UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANISATION

REGIONAL PROGRAMME FOR POLLUTION CONTROL IN THE TANNING INDUSTRY IN SOUTH EAST ASIA

US/RAS/92/120-MODEL CETPs

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COMMON EFFLUENT TREATMENT PLANT PALLAVARAM, CHENNAI, INDIA

Prepared by

A. Sahasranaman, K. V. Emmanuel
Regional Programme Office

Project Manager

Jakov Buljan, SIDO, UNIDO, Vienna

TABLE OF CONTENTS

Annexures

LIST OF SYMBOLS & ABBREVIATIONS

BOD_5	:	Biochemical oxygen demand, 5 days
BoD	:	Board of directors
CETP	:	Common effluent treatment plant
CMDA	:	Chennai Metropolitan Development Authority
COD	:	Chemical oxygen demand
CO_2	:	Carbon dioxide
cm	:	Centimetre
^0C	:	Degree Celsius
DS	:	Dry solids
d	:	Day
dia/Ø	:	Diameter
FB	:	Free board
F/M	:	Food to micro organism ratio
h	:	hour(s)
HRT	:	Hydraulic retention time
HDPE	:	High density poly ethylene
INR	:	Indian Rupees
kg	:	Kilogram(s)
kW	:	Kilowatt(s)
l	:	Litre(s)
m^3	:	Cubic meter (1000 litres)
mg/l	:	Milligrams per litre
min	:	Minutes
MLSS	:	Mixed liquor suspended solids
MLVSS	:	Mixed liquor volatile suspended solids
ND	:	Not detected
no	:	Number
RPM	:	Revolutions per minute
pH	:	Negative logarithm of hydrogen ion concentration
SWD	:	Side water depth
SDB	:	Sludge drying beds
US $	:	US Dollar(s)
TDS	:	Total dissolved solids
TNPCB	:	Tamil Nadu Pollution Control Board
t	:	Tonne (1000 kg)
TEFC	:	Totally enclosed fan cooled
W	:	Watts

Rate of exchange: 1 US $ = INR 46.80

1. INTRODUCTION

Pallavaram, now a part of the CMDA and less than 3 kilometers south of Chennai airport, has a cluster of 150 tanneries. Though it was away from residential areas when the tanneries came up nearly a century ago, now it has become a part of the city with a substantial population residing there. Density of population is quite high and land is scarce. Accordingly designing and creating a CETP for tanneries in this location was an absolute need and a challenge.

1.1. General information

Total number of tanneries	158
Number of tanneries operating now	152
Number of tanneries processing raw hides/skins to semi finished stage	9
Number of tanneries processing raw hides to finished leather	143
Raw material processed	Buffalo & cow calf hides, goat & sheep skins
Total production capacity of tanneries, as per design of CETP	55,000 kg/day
Current production in the cluster	47,000 kg/day
Number of tanneries doing chrome tanning	9
Number of tanneries processing wet blue leather	12
Number of tanneries processing vegetable tanned leather	131
Approximate ratio of effluent from raw tanning: finishing effluent	10:90
Designed flow rate to the CETP	3000 m^3/day
Current flow rate to the CETP	2600 m^3/day
Commissioning date of the CETP	February 1995
Total area covered by the CETP	0.8 hectares
Total length of effluent conveyance pipeline	23 km
Number of pumping stations	7
Total project cost in Indian rupees	83 million

2. FEATURES OF THE CETP

The CETP was the second to be commissioned for treatment of tannery effluent in Tamil Nadu, India. With the technical assistance of UNIDO, the CETP registered many innovative features such as:

- Mechanically cleaned screen for removal of solids
- Ejector aerators in equalization tanks
- Diffused aeration system
- Belt press filter for sludge dewatering

The CETP was designed to provide for all important units (such as equalization tank, clariflocculator, aeration tank, clarifier) in two parallel sets so that one half of the CETP only could be operated when it received a lower volume of effluent.

3. PROJECT PLANNING & EXECUTION

3.1. Design

The basic design of the project was done by Enkem Engineers, Chennai. It was later modified by the UNIDO subcontractor, M/s. TEH-PROJEKT, Croatia, in consultation with the main contractor selected for turnkey implementation of the project, UEM India Private Ltd., New Delhi.

3.2. Finance

The CETP was given a total subsidy of INR 10 million by the state and the central governments. The tanners contributed INR 10 million and an amount of INR 46 million was taken as loan from Industrial Development Bank of India. UNIDO had contributed hardware worth INR 11 million.

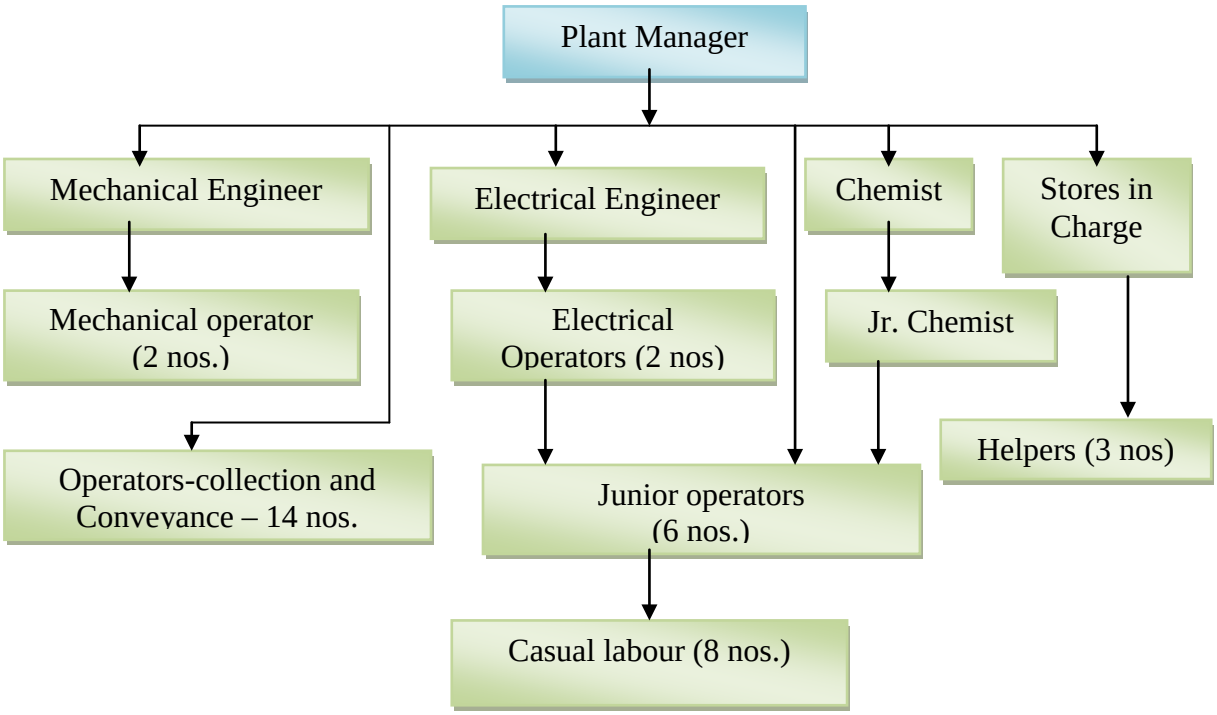
3.3. Implementation

The project was implemented by a company formed by the tanners of the Pallavaram area by name Pallavaram Tanners Industrial Effluent Treatment Co. Ltd. (PTIET) and UNIDO made available the services of a Project Officer for its implementation.

M/s. UEM India P. Ltd., New Delhi undertook the construction of the CETP on turnkey basis and implementation of collection & conveyance system was undertaken by the PTIET employing a local contractor. Tamil Nadu Pollution Control Board was the counterpart of UNIDO and took the overall responsibility for monitoring the implementation of the project.

3.4. Management

The management of the CETP is done by a BoD headed by a Chairman, who is assisted by a Managing Director. The administrative head of the CETP is a qualified engineer.
The organigram of the CETP as at present is as follows:



3.5. Recovery of operational cost

The cost of operation and maintenance of the plant, repayment of loan with interest and other expenditures relating to the plant are covered by monthly contributions made by the tanner members according to their respective production capacity.

Two types of charges are being collected. The fixed cost, which covers loan repayment, salary of staff and regular maintenance expenditure etc., is charged based on the installed capacity of the tannery @ INR 3,500 per drum per month. Additionally, a variable charge, based on actual production, is charged which varies from INR 5,000 - INR 15,000 per month per tannery.

At present, the average collection from individual tanners is in the range of INR 8,500 to INR 29,000 depending on the actual production.

For unforeseen expenses or new investments, special contributions are collected from the members, pro-rata.

4. PROCESS FLOW

4.1. Pre-treatment in tanneries

4.1.1. Chrome segregation

Out of the nine tanneries processing raw hides & skins, only seven were processing raw hides / skins during the project design. As these were all small-scale units, it was decided to have a common chrome recovery unit (CRU) for these tanneries. Accordingly a common chrome recovery unit was installed in Arafath Leathers by UNIDO based on the design of Central Leather Research Institute (CLRI), Chennai.

The tanneries connected to the CRU made arrangement within their premises for segregation of chrome liquor and collecting it in a chrome collection tank of 3 m x 3 m x 1.5 m.

4.1.2. Pre-treatment of effluent other than chrome liquor

The pre-treatment unit in each tannery consists of a grit chamber of size 1.5 m x 1.0 m x 1.0 m and two coarse bar screens (MS construction) of 10 mm bar spacing. Bar racks have been provided for cleaning the screen manually. The grit and screenings separated are taken to a plastered floor for dewatering and for onward disposal in the sludge dumping site of the CETP. Details of pre-treatment is given in Dwg. 1 in Annex 2.

4.1.3. Collection & conveyance system

Effluent from pre-treatment units is admitted into the manhole of the main collection line [HDPE pipes, diameter varying from 110 to 200 mm) that extends to a collection well by gravity. There are seven collection wells constructed in various locations of the tannery cluster. Each collection well is equipped with one coarse screen and two submersible pumps of varying capacity (from 11 kW to 45 kW). The effluent is pumped from the collection wells to the CETP. Details of pre-treatment is given in Dwg. 2 in Annex 2.

4.2. Treatment process

The seven collection wells receive effluent from 142 tanneries, which is pumped to the receiving sump. Eight tanneries discharge effluent directly into the receiving sump by gravity. The effluent collected in the receiving sump is pumped through a mechanically cleaned screen (Konica model, Italprogetti make) shown in figure 1.

Fig 1. Mechanical Screen

Fig 2. : Ejector aerator in the equalization tank

The effluent then is passed through a grit chamber and collected in two numbers of equalization tanks provided with submerged ejector aerators. The ejector aerators homogenize the effluent, besides oxidizing sulphides present in the raw effluent.

A view of the ejector aerator is given in figure 2.

The equalized effluent is then pumped to the flash mixer where alum, lime and polyelectrolyte slurry are added.

The effluent thereafter enters two clariflocculators where the chemical sludge settles in the bottom. The physico-chemical treatment removes approximately 25-30% of BOD, 35-45% of COD and almost all chromium. The overflow from the clariflocculators is admitted into two aeration tanks provided with fine bubble diffused aeration system which comprises of 1,200 tubular membrane diffusers (Aertec make) the air supply for which is provided by 5 positive displacement blowers (Roots make). The biological treatment removes 90-95% of BOD and 85-90% of COD. The overflow from the aeration tanks with active biological solids is admitted into two secondary clarifiers. The settled sludge in the clarifiers is pumped back to the aeration tank to maintain the bacteriological population. Some quantity of sludge is wasted by diversion to the sludge thickener. The overflow from the clarifiers is the treated effluent and it is discharged into the Adyar river through a pressure pipeline. A part of the treated effluent is filtered using pressure sand filter and used for process applications in the CETP.

The sludge settled in the primary clariflocculator is taken to a sludge well and then pumped to a sludge thickener. The thickened sludge is dewatered in a belt press filter (Italprogetti make) and a portion of the sludge is dewatered in sludge drying beds. The dewatered sludge is disposed of in a sludge dumping site. The system is regularly operating for the past over six years.

5. CETP UNITS AND SPECIFICATIONS

The layout and the process flow of the CETP is given in Dwg 3 and 4 in Annex 2.

Treatment step	Description/service	Dimension/capacity
	Plant design capacity	3000 m^3/day
Primary treatment		
Coarse screening	1 no. manually cleaned screens	15 mm bar spacing
Pumping	Circular RCC receiving sump of 140 m^3, 3 nos. submersible pumps, 22..5 kW each	Retention time 30 min Pump capacity 300 m^3/h each
Fine screening	1 no. drum screen, Konica model, self cleaning type	3 mm bar spacing Capacity: 450 m^3/h
Grit removal	1 no. grit removal comprises of grit settler, screw type grit conveyor and grit washer	Capacity: 450 m^3/h, retention time 50 seconds.
Equalisation	2 nos. rectangular tank	Capacity 1,300 m^3 each, total retention time 21 h
	Aeration/mixing: 4 nos ejector type pump aerator 18.5 kW each	Specific mixing power 28.7 W/m^3
Equalised effluent pumping	3 nos. centrifugal pumps of 11.5 kW each	Capacity 125 m^3/h each
Flocculation	Flash mixer with 1.5 kW agitator Chemicals: alum (Al_2SO_4. 16 H_2O_2), lime ($Ca(OH)_2$) and anionic polyelectrolyte	Capacity 8 m^3 Retention time 3.8 min
Primary sedimentation	2 nos circular clariflocculators with sludge scraper 12 m dia, flocculator portion 6 m dia with comb type mechanism	Capacity clarifier 300 m^3, flocculator 42 m^3, total retention time clarifier 4.8 h, flocculator 40 min
Biological treatment		
Biological aeration	2 nos. rectangular tanks with diffused aeration 1,200 no. retrievable type tubular diffusers (600 in each tanks) powered by 5 (3 working + 2 standby) positive displacement type blowers of 37.3 kW each, diffuser sleeve material EPDM	Capacity 2,400 m^3 each Total retention time 1.6 days Specific mixing power 23.3 W/m^3
Sedimentation	2 nos. circular tank 12 m dia with scrapper, recycle of biological sludge: 3 nos. submersible pumps 11.5 kW each	Capacity 250 m^3 each, total retention time 4 h, pump capacity 125 m^3/h each
Sludge treatment		
Design capacity	About 1,500-3,000 tonnes DS per year	
Sludge thickener	1 RCC circular tank 12 m dia with scrapper	Capacity 340 m^3

Sludge dewatering	1 no. belt press filter Diemme make, 2 m cloth width, with polymer dosing, flocculator and cake conveyor 6 nos. sludge drying beds	Capacity of belt press filter 450 kg DS/h Total SDB area 960 m^2

Note: The addresses of suppliers may be seen at Annex 1.
The dimensions of the CETP units can be seen in drawings at Annex 2.

6. OPERATIONAL FEATURES

6.1. Operational parameters

Operational parameter	**Factors maintained at present**
Chemical dosage prior to primary clarifier	200-300 ppm of alum and 600 ppm of lime. Anionic polyelectrolyte at the rate of 1 ppm.
Nutrients	No nutrient is added at present.
Dissolved oxygen	DO level in aeration tank-1 is 1.0 mg/l and in aeration tank-2, 2.5 mg/l.

Sludge re-circulation	Around 55%
MLSS concentration	Aeration tank-1, 3,500 mg/l and aeration tank-2, 2,200 mg/l
Sludge wasting	Approximately 10% of the aerobic bio-sludge
Screenings removal and sludge withdrawal timing	The screenings are removed once in a shift. Sludge from primary clarifier is withdrawn once in two or three hours.

Maintenance	
Oiling and greasing cycle	15 and 20 days respectively
Frequency of painting	Once a year

Power consumption	
Total connected load	440 kW
Operating load	310 kW
Capacity of diesel generating set	330 kW

6.2. Laboratory

The CETP has a laboratory, accommodated in two rooms in the first floor of the administration building.

Room No. 1 is generally used for the main analysis. The equipment available in this room are:

#	Instrument/equipment	No. of units
1.	Hot air oven	3
2.	Fume cupboard	1
3.	COD apparatus	1
4.	Distilled water still	1
5.	Electric Bunsen	2
6.	Heating mantle	3
7.	Vacuum pump	2
8.	BOD incubator	1
9.	Refrigerator.	1
10.	Glass wares & Chemicals	

Room no.2 is used as the instrumentation room. The instruments in this room are:

#	Instrument/equipment	No. of units
1.	Spectrophotometer	1
2.	pH meter	2
3.	Automatic sampler	1
4.	Dhona monopan balance.	1

6.3. Analyses done in the laboratory

Various analyses done in the laboratory are as follows:

Parameter	Raw effluent	Equalised raw effluent	Clariflocculator outlet	Final treated effluent
pH	Daily	Daily	Daily	Daliy
Suspended solids	Daily	Daily	Daily	Daily
Total suspended solids		Daily	Daily	Daily
Chlorides		Weekly		Weekly
Sulphides	Daily	Daily		
Sulphates		Weekly		Monthly
BOD_5	Daily	Daily	Daily	Daily
COD	Daily	Daily	Daily	Daily
Total chromium	Daily	Daily	Daily	Daily
Phosphates		Weekly		Weekly
Ammonia nitrogen		Weekly	Weekly	Weekly
Nitrates				Weekly

Parameter	Aeration tanks	Treated effluent
DO	Daily	Daily
MLSS	Daily	
MLVSS	Daily	

6.4. Manpower

Following key technical personnel are available in the CETP:

Personnel	Qualification & experience
Plant Manager	B.Tech. with 2 years experience in ETP management
Electrical Engineer.	Graduate in mechanical engineering with 6 years experience
Sr. Chemist	B.Sc. Chemistry with 5 years experience in effluent testing
Chemist	B.Sc. Chemistry, 6 years experience in effluent testing
Civil Engineer	Diploma in civil engineering with 2 years project experience
Stores in charge	Graduate with 3 years experience in material management

6.5. Monitoring

Following is the list of log sheets presently maintained by the CETP:

- Pumping details
- Chemical dosage and stock
- Aeration details
- Complaints register
- Store and spare parts register
- Maintenance schedule

The plant manager reviews the log sheets daily and necessary instructions for modifications in operation and maintenance are given in consultation with chemists and other engineers.

7. EFFLUENT CHARACTERISTICS BEFORE & AFTER TREATMENT

(Average for the period from December 1999 to June 2001)

Parameter	Unit	Raw effluent	After chemical treatment	Final treated effluent	TNPCB norms*
pH		5.9	7.1	7.2	5.5 – 9.0
Suspended solids	mg/l	1,185	225	148	100
BOD	mg/l	1,452	1,125	132	30
COD	mg/l	4,210	2,955	890	250
Chromium	mg/l	56	13	5	2
Sulphides	mg/l	64	15	2	2
TDS	mg/l	5,150	4,810	4,822	2,100

for discharge to inland surface waters

Note: ***The above values indicate the average during the period mentioned. During April-May 2001, some modifications were carried out in the CETP resulting in marked improvement in the CETP performance and the average values of COD and BOD_5 after June 2001 until September 2001 were 320 mg/l and 41 mg/l respectively.***

8. COST OF TREATMENT

(Average for the period from 1 January 2000 to 30 June 2001)

Cost component	Cost in INR	Cost in US$
Power	521,622	11,146
Chemicals	122,330	2,614
Salary & labour	96,152	2,055
Repair and maintenance	341,355	7,294
Laboratory analysis	11,450	245
Sludge dewatering	85,625	1,830
Miscellaneous	26,424	565
Consents & license	2,919	62
Loan repayment	2,030,769	43,392
Other costs (R&D etc.) lumpsum	242,583	5,183
Depreciation on investment	885,833	18,927
Total	4,367,062	93,313

Treatment cost per cubic meter of effluent: INR 55.3 (US$ 1.19)
Treatment cost per kg of BOD removed: INR 41.93 (US$ 0.90)
Treatment cost per kg of COD removed: INR 16.67 (US$ 0.36)
Total treatment cost per square ft. of leather: INR 0.7 - 0.9 (0.15 – 0.19 US cents)

(RoE: 1 US $ = INR 46.8)

9. UNIDO ASSISTANCE

Besides giving technical assistance for the design, implementation and ongoing operation and maintenance, UNIDO assisted the CETP in obtaining certain vital equipment like the mechanical screen, diffused aeration system and belt press filter.

UNIDO assisted the CETP in development of the environmental laboratory too.

UNIDO's investment in the CETP is US$ 280,000.

UNIDO had organized a three-week in house training program for the operating staff of the CETP during December 1997 and January 1998.

Besides this, a number of training workshops organized by UNIDO were participated by key staff members of the CETP. These also included training in occupational safety & health of workers of the CETP.

10. CLRI/NEERI INTERVENTIONS

In 1997, AISHTMA (All India Skin and Hide Tanners & Merchants Association), Chennai had engaged Central Leather Research Institute (CLRI) and National Environmental Engineering Research Institute (NEERI), the two leading national organizations to study the tanneries connected to the CETPs and the CETP itself with a view to identify scope for improvement. While CLRI focused its efforts towards introduction of cleaner technologies in the tanneries connected to the CETP, NEERI gave recommendations on optimization of the CETP operation. NEERI's main recommendations relating to the CETP were:

1. Chrome bearing waste water should be segregated in tanneries
2. Modification in the inflow and outflow pipes in equalization tanks
3. Regular de-sludging of primary and secondary clarifiers
4. Maintenance of appropriate chemical dosing in primary treatment
5. Replacement of pumps in receiving sump
6. High rate transpiration system for dealing with saline effluent

The CETP has implemented all these measures except the high rate transpiration system.

The CLRI/NEERI project was completed by the end of 1997.

11. UNIDO'S ASSESSMENT

Though this CETP has been acknowledged as one of the best designed in the country for treating tannery effluent, the performance of the CETP has been not consistently good mainly due to managerial inadequacies.

The following technical measures can further improve the performance of the CETP:

- The treated effluent line requires modification to carry the full flow of the CETP.
- The aeration system requires suitable adjustments to ensure good distribution of diffused air.
- Proper operation and maintenance of the belt filter and procuring an additional sludge dewatering system will ensure mechanical dewatering of all sludge generated.
- The instrumentation system requires necessary adjustment.
- Better maintenance of pre-treatment units will reduce the pollution load to the CETP, besides containing maintenance problems in the collection and conveyance system.
- Disposal of sludge in a properly designed safe landfill
- Better maintenance of structures of the CETP by way of proper lubrication and painting to ensure their longevity

The best designed CETP may not produce the required results if the day-to-day management is not of the required standard. The BoD of the CETP must give special attention to the managerial inadequacies, particularly relating to regular collection of dues from members, preventive maintenance according to schedule and efficient monitoring and operation of the system.

Annex-1

List & address of suppliers of equipment

Item	Supplier	Local service person/agent
CETP turnkey contractor/supplier of all drives	UEM India P. Ltd., A-2, Greater Kailash Enclave Part-2, New Delhi: 110 048, India Tel: 91-11-6447825/6421634 Fax: 91-11-6214482/6431099	UEM India P. Ltd. A-2, Greater Kailash Enclave, Part-2, New Delhi 110 048, India Tel: 91-11-6447825/6421634 Fax: 91-11-6214482/6431099
Belt filter press	Italprogetti Engineering Via Lungarna, Pacinotti 59A-56020, San Romano Pisa, Italy Tel: 39-571-450477 Fax:39-571-450301	Tanmac India 25, Jawaharlal Nehru St. 3rd Floor Pondicherry. 605 001 India Tel:91-413-39429
Mechanical screen	Italprogetti Engineering Via Lungarna, Pacinotti 59A-56020, San Romano Pisa, Italy Tel: 0039-571-450477 Fax: 0039-571-450301	Tanmac India, 25, Jawaharlal Nehru St. 3rd Floor Pondicherry: 605 001, India Tel:0413-39429
Submersible pumps	Kishor Pumps P. Ltd. A-13/H, MIDC, Pimpri Pune 411 018 India Tel: 772616/3579	Beam Engineers 102, Mogappair Chennai. 600 050 India. Tel: 91-44-6266465/6257915
Centrifugal pumps	Johnson pumps, No. 3, Anthu Street, Santhome, Chennai 600 004 India. Tel: 91-44-4933341 Fax: 91-44-4941176 e-mail: pumps@mds.ateel.com	Fabriken Agencies P. Ltd, 11, 7th Cross St, Shastri nagar, Adyar, Chennai-600 020 India Tel: 91-44-4462605/4460602 Fax: 91-44-4461359/4913601 e-mail: sridhark123@eth.net
Screw pumps	Rotomac 162-B, Co-op Industrial Estate Udyog Nagar Kanpur. 208 022, India Tel: 91-512-296039/6086	Rotomac 162-B, Co-op Industrial Estate, Udyog Nagar Kanpur. 208 022, India Tel: 91-512-296039/6086