask

Vacuum pump

- Stainless steel
- Triple pump
- Minimum upstream pressure: 1 bar
- Flow rate at 2 bar: 640 litres per hour

Volumetric flasks, 25 ml

- Standard shape
- Borosilicate glass
- Furnace-enamelled markings
- Accuracy: 0.04 ml
- 10/19 ground joints
- Polyethylene stopper

Volumetric flasks, 50 ml

- Standard shape
- Borosilicate glass
- Furnace-enamelled markings
- Accuracy: 0.06 ml
- 12/21 ground joints
- Polyethylene stopper

Volumetric flasks, 100 ml

- Standard shape
- Borosilicate glass
- Furnace-enamelled markings
- Accuracy: 0.10 ml
- 12/21 ground joints
- Polyethylene stopper

Volumetric flasks, 200 ml

- Standard shape
- Borosilicate glass

- Furnace-enamelled markings
- Accuracy: 0.15 ml
- 14/23 ground joints
- Polyethylene stopper

Volumetric flasks, 250 ml

- Standard shape
- Borosilicate glass
- Furnace-enamelled markings
- Accuracy: 0.15 ml
- 14/23 ground joints
- Polyethylene stopper

Volumetric flasks, 500 ml

- Standard shape
- Borosilicate glass
- Furnace-enamelled markings
- Accuracy: 0.25 ml
- 19/26 ground joints
- Polyethylene stopper

Volumetric flasks, 1,000 ml

- Standard shape
- Borosilicate glass
- Furnace-enamelled markings
- Accuracy: 0.40 ml
- 24/29 ground joints
- Polyethylene stopper

Volumetric flasks, 2,000 ml

- Standard shape
- Borosilicate glass
- Furnace-enamelled markings