OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

FAIR USE POLICY

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

22724

PROJECT FINAL REPORT

PILOT CHROME RECOVERY UNIT, KASUR

UNIDO CONTRACT NO. 99/036/VK

AFTEC
(PVT) LIMITED

PROJECT FINAL REPORT

PILOT CHROME RECOVERY UNIT, KASUR (UNIDO CONTRACT NO. 99/036/VK)

Submitted to

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
VIENNA, AUSTRIA

May, 2002.

Address: 21-A, Gulberg-5, Lahore, Pakistan.
E.mail: aftec@lhr.paknet.com.pk
Tel : (92-42) 5755614-5755615
Fax: (92-42) 5755615

PROJECT FINAL REPORT

PILOT CHROME RECOVERY UNIT, KASUR.

1. THE PROJECT

AFTEC (Private) Limited, Lahore, Pakistan was engaged by United Nations Industrial Development Organization, Vienna, Austria, to establish a "Pilot Chrome Recovery Unit as a Turnkey Project at Kasur", Pakistan. The Plant was established in association with Installation & Fabrication Engineers (Pvt) Limited, Lahore, Pakistan.

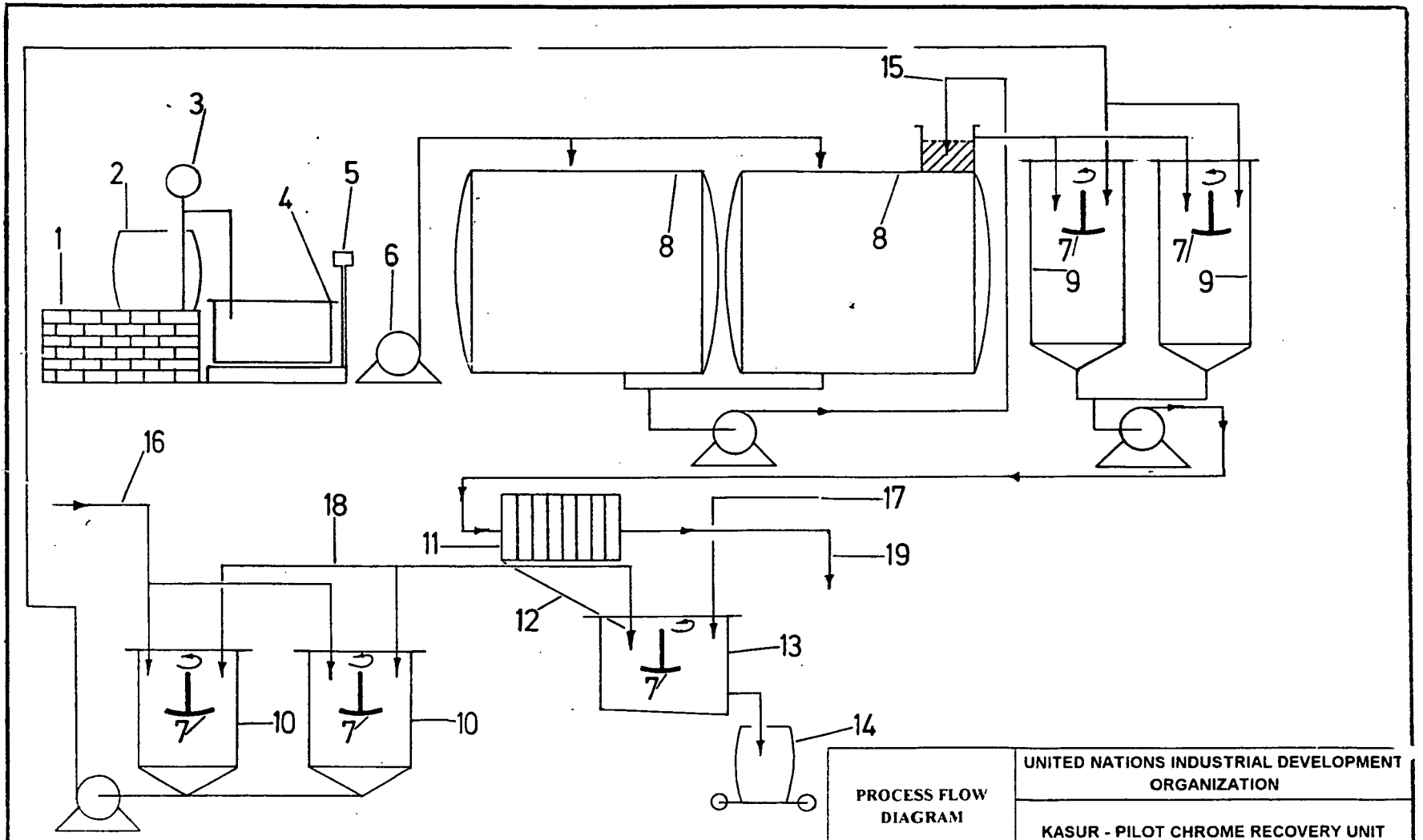
The Project is required to be capable of processing 20 m^3/day of Waste Chrome Liquor with 1,500 to 5,000 ml/liter concentration collected from neighbouring tanneries.

2. PROCESS

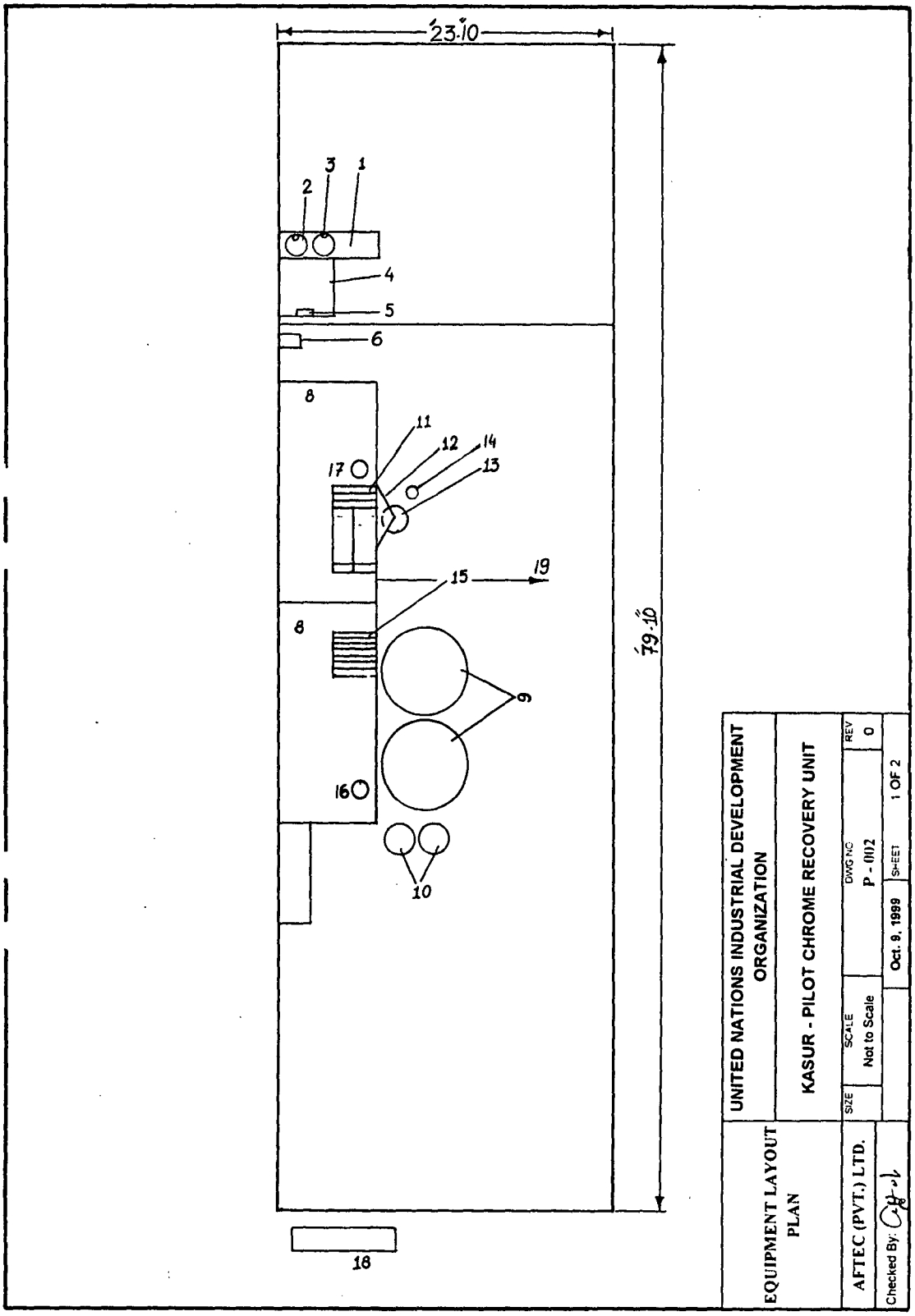
2.1 Process Flow is shown in drawing No. P-001 and Equipment Layout in drawing No. P-002.

The pilot plant is designed to process 20 m^3 of spent chrome liquor per day. It is designed as a pilot plant facility so that it may handle a variety of spent liquors, coming from different tanneries.

2.2 The chrom ium in solution is trivalent and soluble only at acidic pH. It gets precipitated at pH 8 or above. A variety of alkalis can be used for this



PROCESS FLOW DIAGRAM	UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION			
	KASUR - PILOT CHROME RECOVERY UNIT			
AFTEC (PVT.) LTD.	SIZE	SCALE: Not to Scale	DWG NO: P - 001	REV: 0
Checked By:		Oct. 9. 1999	SHEET 1 OF 1	


23.10
79.10
1
2
3
4
5
6
8
8
9
10
11
12
13
14
15
16
17
18
19
UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
KASUR - PILOT CHROME RECOVERY UNIT
EQUIPMENT LAYOUT PLAN
AFTEC (PVT.) LTD.
SIZE
SCALE Not to Scale
DWG NO P - 0012
REV 0
Oct. 9, 1999
SHEET 1 OF 2
Checked By:

ITEM	DESCRIPTION
1	RAMP
2	PLASTIC BARREL
3	SYPHON PUMP
4	WEIGHING RECEPTACLE
5	WEIGH BRIDGE
6	PUMPS
7	AGITATORS
8	EQUALIZATION TANKS
9	REACTORS
10	ALKALI TANK
11	FILTER PRESS
12	SLUDGE CHUTE
13	CHROME SLUDGE DISSOLVER
14	REDISSOLVED CHROME BARREL
15	DE-EMULSIFIER
16	ALKALI SUPPLY
17	ACID SUPPLY
18	WATER SUPPLY
19	EFFLUENT

EQUIPMENT LAYOUT PLAN (Lagend)	UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION			
	KASUR - PILOT CHROME RECOVERY UNIT			
AFTEC (PVT.) LTD.	SIZE	SCALE Not to Scale	DWG NO P - 002	REV 0
Checked By:		Oct. 9, 1999	SHEET 2 OF 2	

purpose and the plant is designed to handle any alkali of choice such as Sodium Hydroxide, Sodium Carbonate, Magnesium Oxide, or Calcium Oxide.

Magnesium hydroxide is commonly used where it is economically available and the chrome recovery plant is installed within a tannery. It has the advantage that the precipitate formed settles readily and a sludge with 25% of the original volume is obtained within a few hours of its addition and the system can be operated without a filter press.

The main draw back of magnesium hydroxide is that the recovered solution is concentrated only four times and contains 25% of the impurities present in the original waste liquor.

The precipitate formed by sodium hydroxide is very fine and does not settle readily. This necessitates the use of a filter press. The advantages are that the recovered chrome solution may be more than 20 times concentrated than the original waste liquor. The level of soluble impurities is also reduced to 5%. If the chrome recovery plant is not installed within a tannery, and the recovered chrome solution needs to be transported, than it becomes essential to use sodium hydroxide route.

2.3 Sulphuric acid and caustic soda are readily available in the local market in Kasur and are available at retail outlets. For this reason only day tanks are provided for stocking these chemicals.

2.4 The pilot plant is designed to receive the spent chrome liquor effluents from different tanneries. The smallest quantity of effluent generated by a tannery may be as small as 224 liters per day and out of a list of 20 tanneries, only four tanneries were generating more than one thousand liters of spent chrome liquor per day and nine tanneries were generating less than five hundred liters per day.

2.5 The most common means of transport employed by tanners at present is donkey cart and the spent chrome liquor is generally collected and transported in plastic (PVC or HDPE) barrels of 100 liters. The market has developed an economical method for transporting the liquor and at present, it is difficult to suggest a better alternative.

2.6 The waste chrome liquor is transported in barrels on a donkey cart, which can not enter the plant building due to narrow access road. It was found convenient to install a sump pump hanging on a gantry. The pump is dipped in the barrel without removing it from the donkey cart and the contents are transferred to measuring receptacle.

At present, there is not a single tannery where waste chrome liquor storage facility is installed. The cart driver collects the waste chrome solution directly from the tanning drum. This poses two problems. Firstly, if the cart driver is not present at the time of decanting the drum, the tanning contractor drains the chrome liquor in the gutter. Secondly, all the fleshings present in the waste liquor are also transferred to the waste liquor collection drum. These fleshings choke the inlet of the sump pump. With the installation of waste chrome collection tanks within the tanneries, these problems shall be solved.

Initially a weigh bridge was installed to measure the waste liquor received. However, the experience showed that the density of the liquid is very close to unity and volume measurement is sufficiently accurate. The measuring tank has 800 liters of effective volume and one centimeter is equal to 13 liters. A graduated dip stick SS 316 has been provided and the volume received from a tannery is collected in the tank and its dip taken before it is transferred to the storage tanks.

A screen with 25 mesh (1 mm) opening with suitable reinforcement is placed on top of the measuring tank and removes most of the solid material present in the waste liquor.

A sample of the solution received is also collected for analysis purpose.

A small cartridge filter with 100 mesh, (0.25 mm) screen is installed between the tank and the transfer pump to further remove fine solids present in the liquor received.

2.6.6 Transfer Pump: 50 (suction) x 37 mm (discharge), mono block, capacity 200 liters/minute, mechanical seal, 3 HP Siemens motor All parts in contact with shall be in SS 316. (One only).

The spent liquor is mostly brought in plastic barrels 35 liters to 200 liters. Sampling is carried out manually by the chemist.

2.7 Since the pilot plant is not installed within the premises of a tannery and shall receive feed solution from a number of small, medium or large size tanneries, it is designed to have a day supply of spent liquor at plant premises, so that the plant may operate smoothly. The designed capacity of the pilot plant is 20,000 liters of liquor per day, but the total capacity of storage tanks is designed at 30,000 liters of liquor. This capacity is divided into two tanks of 15,000 liters of volume each. In this way the variation in the quality and quantity of feed can be handled in a better way. A de-emulsification tank is mounted on the first floor, designed to break up the emulsion, if any.

2.8 Tanks: Quantity 2 nos., Volume 15,000 liters each, Diameter 2,130 mm, Length, 4,300 mm, Thickness 3 mm, with reinforcements, Saddle in CS with SS doublers. Fitted with manhole, level indicator tube, drain etc. All parts in contact with liquid shall be in SS 316.

2.9 De-emulsification tank: (One only) 1,000 mm length, 100 mm width, 600 mm height, 2 mm thick SS 316 sheet material; PVC film packing, embossed and corrugated with 100 sq. meter surface area (approximately).

During the course of operation, hardly any floating organic matter (oil, or grease) has been detected floating on the surface in the de-emulsifier. However, it acts as a packed bed sedimentation tank and collects sludge which needs to be removed periodically.

Originally the plant was designed to handle 50% caustic soda solution. However, it was found that only solid caustic is available in the local market. It is easier to stock and transport solid sodium hydroxide and the system is modified to handle only solid sodium hydroxide.

2.11 Alkali dissolution tanks: quantity two numbers, Volume 250 liters Diameter of tank 550 mm, height 1,100 mm, conical bottom, fitted with agitator, sheet thickness 3 mm, all liquid wetted parts in S S 316.

2.12 Reactors: quantity two numbers, Volume 5,000 liters each, Diameter, 1,700 mm, height 2,200 mm, conical bottom fitted with agitator, sheet thickness 6 mm, fitted with necessary reinforcements, outlets at bottoms and sides. All liquid wetted parts in SS 316, fitted with automatic level controllers.

2.13 Pump: (feed to reactor), Same as specifications as given for item 2.6.6, above.

2.14 Pump: (for alkali feed), 37 (suction) and 25 mm (discharge), capacity 80 liters per minute, One HP Siemens motor.

2.15 If Magnesium oxide is used as alkali, the separation of precipitated sludge may be carried out through simple sedimentation. When Sodium hydroxide is used as alkali, the precipitate does not settle readily and needs filtration. Keeping in view the local conditions a filter press is

designed to filter the sludge. This fitter press has been placed at an elevation.

Originally, the plant was designed for 20,000 liter/day of 24 hours and a stainless steel filter press with 10 frames and ten plates of 600 mm X 600 mm was installed. However, on the advice of UNIDO expert that the plant operation should be completed within eight hours, a polypropylene filter press of the following specification has been installed:

-	Type of Plates	=	Recessed Type
-	Size of Plate	=	600 X 600 mm.
-	Material	=	Polypropylene
-	Operation	=	Manual

Initially, a chute was installed to collect the filter cake and discharge it to the re-dissolution tank. However, with sixty plates, the length of the filter press increased to more than two and a half meters. A screw conveyor was required to col'ect the cake and transfer it to the redissolution tank.

The screw conveyor is 3 meter long and 200 mm diameter. The filter cake discharges directly from the press to the conveyor and passes on to the redissolution tank.

Initially, one filter feed pump was installed but on the advice of UNIDO expert a second filter feed pump has also been installed. One pump is operational and the second pump is standby.

- Pump to filter: Maximum static pressure 3.5 Bars, Maximum flow rate 200 liter/

minute, Fitted with mechanical seal, Suction 50 mm, Delivery 37 mm. 3 HP Siemens motor, all liquid wetted parts in SS 316.

- The filter is provided with a screw conveyor at the bottom of filter press to remove the filter cake from filter press to redissolution tank.

- In case, the filter press is not used, the feed to filter pump can be used to .pump the sludge to the redissolution tank

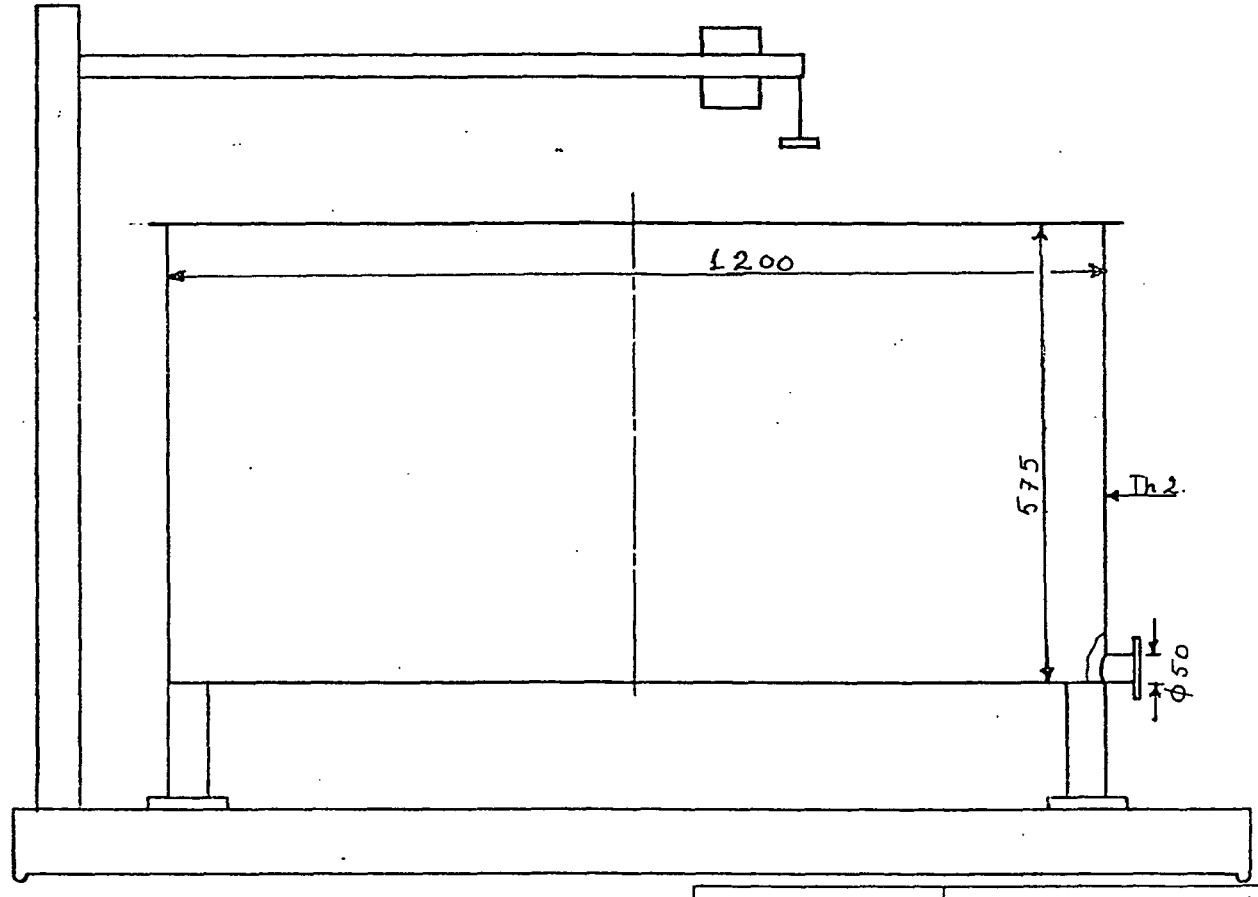
2.16 The filter cake is dissolved in sulphuric acid. The recovered Chromium sulphate solution is a concentrated solution. It is stacked in plastic barrels of 100 liter volume, which are extensively being used by tanners for handling different chemicals. These containers are filled by gravity.

2.17 Specifications of Acid Handling are as under:-

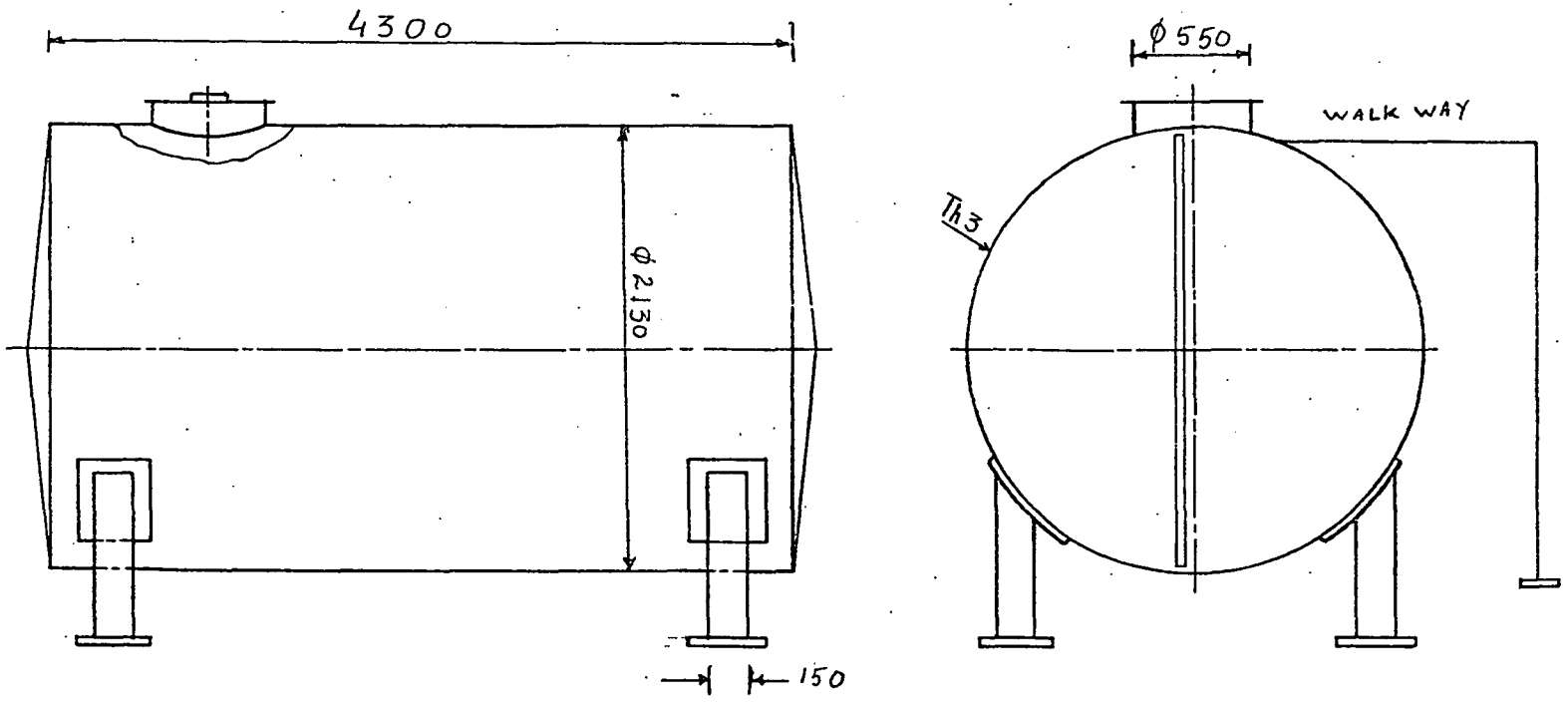
Acid Handling:

-	Storage Tank	=	Polypropylene
-	Size	=	900x900x450
-	Volume	=	300 litres.
-	Acid Pump	=	25 x 37 mm centrifugal pump.
-	Motor	=	One H.P.
-	Capacity	=	50 liter per minute.

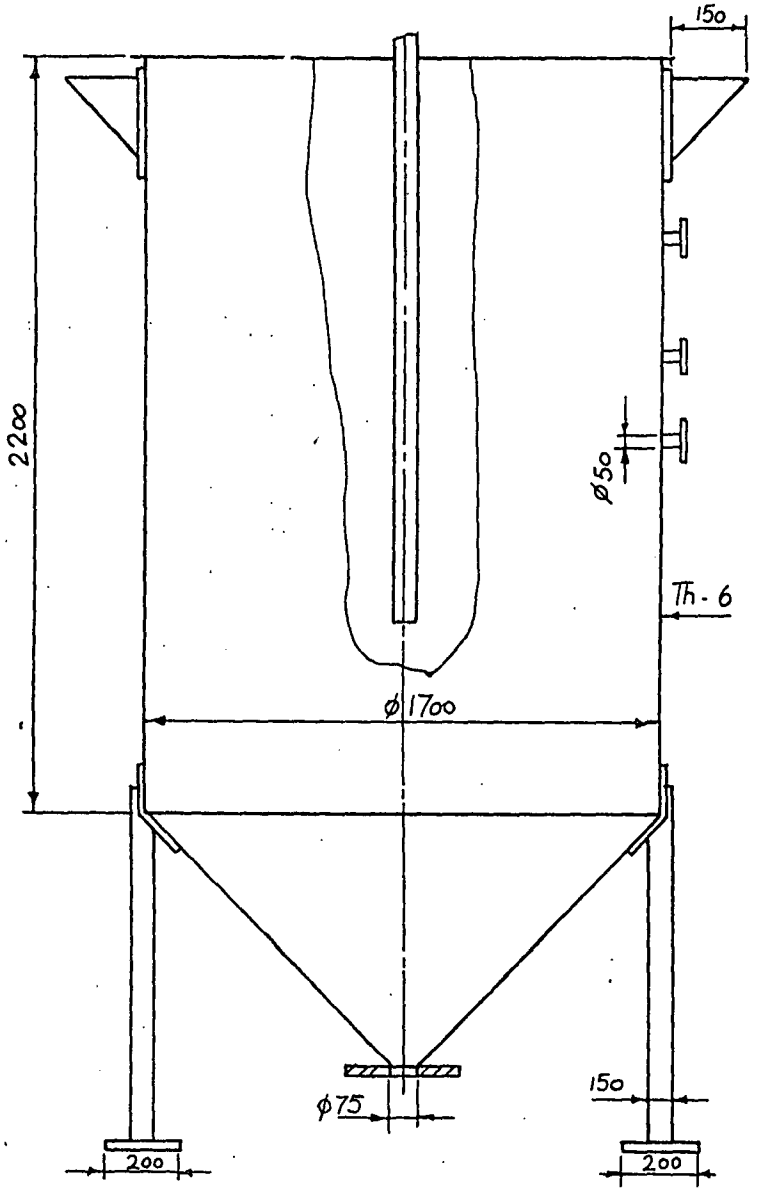
2.18 The equipment details are shown in Drawing Nos. E001 to E006.



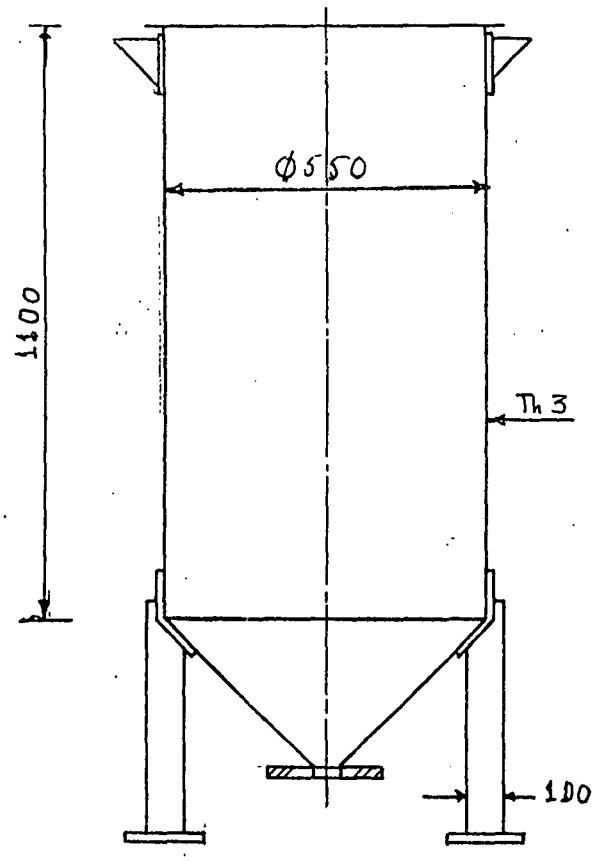
WEIGH BRIDGE & RECEPTACLE ITEMS - 4 &5	UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION			
	KASUR - PILOT CHROME RECOVERY UNIT			
AFTEC (PVT.) LTD.	SIZE	SCALE: Not to Scale	DWG NO: E - 001	REV: 0
Checked By:		Oct. 9, 1999	SHEET: 1 OF 1	



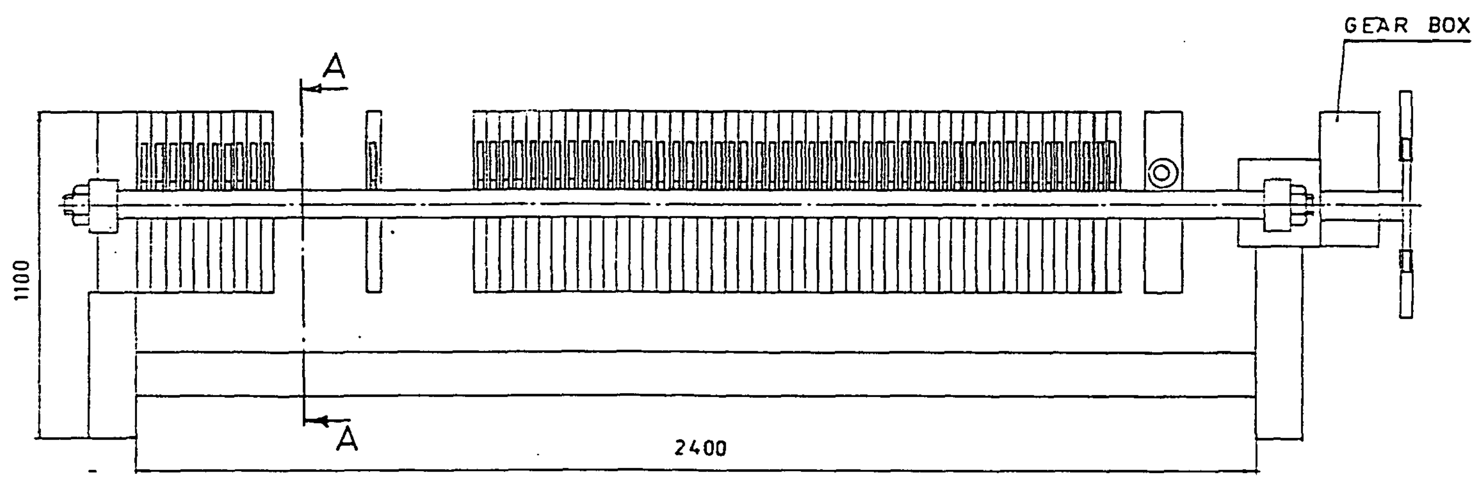
EQUALIZATION TANKS ITEM - 8	UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION			
	KASUR - PILOT CHROME RECOVERY UNIT			
AFTEC (PVT.) LTD.	SIZE	SCALE: Not to Scale	DWG NO: E - 002	REV: 0
Checked By: GH-L		Oct. 9, 1989	SHEET: 1 OF 1	



REACTOR ITEM - 9	UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION			
	KASUR - PILOT CHROME RECOVERY UNIT			
AFTEC (PVT.) LTD.	SIZE	SCALE Not to Scale	DWG NO E - 003	REV 0
Checked By:		Oct. 9, 1999	SHEET 1 OF 1	

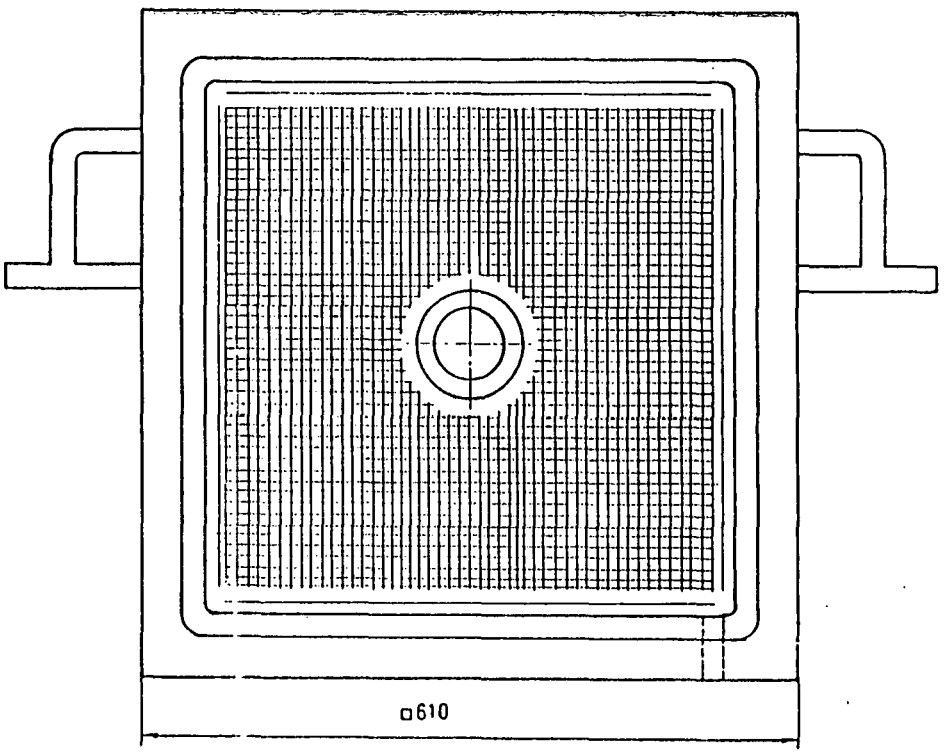


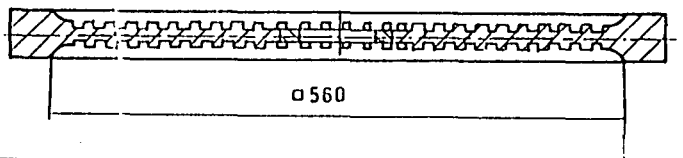
ALKALI TANK ITEM - 10	UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION			
	KASUR - PILOT CHROME RECOVERY UNIT			
AFTEC (PVT.) LTD.	SIZE	SCALE Not to Scale	DWG NO E - 004	REV 0
Checked By:		Oct. 9, 1999	SHEET 1 OF 1	

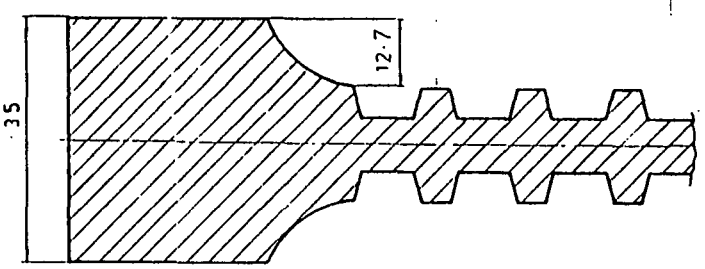


NOTE		NAME	SIGN	DATE
	DRAWN BY	ARIF ALI	[signature]	19-6-2000
CLIENT	CHECKED BY	M. ASLAM	[signature]	20/06/2000
	APPROVED BY	AFTAB AHMAD	[signature]	21/06/2000
FILTER PRESS	SCALE :	DRG. No. E-005/A		
	AFTEC (Pvt) Ltd. Lahore.			

AFTEC (Private) Limited







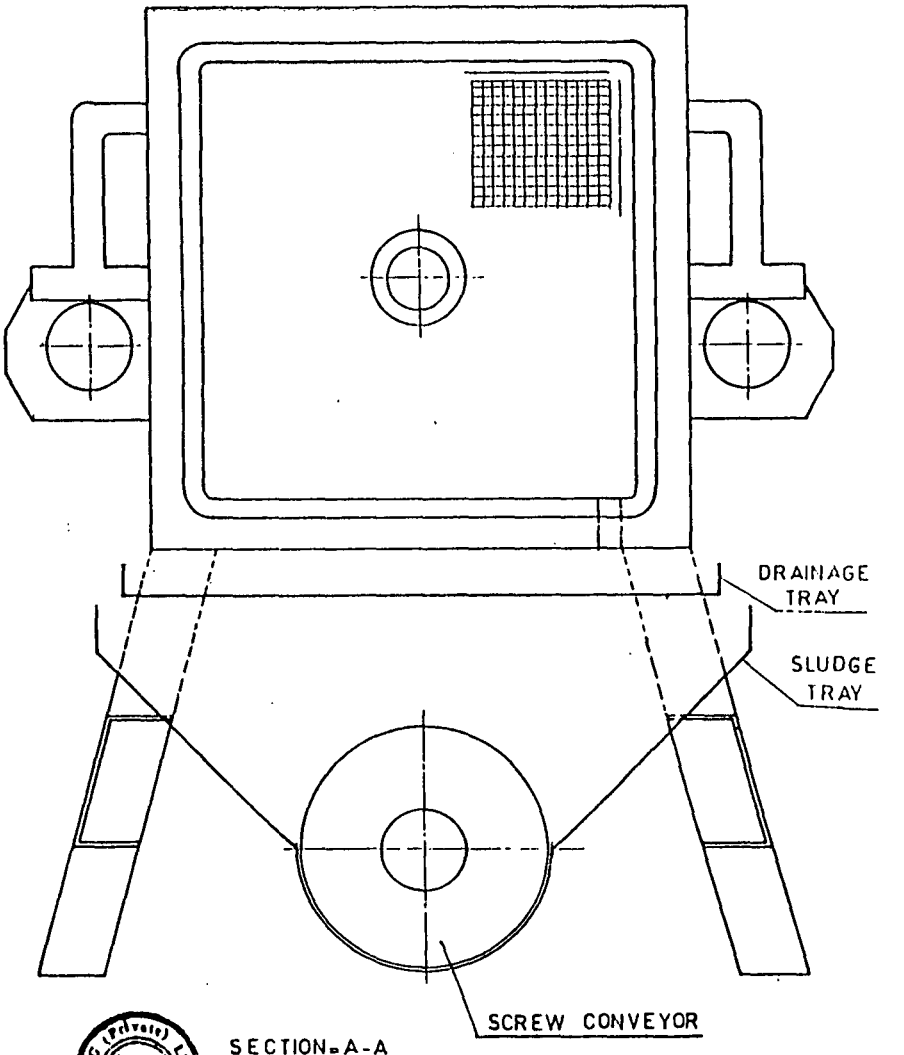
NOTE

CLIENT

	NAME	SIGN	DATE
DRAWN BY	ARIF ALI		19-6-2000
CHECKED BY	M. ASLAM		20/06/2000
APPROVED BY	AFTAB AHMAD		21/06/2000
SCALE :	DRG. No.	E-005/B	

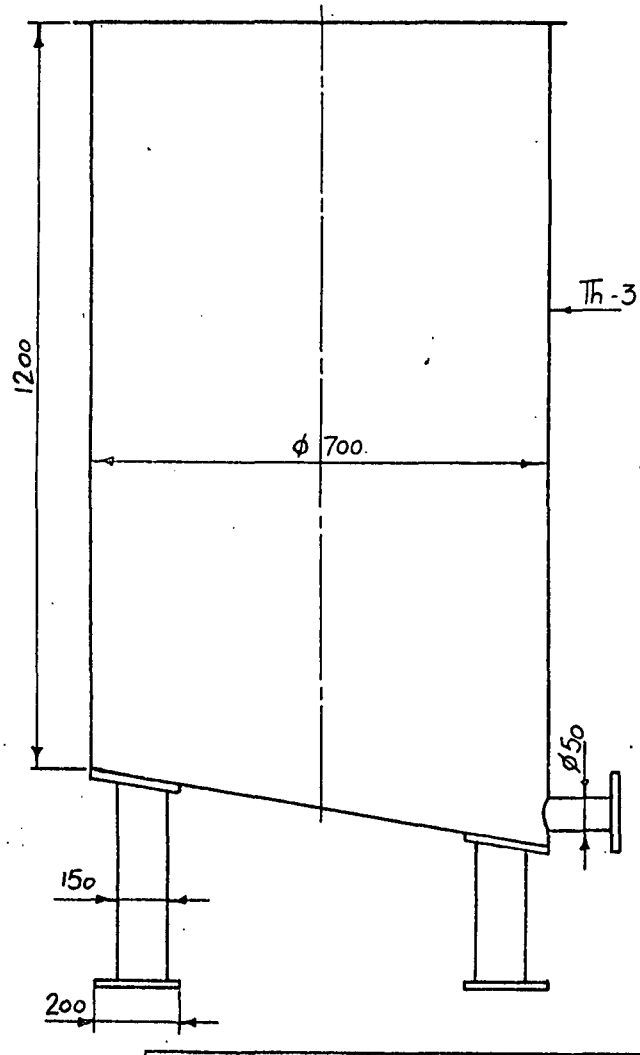
PLATE
(Filter Press)

AFTEC (Pvt) Ltd. Lahore.



SECTION-A-A

NOTE		NAME	SIGN	DATE
	DRAWN BY	ARIF ALI		19-6-2000
CLIENT	CHECKED BY	M. ASLAM		20/06/2000
	APPROVED BY	AFTAB AHMAD		21/06/2000
	SCALE :	DRG. No.	E-005/C	
FILTER PRESS	AFTEC (Pvt) Ltd. Lahore.			



CR. SLUDGE DISSOLVER ITEM - 13	UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION			
	KASUR - PILOT CHROME RECOVERY UNIT			
AFTEC (PVT.) LTD.	SIZE	SCALE: Not to Scale	DWG NO: E - 006	REV: 0
Checked By: CHZ		Oct. 9, 1999	SHEET: 1 OF 1	

3. THE PROJECT PERFORMANCE:

3.1 Operational Trials No. 1 & 2

These two trial-runs were conducted on April 21 and 25, 2000, using stainless steel filter press.

Operational Data

* Quantity of Waste Chrome Liquor Batch Used for Each Trial = 5,000 liters

* Total Time Utilized for Completion of Each Trial = Less than 2 hours.

* Trial Run Data is attached in the following pages.

* First Delivery of Waste Chrome Liquor started on April 6, 2000 and till end May 2, 2000, 18,804 kg of waste liquor has been received at the Pilot Unit. Out of this quantity, for two trials, 10,430 kg has been used.

* Waste Liquor has been received from four (4) tanneries.

* Two batches, 200 liters and 250 liters, of Recovered Chromium Sulphate Liquor have been prepared during Trial-Run No.1 & 2.

Trial-Run No. 1

Date of Test-Run	=	April 21, 2000
First Batch of Waste Chrome Liquor Received on April 6, 2000	=	360 kg. (348 liters)
Total Quantity of Waste Liquor Received on morning of Trial-Run [Period April 6 – April 20, 2000]	=	8,542 kg. (8,261 Liters)
Quantity of Waste Liquor Used for Trial-Run	=	5,000 liters.
Duration of Processing in Reactor No.1	=	25 minutes
Duration of Operation of Filter Press	=	1 hour.
Quantity of Recovered Liquor Containing Basic Chrome Sulphate	=	200 liters

Analysis of Recovered Basic Chromium Sulphate Solution:

*	Basic Chromium Sulphate	=	73 gms/liter
*	pH	=	3.5

Trial-Run No. 2

Date of Trial-Run:	=	April 25, 2000
Waste Liquor Available on Morning of Trial-Run	=	6,251 kg (6,045 liters)
Total Quantity of Waste Liquor Received on morning of Trial-Run [Period April 6 – April 24, 2000]	=	11,251 kg (10,880 liters)
Quantity of Waste Liquor Used for Trial-Run	=	5,000 liters.
Duration of Processing in Reactor No.1	=	22 minutes
Duration of Operation of Filter Press	=	1 hour.
Quantity of Recovered Liquor Containing Basic Chrome Sulphate	=	250 liters

Analysis of Recovered Basic Chromium Sulphate Solution:

*	Basic Chromium Sulphate	=	84 gms/liter
*	pH	=	3.5

3.2 Operational Trials No. 3

This trial-run was conducted on May 15, 2000.

Operational Data

* Number of Trials Conducted = One (1)

* Quantity of Waste Chrome Liquor Used for Performance Test. = 10,000 liters

* One day of Performance Test, Waste Tannery Chrome Liquor available was 18,874.5 liters as per details shown in Table-1. Out of this quantity, only 10,000 liters, in two batches of 5,000 liters could be utilized for the Test, as further test could not be carried out due to electricity supply fluctuations.

* Waste Liquor has been received from six (6) tanneries. (Details in Table-1).

* Total Time Utilized for Completion of the Test =Nine(9) Hours.

Data on Waste Chrome Liquor Received from Tanneries:

* Total volume of waste chrome liquor from each tannery and analysis of composite sample is given below:-

Tannery	Total Waste Chrome Liquor Available for Test (liters)	Analysis of Composite Sample, Chrome, (mg/liter)	Equivalent BCS Available for Processing, (kgs.)
Shahqaddar	2,517.2	2,549.1	38.7
Saddar Ali/ Akhtar Ali	1,628.1	3,533.1	34.7
Goodluck	1,826.0	2,048.1	22.6
Yousaf	1,565.3	2,388.8	22.5
Aleem Azam	2,342.8	3,747.5	52.9
Raji	120.6	2,166.3	1.6
TOTAL	**10,000.0**		**173.0**

Note: BCS is Basic Chromium Sulphate, calculated from Composite Sample Analysis

Recovered Chromium Sulphate

After completion of Test Run, using 10,000 liters of waste liquor received from tanneries, the following product was obtained:

* Total Recovered Solution Produced = 730 liters
* Chromium Content of Recovered Solution = 47.07 gm/liter.
* Equivalent Content as BCS in Recovered Solution =234.88 gm/liter
* Total Equivalent BCS Recovered = 171.46 kg.
* Recovered Solution pH = 3.02

Operational Yield of the Plant

* Input equivalent BCS in 10,000 liters = 173.0 kg.

* Output equivalent BCS in 730 liters Recovered Solution = 171.46 kg.

* Yield = 99.1%

Consumption of Operational Chemicals (for 10,000 liters of waste liquor)

* Caustic Soda, flakes, 96% = 43 kg.

* Sulphuric Acid, 98% = 44 kg.

Cost of Chrome Recovery

* The cost of recovery indicated below is direct cost of operating chemicals. It does not include electricity, labour, supervision, handling & delivery of waste liquor, and overheads.

* Cost of Operational Chemicals is as below:-

  - Caustic Soda, 43 kg. for Test Run @ Rs. 24/kg (Sitara Flakes) = Rs. 1,032

  - Sulphuric Acid, 44 kg. for Test Run @ Rs. 5/kg. = Rs. 220

  - Total Direct Chemicals Cost = **Rs. 1,252**

* Equivalent Basic Chromium Sulphate (BCS) Produced. = 171.46 kg.

* Cost of Chemicals. = Rs. 7.30 per kg. of Recovered Equivalent BCS

* It is estimated that at 100% capacity utilization other operational & overhead costs would range at Rs. 3 to 5 per kg. of equivalent recovered BCS.

4 MODIFICATION TO THE PILOT PLANT

Mr. M. Aloy, UNIDO Consultant, after inspection and various trial-run during his presence recommended certain modifications. Major modification included a larger filter press to handle 20 m^3 of Waste Chrome Liquor in eight (8) hours instead of 20 hours designed originally. The larger filter press plates were recommended to be made of plastic materials or fiber-glass.

5 OPERATIONAL TRIALS NO. 4 & 5

After modifications completion and availability of sufficient waste chrome liquor, trials-run were carried out on December 4 and 6, 2000 to prove the revised capacity of the Project.

Operational Data:

* Quantity of Waste Chrome Liquor Processed = 10,000 liters (each day).

* Duration of Trial-Run = 2.5 hours each day

Note:- Unfortunately, the trial-run could not be carried out continuous to process 20,000 liters due to electric power break-down and fluctuations. The trial-run confirmed that 20,000 liters can be processed in total of 5 hours instead of designed 8 hours. The overall chrome recovery in both trial-runs ranged at 99.9% and 99.8% respectively.

6 OPERATIONAL TRIALS NO. 6

At the request of Kasur Tannery Waste Management Agency (KTWMA), another trial was carried out on February 15, 2001. During this trial, only 10,000 liters of waste chrome liquor was processed due to non-availability of sufficient sulphur acid (procured by KTWMA). The duration of processing 10,000 liters was 2.45 hours with chrome recovery of 99.9%.

7 OPERATIONAL TRIALS NO. 7 TO 10

At the request of KTWMA, three trials were carried out on following dates:

- February 21, 2001.
- February 28, 2001
- March 02, 2001

All the above trial-runs were successfully performed indicating that 20 m^3 of waste chrome liquor was processed in 5 to 6 hours, with chrome recovery efficiency ranging at 99.85% to 99.9%.

8. PRESENT STATUS OF PILOT PLANT

Since the initial trials-runs in April & May, 2000, the Pilot Plant is being operated by the staff of KTWMA. No process, equipment or design problems have been observed after modifications in December, 2000.

For & On Behalf of
AFTEC (Private) Limited

(AFTAB AHMAD)
Chief Executive