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(1 of 2)

KASUR TANNERY POLLUTION CONTROL PROJECT
KTWMA KASUR
12" DIA. FRP PRESSURE PIPELINE

PROJECT NO. DG/PAK/93/006
UNIDO Contract No. 99/246/VK

FINAL REPORT

June 17, 2000

OYSTER INDUSTRIES (PVT) LTD.
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ATTACHED REPORTS

1.0 INTRODUCTION & LOCATION OF THE PROJECT

The UNIDO Contract No. 99/246/VK, awarded to Oyster Industries (Pvt.) Ltd. for the turnkey construction of 12 inches diameter FRP Pressure Pipeline, is part of the overall **KASUR TANNERY POLLUTION CONTROL PROJECT.** This Pipeline will carry the discharge from the Dingarh Sewage Pump Station to a concrete covered drain. The Pipeline will run through the already constructed concrete channel.

The present Phase II of the overall project concentrates on constructing and starting up the operation of CTEPTP and TSWDS, establishing an effluent treatment laboratory and improving working conditions in the tanneries.

The Pipeline Project is located in the town of Kasur. Kasur is a district having a gross area of 981,702 acres located about 55 km southeast of Lahore, in the province of Punjab. The pipeline passes through a cluster of tanneries at a gradually rising gradient. The location map is attached as FRP/01 in the attached "Detailed Design Documentation."

2.0 PURPOSE OF FINAL REPORT

The main purpose of this report is to comply with the requirements of **paragraph 3.7** of the ***"Terms of Reference"*** as follows:

3.7 Prepare a Final Report on work done and lessons learned in the construction of the pipeline and recommend measures to overcome problems in future projects.

Other purposes of this report are to:

- Redefine the scope of engineering services performed
- Reiterate the Contractor's Scope of Work
- Detail the design criteria of pipeline components
- Explain the Installation Procedure followed at site in detail
- List the problems and difficulties encountered
- Explain the solutions evolved for the problems and difficulties
- Explain the lessons learnt in executing the Project
- Redefine the final *"as-built"* layout of the pipeline
- Provide a checklist for works completed in accordance with *"Terms of Reference"* (hereinafter referred to as **"TOR"** - Annex G of the Contract)

As required by the TOR for the project, the following manuals have previously been prepared and submitted, and are also part of this Final Report:

a) Sample Progress Report
b) Detailed Design Documentation
c) Operation & Maintenance Manual
d) Performance Test Report

3.0 CONTRACTORS OVERALL SCOPE OF WORK

The detailed design and tender documents (consisting of geodetic survey data and as-built drawings for existing objects) prepared by IN-CONSULT served as the basis for all civil engineering activities, including the installation of the pressure pipeline as part of the Pucca Drain. Place for the pressure pipeline was available in form of a filled concrete channel (although major cleaning and minor corrections were required to accommodate the pipeline itself). The *Contractor* was to provide the following services, which were the limit of his Scope of Work:

3.1. *Study/review* the detailed design documents prepared by IN CONSULT. The general layout of the sewage system and location data for the pressure pipeline were supplied in form of an AutoCAD drawing on a floppy disc along with the tender documents by UNIDO.

3.2. *Prepare a Detailed Design Documentation* for the entire pipeline - including connections to the existing pipes at both ends - having the following specifications:

Diameter:	300mm (12") nominal
Wall thickness:	8 mm
Estimated length:	540 m (including bends, fittings etc.)
Material:	Fiberglass Reinforced Plastic (FRP) Pipe resistant to tannery effluent (pH 8 – 10).

3.3. *Clean* and *repair* (where required) the already laid concrete channel in which the pressure pipeline was to be placed.

3.4 *Buildup the pipeline,* connect it to the Dingarh pumping station and the follow-up pipeline, *check* reliability of joints and fittings, provide a certificate issued by an independent laboratory on the quality and anticipated performance of the pipeline.

3.5 Provide appropriate *sand filling* in the channel, as well as *concrete slab cover* over the channel where required.

3.6. Prepare an *Operational and Maintenance Manual* on the entire pipeline and provide instructions on the use and preventive maintenance, as well as re-compute pumping power requirements.

3.7. Prepare a *Final Report* on work done and lessons learned in the construction of the pipeline and recommend measures to overcome problems in future projects.

4.0 PIPELINE SYSTEM COMPONENTS

The Project consisted of the following System Components starting from the Pumping Station end:

- Connection with the Dingarh Pump Station Main Discharge Header.
- Laying of approximately 530 metres of 12 inches diameter FRP Pipeline and Flanges.
- Installation of Maintenance Sections for Pipeline.
- Sand filling in the concrete channel.
- Installation of Concrete Cover Slabs made with Sulfate Resistant Cement and Grade 60 Steel.

5.0 FRP MATERIALS & CONSTRUCTION DETAILS

A layer of resin rich "C" Glass Veil was used as the Primary Corrosion Barrier. The next Primary Corrosion Barrier consisted of Chopped Strand Mat (CSM). The resin used in both the Primary Corrosion Barriers was Vinyl Ester resin.

The Primary Corrosion Barriers was backed up with two layers of CSM utilising Orthopthalic resin as a Secondary Corrosion Barrier. The balance of the thickness was built up with Winding Roving, also utilizing

Orthopthalic resin. All FRP components were sealed with a suitable Top Coat. Details can also be seen in the Operation & Maintenance Manual and Construction Drawing FRP/03 of "Detailed Design Documentation".

6.0 INSTALLATION PROCEDURE

The pipeline project was carried out in the following manner according to site conditions:

- Removal of silt, sludge, muck & debris from the concrete channel
- Cleaning of channel
- Rerouting of individual effluent pipes of houses and tanneries as a gesture of social goodwill
- Laying of sand bedding
- Jointing & laying of pipes in channel
- Pipeline performance tests
- Backfilling of channel with sand
- Construction and placement of concrete cover slabs

6.1 REMOVAL OF SILT, SLUDGE & DEBRIS FROM CHANNEL

The Pipeline was to be laid in the already constructed concrete channel which was constructed some years ago . In the meantime, it was filled with silt, sludge, muck, sewage and debris due to non provision of cover slabs initially.

As the first part of the project, the concrete channel was cleared of all this deposition, which involved removal of hazardous tannery wastewater as well. Care was taken so that the existing channel was not damaged in the process.

6.2 REROUTING OF INDIVIDUAL EFFLUENT PIPES OF HOUSES AND TANNERIES

At many points in the pipeline route, houses and tannery units were discharging waste directly into the channel. In order to control the flooding of the concrete channel during and after the installation of pipeline, rerouting arrangements were provided by installing pipes to the sewage channel across the road. This was done also as a social

goodwill gesture. This goodwill act resulted in tremendous cooperation from the local residents.

6.3 LAYING OF SAND BED

The channel was filled with 150 mm of compacted sand bed. The sand bed was provided to evenly support the pipe throughout its length and also to cover any imperfections in the base of the existing concrete channel. This initial sand bed was ruined as the empty channel was treated as a sewage channel by local children while testing was in progress. The sand bed had to be eventually changed.

6.4 JOINTING & LAYING OF PIPES IN CHANNEL

Although this aspect has already been explained in the Detailed Design Documentation, it is being repeated for ready reference.

Pipes were jointed together with Butt Wrapped Joints. The Joints are capable of withstanding the same operating/test pressure and external loads as the Pipe itself.

Flanges for testing and removal of pipe sections are provided as shown in FRP/02 of the "Detailed Design Documentation". The pipeline, after commissioning, may require periodic maintenance tasks such as flushing with clean water and removal of sludge and other settled materials. Therefore, a removable flanged pipe section of 3 meter length has been provided after every 100 meter interval for maintenance purposes and removal of sludge deposits as explained in the Operation & Maintenance Manual. All flanges and Maintenance Sections have been shown in detail in the attached Drawing **FRP/07**.

The pipes were transported and placed with utmost care so as not to cause any damage.

6.5 PIPELINE PRESSURE TESTS

The Pipeline was successfully subjected to a variety of pressure tests.

Working Pressure

The pipeline will receive discharge from submersible non-clogging pumps manufactured by KSB (KRTF 150-315/264 UG). These pumps are designed to operate at a 106 liters/sec with maximum pressure of 14 m (1.35 bar). Public Health Department (Punjab)and textbooks on pressure testing require pipelines to be tested at 1.5 times the working pressure, i.e., 2.03 bars.

Although these pumps have not yet been installed, the Contractor has undertaken to connect the Pipeline to the Dingarh Pumping Station and the follow-up pipeline whenever they are ready. The Contractor has further undertaken that he shall stand responsible for the integrity and performance of the Pipeline to the required standards even after installation and operation of the pump at Dingarh. The Undertaking is further elaborated in Annex "A" of the Performance Test Report.

Test Pressure

As required in the Detailed Design Documentation, the pipeline was subjected to a hydraulic test pressure of 6 bars, which is approximately 4.5 times the working pressure.

Length of Test Section

The length of each test section was between 84 m and 112 m depending on the obstructions at the site, starting from the sections at the high level end. Details have been given in the attached Drawing **FRP/07.**

Sectional Pressure Test Procedure

The section of the pipeline to be tested was filled with water at a rate sufficiently slow to ensure that all air was expelled. Water was then introduced at the lower end of the test section. The hydraulic pressure in the test section was raised to the working pressure (1.35 bars) and kept static for 6 hours.

On successful retention of the working pressure, the pressure in the pipe was raised to the test pressure (6.0 bar) and maintained for one

hour. The pressure was raised initially to 2.0 bars and kept static for 10 minutes. It was then raised by 1.0 bar at a time with the same holding time of 10 minutes. On successful completion of this test, the Pipeline section was emptied and the test repeated on the next section. All problems encountered in this phase of testing along with solutions found have been mentioned in detail in the attached Performance Test Report.

Final Test

After the Pipeline was completely laid and jointed, it was subjected to a final pressure test of 6.0 bars the same way as the Sectional Tests. The duration of this test after attaining the required pressure of 6.0 bars was approximately two hours, which was the time required to carry out a visual inspection of the closure joints between the previously tested individual test sections of the entire Pipeline. Each joint of the Pipeline was also visually inspected jointly for leakage before the pressure was released. Again, the problems encountered in this phase of testing along with solutions found have been explained in detail in the Performance Test Report.

All parties mentioned in Paragraph 2.08 d) of the Contract witnessed the test, and a Certificate of Acceptance of Work was issued as required in this paragraph. This Certificate is appended with the Performance Test Report.

6.6 BACKFILLING OF CHANNEL WITH SAND

After testing, the channel was completely filled with sand, which was watered and compacted. The sand placed initially was replaced as it became contaminated due to prolonged exposure after testing.

6.7 CONSTRUCTION AND PLACEMENT OF CONCRETE COVER SLABS

Concrete cover slabs were placed over the filled channel so that they were fully supported on the sand bed. Although light vehicular loading is not expected in the concrete channel area, this sand support will enable the slabs to sustain light loads in unforeseen situations.

All concrete slabs were not put in place initially as the pumps in the pumping station were not installed. These will be put in place after

installation of the pumps and subsequent checking of the pipeline to the contractor's satisfaction.

The Concrete Cover Slab and Laying Details are attached as FRP/05 in the Detailed Design Documentation.

7.0 CHECKLIST FOR WORKS COMPLETED ACCORDING TO THE TERMS OF REFERENCE (TOR)

The following is an activity-wise checklist for works completed as per requirements of the TOR. The activity numbers are the same as given in the TOR.

3.1 Study/review the detailed design documents prepared by IN CONSULT.

All available information was studied before starting the construction activities. Detailed meetings were arranged with KTWMA in Kasur to clarify all items of the work.

Status: Completed

3.2 Prepare a detailed design documentation for the entire pipeline

Detailed Design Documentation was prepared and submitted to KTWMA in Kasur initially and was thoroughly discussed. After incorporating all points made by KTWMA, Kasur, the same was submitted to UNIDO and is also attached with this Final Report.

Status: Completed

3.3 Clean and *repair* (where required) the already laid concrete channel

The concrete channel was cleared of all debris and cleaned before laying of pipeline. Repairs to the existing concrete channel were made where required.

Status: Completed

3.4 Buildup the pipeline, connect it to the Dingarh pumping station and the follow-up pipeline, *check* reliability of joints and

fittings, provide a certificate issued by an independent laboratory on the quality and anticipated performance of the pipeline.

The pipeline was laid for the complete length. Connection to Dingarh pumping station is pending due to the delay in installation of pumps (which is not in the scope of work of the Contractor). Certificate of Acceptance of Work signed by the Contractor, UNIDO representative, KTWMA and Independent Laboratory on the anticipated performance of the pipeline have been obtained and are attached with this Final Report as an Annex to the Performance Test Report.

Status: Completed

3.5 **Provide appropriate *sand filling* in the channel, as well as *concrete slab cover* over the channel where required.**

The entire channel was backfilled with sand and concrete slab cover over the channel was provided where required. Some slabs have deliberately not been placed for technical reasons explained above.

Status: Completed

3.6 **Prepare an *Operational and Maintenance Manual* on the entire pipeline and provide instructions on the use and preventive maintenance, as well as re-compute pumping power requirements.**

Operation & maintenance manual was submitted and pumping power requirements were recomputed. This report is attached with this Final Report.

Status: Completed

3.7 **Prepare a *Final Report* on work done and lessons learned in the construction of the pipeline and recommend measures to overcome problems in future projects.**

A Final Report has been prepared. This is now being submitted.

Status: Completed

The UNIDO Contract No. 99/246/VK is now complete in all respects as far as the Scope of Work of Oyster Industries (Pvt.) Ltd. is concerned.

8.0 LESSONS LEARNT, PROBLEMS FACED & SOLUTIONS

Numerous problems were faced, solutions were found and lessons were learnt. The problems fell into the following broad categories:

8.1 SOCIAL PROBLEMS

A lot of minor problems of a social nature were faced. The emphasis of the Contractor was to secure the goodwill of the local population. A lot of encroachments were noted; residential and industrial effluent was being drained into the channel; and houses had actually been constructed over the existing channel.

a) Discussions with local residents and businesses:
Initial discussions were held with all locals who were likely to be affected by the work. They were all reassured that this was a Project that would benefit them directly by eliminating the dangerous effluents from their surroundings.

They were further reassured that all efforts would be made to ensure that there would be no damage to their property or way of life. They were further requested to help the Contractor in completion of the Project where possible.

As the encroachments were illegal, the residents were scared initially. When they realized that the Contractor was not utilizing the authorities to make them remove their houses, they went out of their way to help the Contractor complete the Project without damaging any property. **The Pipeline actually went under all existing construction, five houses and no property was permanently damaged.**

b) Diversion of existing sewage lines:
As sewage was being drained into the pressure pipe channel, arrangements were made by the Contractor to

divert it across the road into the sewage drain. **15 pipes of 6" & 8" diameter were laid across the road and covered to divert the sewage.** The pipes have been left in place, earning the gratitude of the local residents.

c) **Disposal of excavated debris from the channel:**
Although not in the Scope of Work of the Contractor, the debris excavated from the Pipeline was deemed to be dangerous to people. Thus, the Contractor, on his own, removed the debris to the local dump as a social goodwill gesture that cost a substantial amount. This was not billed as there was no provision in the contract for such billing.

d) **Pipe willfully damaged during testing:**
After the Sectional Tests but before the Final Test, the Pipeline was deliberately damaged physically at night by vandals. At that time, the sand backfill and concrete cover had not been provided, and the Pipeline runs through a heavily populated area. **This delayed the Final Test by almost a week.** The Pipeline had to be emptied and the damaged section replaced.

8.2 SUB CONTRACTOR RELATED PROBLEMS

a) **Sand Sub-Contractor:**
After the Final Test had been conducted and the tensions had been relieved, the sand Sub-Contractor was asked to start backfilling the channel with prime sand. Instead, he brought sub-standard sand and started to put it in the channel. This was subsequently noticed; the sub-contractor was terminated and the sand replaced.

b) **Excavation Sub-Contractor:**
After excavating the easy portion of the channel, the Sub-Contractor was asked to complete the job and excavate the debris under the bridges and houses. Afraid of the poisonous gasses that would be found, and the sheer difficult prospects of the job, he abandoned the sub-contract. The skilled workers of Oyster Industries finished the job.

8.3 PROBLEMS RELATED TO PREVIOUS CONSTRUCTION

a) **Uneven channel direction, depths and unnecessary diversions:**
It was noted that the channel was not straight, but actually followed the illegal constructions. The depth of the channel varied along its length. This was impossible to ascertain before start of work as the channel was mostly hidden under the accumulated debris.

b) **Electrical poles rising from the bed of the channel:**
It was noted after excavation that there were electrical transmission poles in almost the center of the channel. The Pipeline was diverted at these points to go around the poles. Elbows were not used as that could have interfered with the flow of the sludge later. Instead, an angle was given to the pipe horizontally and the concrete wall of the channel at those points was broken. After laying the pipe, the walls were made up again. Special size slabs were laid at those points.

c) **Wall across the channel under the main road:**
When the last section of the Pipeline was being laid under the main road, it was found that the previous contractor of the channel had not dismantled fully a wall of concrete which supposedly used to be part of another drain. This was the most difficult part of the entire project. It took three days to dismantle this wall as access under the road was very limited and poisonous gasses were present.

8.4 TECHNICAL PROBLEMS

a) **Laying the pipe under the main road without disturbing traffic:**
Not many technical problems arose which were not foreseen. However, the laying of the 20 meter pipe section under the main road was a major problem. The channel under the road was full of oozing muck. When the retaining wall on the pumping station side was

dismantled, poisonous gases were released. It was found that the opening under the road was only 0.7 meters high. This too was full of muck which had oozed across over a period of years.

First, the old wall across the channel was broken. Then, the debris was flushed out using a fire engine hose. After the gasses had been cleared, the wall components, including steel reinforcement were cut with a small grinder. All this took place more than 3 meters into the narrow channel. **It was truly an inhuman task.**

8.5 TESTING PROBLEMS

a) **Problems faced in finding water for filling the line:** The main problem, besides the expected occasional leakage at three flanges, was finding water to fill the pipeline. The electricity remained off for hours at a time initially. A generator was then found and an old bore was used. However, it took almost a day to fill one section, resulting in initial delays in testing. The problem was solved by bringing in mobile water tankers.

9 RECOMMENDATIONS & MEASURES FOR FUTURE PROJECTS

There are some recommendations for future projects, which will make the next Pipeline easier to lay and will result in a longer life:

a) It should be a requirement of the TOR that excavated materials be safely disposed of. Although this has been done in this project without charges, the cost of this activity was not taken into account initially.

b) The contractors for the construction of the channel and laying of the pipeline should be the same. If that is not possible, the sub-contract should be given by the Pipeline contractor. The channel would then be made in a more sensible way.

c) There should be a provision in the TOR that existing sewage lines would have to be diverted as required. Again, as this activity was not mentioned, its' cost was not taken into account initially. Thus, the contractor had to absorb the cost of this activity also.

15 FRP pipes of 8" & 6" dia were laid across the road to divert the sewage costing almost US $ 8,000 without any compensation to-date. ***We are expecting to be compensated by UNIDO in some way, as there was no provision in the contract to claim this money.*** **However, without performance of this activity, the job would have been a social crime.**

d) The Pipe Maintenance Sections should be reduced to one every 200 meters. Moreover, a loop should be provided if the line is over 700 Meters to cater for thermal expansion.

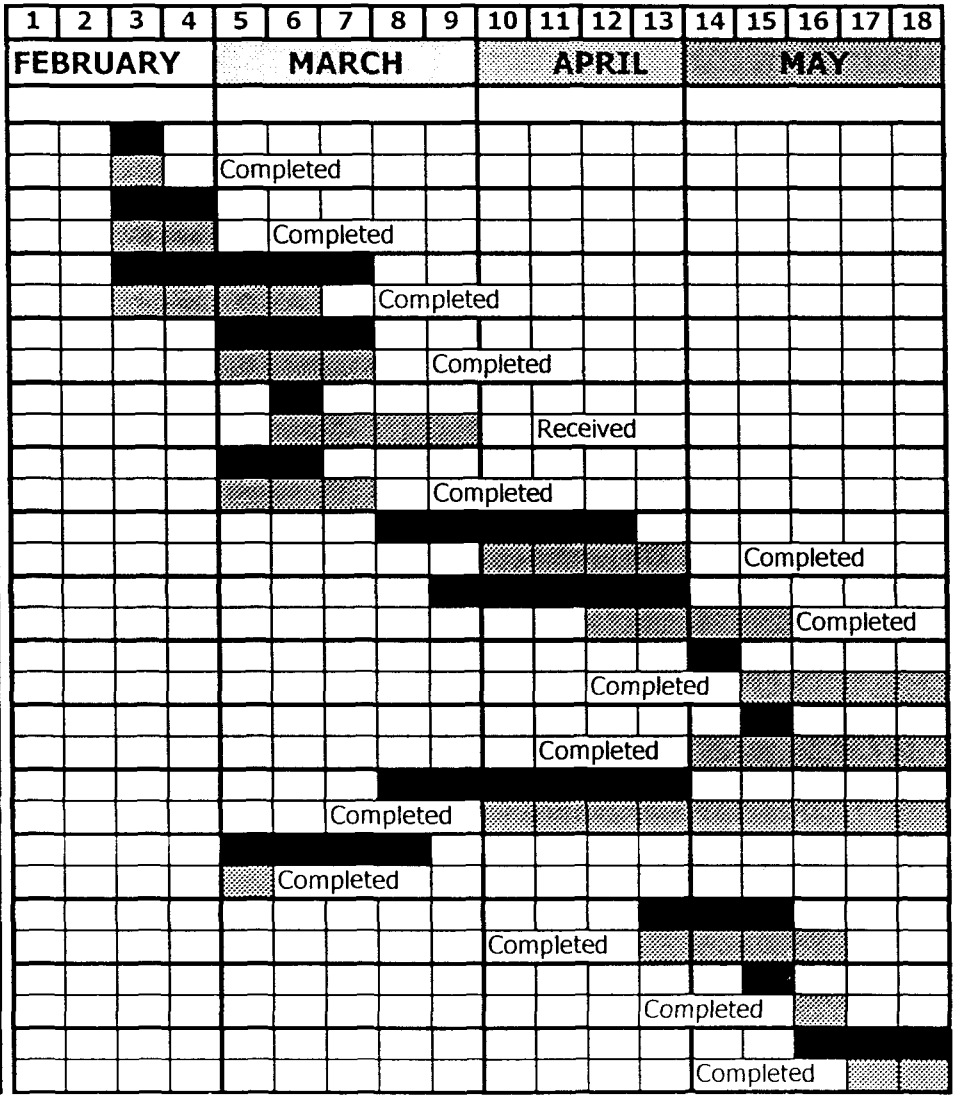
e) The depth of the channel should be at least four times the pipe diameter plus 750 mm. This will allow for the provision of loops needed for expansion in lines of over 700 meter length.

f) Instead of flanges, the pipeline should have stub collars for the maintenance sections, backed up by steel slip-on flanges. This would greatly increase the standardization and reduce chances of any stresses on the Pipeline.

OYSTER INDUSTRIES (PVT.) LTD. **BAR CHART** UNIDO CONTRACT NO. 99/246/VK

JUNE 15, 2000 **12" DIA PRESSURE PIPE LINE - KASUR TANNERY PROJECT**

SR. NO.	ACTIVITY	WEEK NOS.>>>> / MONTHS>>>> / DATES
1	Briefing with UNIDO	FEB 16
		FEB 17
2	Finalization of Work Plan	FEB 17 TO FEB 25
		FEB 25
3	Survey of Trench	FEB 14 TO MAR 15
		MAR 3
4	Excavation of Trench	FEB 28 TO MAR 15
		MAR 18
5	Receipt of Advance	MAR 6
		MAR 31
6	Pipe, Steel & SlabTesting	FEB 28 TO MAR 11
		MAR 16
7	Manufacturing of Pipes	MAR 20 TO APR 15
		APR 28
8	Pipe Laying	MAR 27 TO APR 30
		MAY 15
9	Pipeline Testing	MAY 1 TO MAY 6
		MAY 30
10	Back Filling	MAY 8 TO MAY 13
		JUNE 10
11	Manufacturing of Slabs	MAR 13 TO APR 30
		JUNE 8
12	Detail Design Documentation	FEB 28 TO MAR 15
		MAR 6
13	Maintenance & Ops Manual	APR 24 TO MAY 13
		MAY 15
14	Draft Final Report	MAY 8 TO MAY 13
		MAY 22
15	Final Report	MAY 15 TO MAY 31
		JUNE 15



TARGET ACTIVITY DATES	
ACTUAL ACTIVITY DATES	

BASIR H. SYED
Overall Monitoring

KASUR TANNERY POLLUTION CONTROL PROJECT
KTWMA KASUR
12" DIA. FRP PRESSURE PIPELINE

PROJECT NO. DG/PAK/93/006
UNIDO Contract No. 99/246/VK

PERFORMANCE TEST REPORT

MAY 30, 2000

OYSTER INDUSTRIES (PVT.) LTD.

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1.0 INTRODUCTION

The UNIDO Contract No. 99/246/VK, awarded to Oyster Industries (Pvt.) Ltd. for the turnkey construction of 12 inches diameter FRP Pressure Pipeline, is part of the overall **KASUR TANNERY POLLUTION CONTROL PROJECT.** This Pipeline will carry the discharge from the Dingarh Sewage Pump Station to a concrete covered drain. The Pipeline will run through the already constructed concrete channel.

The Pipeline has now been laid and tested for proper performance as per the requirements of UNIDO detailed in the above Contract in Paragraph 2.08. This report is being sent to UNIDO, Vienna, as per the requirements of Paragraph 2.18 a), along with an Invoice for Progress Payment as per Paragraph 4.05 b), of the above Contract. A Certificate of Acceptance of Work as required in Paragraph 2.08 d) and Paragraph 3.4 of Annex G) is also appended. All Paragraph references are from the Contract referred to above.

2.0 PURPOSE OF PERFORMANCE TEST REPORT

The purpose of this report is to:

1. Define the Programme of the Performance Tests
2. Elaborate the Performance Tests required
3. Document the results of the Performance Tests
4. Check reliability of joints and fittings
5. Ensure conformity of the Pipeline with Paragraph 2.07

3.0 DETAILS OF PERFORMANCE TESTS REQUIRED

3.01 STEEL TESTS

These tests were performed as per Section 4.0 of the Detailed Design Documentation.

a) **Steel Test:** The steel specified above was Grade 60 Steel. A sample selected from the random lot brought to site was selected and sent to an independent laboratory for testing. The satisfactory test results are attached as **Annex "C"-2.**

a) **Sulfate Resistant Cement:** The requirement was to use Sulfate Resistant Cement. It was verified by KTWMA that the same had been used as no other cement was brought to the Pipeline site.

3.02 INITIAL PIPE TESTS

The initial tests for determining the physical strength of the pipe were carried in the Contractor's premises as per Section 9.0 of the Detailed Design Documentation. The following tests were performed on the prescribed samples:

	TYPE OF TEST	SAMPLE LENGTH	REQUIRED VALUE
a.	Diametrical Collapse Test	300 mm	400 Kgs
b.	Axial Tension Test	600 mm	8,000 Kgs
c.	Axial Compression Test	300 mm	8,000 Kgs

The test results are given in **Section 5.01** below.

3.03 CONFIRMATORY PIPE TESTS

The pipe was further tested at an independent laboratory to confirm the results achieved at the Contractor's premises. The confirmatory test results of the independent laboratory are given in **Section 5.03** below and the reports are attached as **Annex "C"-1.**

3.04 PIPELINE PRESSURE TESTS

As outlined in the Detailed Design Documentation and reproduced below, the Pipeline was successfully subjected to a variety of pressure tests.

Working Pressure

The Pipeline will receive discharge from submersible non-clogging pumps manufactured by KSB (KRTF 150-315/264 UG). These pumps are designed to operate at a 106 liters/sec with maximum pressure of 14 m (1.35 bar). Public Health Department (Punjab) and textbooks on pressure testing require pipelines to be tested at 1.5 times the working pressure, i.e., 2.03 bars.

Although these pumps have not yet been installed, the Contractor undertakes to connect the Pipeline to the Dingarh Pumping Station and the follow-up pipeline whenever they are ready. The Contractor further undertakes that he shall stand responsible for the integrity and performance of the Pipeline to the required standards even after installation and operation of the pump at Dingarh. The Undertaking is further elaborated in **Annex "A".**

Test Pressure

As required in the Detailed Design Documentation, the pipeline was subjected to a hydraulic test pressure of 6 bars, which is approximately 4.5 times the working pressure.

Length of Test Section

The length of each test section was between 84 m and 112 m depending on the obstructions at the site, starting from the sections at the high level end. Details and "As-Built" Plan will be given in the Final Report.

Sectional Test Procedure

The section of the pipeline to be tested was filled with water at a rate sufficiently slow to ensure that all air was expelled. Water was then introduced at the lower end of the test section. The

hydraulic pressure in the test section was raised to the working pressure (1.35 bars) and kept static for 6 hours.

On successful retention of the working pressure, the pressure in the pipe was raised to the test pressure (6.0 bar) and maintained for one hour. The pressure was raised initially to 2.0 bars and kept static for 10 minutes. It was then raised by 1.0 bar at a time with the same holding time of 10 minutes. On successful completion of this test, the Pipeline section was emptied. Further results are given in **Section 5.04.**

Final Test

After the Pipeline was completely laid and jointed, it was subjected to a final pressure test of 6.0 bars the same way as the Sectional Tests. The duration of this test after attaining the required pressure of 6.0 bars was enough to carry out a visual inspection of the closure joints between the previously tested individual test sections of the entire Pipeline. Each joint of the Pipeline was also visually inspected jointly for leakage before the pressure was released. All concerned parties including a representative of an independent laboratory witnessed the test. Further details are given in **Section 5.05.**

3.05 CERTIFICATE OF ACCEPTANCE OF WORK

A Certificate of Acceptance of Work **(Annex "B")** is appended to this Performance Test Report with the signatures of all parties concerned.

4.0 PROGRAMME OF THE PERFORMANCE TESTS

The programme and methods of the Performance Tests were determined in consultation with UNIDO/KTWMA in March during finalization of the Detailed Design Documentation, which was submitted on March 6, 2000. The programme and progress were further given in the periodical reports submitted to KTWMA from time to time.

5.0 RESULTS OF PERFORMANCE TESTS

5.01 INITIAL PIPE TESTS

The initial pipe tests were carried in the Contractor's premises and the following results were recorded:

TYPE OF TEST	REQUIRED VALUE	TESTED VALUE
a. Diametrical Collapse Test	400 Kgs	875 Kgs
b. Axial Tension Test	8,000 Kgs	16,300 Kgs
c. Axial Compression Test	8,000 Kgs	21,800 Kgs

5.02 DIMENSIONAL PIPE TESTS

The Dimensional Tests were carried out in the presence of KTWMA and Oyster representatives and the following results were noted:

TYPE OF TEST	REQUIRED NOMINAL VALUE	TESTED VALUE RANGE
a. Flange Thickness	36.50 mm	37 - 40 mm
b. Pipe Thickness	8.00 mm	8.3 – 9.2 mm
c. Pipe Length	Not Specified	5.8 – 6.3 m

5.03 CONFIRMATORY PIPE TESTS

The confirmatory pipe tests were carried in CTL (Central Testing Laboratory, an Independent Government Laboratory) and the following results were recorded:

TYPE OF TEST	REQUIRED VALUE	TESTED VALUE
a. Diametrical Collapse Test	400 Kgs	752 Kgs
b. Axial Tension Test	8,000 Kgs	15,546 Kgs
c. Axial Compression Test	8,000 Kgs	22,963 Kgs

5.04 SECTIONAL PIPELINE PRESSURE TESTS

The section of the pipeline to be tested was filled with water at a rate sufficiently slow to ensure that all air was expelled. The water was then introduced at the lower end of the test section. The hydraulic pressure in the test section was raised to the working pressure (1.35 bars) and kept static for 6 hours.

On successful retention of the working pressure, the pressure in the pipe was raised to the test pressure (6.0 bar) and maintained for one hour. The pressure was raised initially to 2.0 bars and kept static for 10 minutes. It was then raised by 1.0 bar at a time with the same holding time of 10 minutes. On successful completion of this test, the Pipeline section was emptied.

This test was successful in the first attempt in all Sections except the first. In Section 1, where the test was performed on May 17, 2000, leakage was observed from two flanges after attaining a pressure of 5.2 Bars. The flange bolts were tightened and Section 1 was tested again. No further leakage was observed till the completion of all Sectional Pressure Tests.

5.05 FINAL PIPELINE PRESSURE TESTS

After the Pipeline was completely laid and jointed, it was subjected to a final pressure test of 6.0 bars the same way as the Sectional Tests. Initially, the Contractor performed the test

unofficially on May 22, 2000 to ensure that all the Sections had been properly jointed together. Three leakage points were observed. One was from a flange, and two were from a pipe section. The flange bolts were tightened. It was then noted that the leaking section of the pipe had been externally damaged. This was due to a lump of concrete being thrown on the Pipeline by vandals, as it had to remain exposed till completion of the witnessed Final Test. The Pipeline was emptied and the damaged section was replaced. This act of vandalism considerably delayed completion of the Final Tests.

After the Contractor had satisfied himself about the functioning of the Pipeline, it was again officially subjected to a final pressure test of 6.0 bars the same way as the Sectional Test. The duration of this test after attaining the required pressure of 6.0 bars was approximately one and a half hours, which was the time required to carry out a visual inspection of the closure joints between the previously tested individual test sections of the entire Pipeline. Each butt joint of the Pipeline was also visually inspected jointly for leakage before the pressure was released.

All concerned parties including a representative of an independent laboratory witnessed the official tests, which were successfully carried out.

ANNEX "A"

Oyster Industries (Pvt.) Ltd. **UNIDO Contract No. 99/246/VK**

PERFORMANCE TEST REPORT

UNDERTAKING

Although the KSB pumps have not yet been installed at the Dingarh Pumping Station and our Pipeline has been completed on time, we still undertake to connect the Pipeline to the Dingarh Pumping Station and the follow-up pipeline whenever they are ready. We further undertake that we shall stand responsible for the integrity and performance of our Pipeline to the required UNIDO standards mentioned in the above Contract even after installation and operation of the pumps at the Dingarh Pumping Station.

We further undertake to be responsible for our Pipeline as stated above for a period of one year after commissioning of the pumps at Dingarh Pumping Station or till the expiration of our Bank Guarantee on September 30, 2001, whichever is earlier.

Authorized Signatory
Oyster Industries (Pvt.) Ltd.

ANNEX "B"

Oyster Industries (Pvt.) Ltd. **UNIDO Contract No. 99/246/VK**

PERFORMANCE TEST REPORT

CERTIFICATE OF ACCEPTANCE OF WORK

We hereby certify the following:

1. The 12" nominal diameter Fiberglass Pipeline has been completed and tested as outlined in the Contract, the attached Terms of Reference and the Detailed Design Documentation till the Dingarh Pumping Station in Kasur. The results of the tests are given in Section 5.0 and Annex "C" of the Performance Test Report.

2. The pumps have not been installed at the Dingarh Pumping Station. The Pipeline is otherwise operational and has passed the pressure tests.

3. The Pipeline has been tested as outlined in the Detailed Design Documentation and found to be satisfactory. The anticipated performance of the Pipeline is expected to be satisfactory.

4. The reliability of the joints and fittings has been checked and has been found to be satisfactory.

5. The Pipeline has been proven in the Performance Tests and has achieved the requirements of Paragraph 2.07 and sub-para 2.08 of the Contract.

Oyster Industries (Pvt.) Ltd.
Contractor

Dr. Robert G. Gumen
UNIDO Representative
UNIDO

30/5/12

KTWMA
Project Counterpart
(Pipe line tested and no leakage observed at 6 bars)

30/5/2012
HAFEEZ-ULLAH EXAMINER (PAK)

Central Testing Laboratories
Independent Laboratory
CTL Ref. No. PE/5323
(No leakage observed)

ANNEX "C"-1

Oyster Industries (Pvt.) Ltd. **UNIDO Contract No. 99/246/VK**

PERFORMANCE TEST REPORT

CONFIRMATORY TEST REPORTS OF INDEPENDENT LABORATORIES

PIPE TEST REPORTS

Sr. No. 00471

Telegraphic Address : LABTEST LAHORE
Telephone No. 5862154
5862153

GOVERNMENT OF PAKISTAN

CENTRAL TESTING LABORATORIES

FEROZEPUR ROAD, LAHORE—54600

Your Ref. No. :-KTP/SDO/319. Our Ref. No:-CTL/4(304)/99-2000.

Dated :-08-05-2000. *Dated* :-16-05-2000.

(Samples received on 16-05-2000).

TEST REPORT

Sample received from The Sub Divisional Officer-II, Kasur Tannery Waste management Agency, Tehsil Road, KASUR.

Report issued to

No. of samples Three(3).

Specification against which tested As per test request.

SUBJECT:- Testing of samples stated to be " Fibre Glass Pipes Dia 12"." (For the Kasur Tanneries Pollution Control Project).

The samples as received have been tested with the following test results:-

Nos.	Description of Tests.	PE/4890.	PE/4891.	PE/4892.
1.	Axial Tension Load (Kg).	15546	....	....
2.	Axial Compression Load (Kg).	.....	22963	....
3.	Diametrical Collapse Load (Kg).	.....	.....	752

Note:- Please see terms & conditions overleaf.

. AZMAT .

PCPPL—41 CTL—3-3-2000—2,000.

DEPUTY DIRECTOR INCHARGE
CENTRAL TESTING LABORATORIES
(474). LAHORE

Terms & Conditions.

(1). The above results pertain to the sample (s) received in these Laboratories. The labs. are unable to guarantee the quality of the stock from which the sample (s) was/were drawn. This report is not to be reproduced in part.

(2). In case of over typing, erasing or any doubtful figures in the test results, the matter should be referred to the Deputy Director Incharge at once for verification.

(3). No counter sample has been retained. In case of any controversy about the results only the sample (s) having the seal of the Labs. and the signature of the competent officer would be entertained for reverification within one month from date of issue of the TEST REPORT.

OR

~~The sample will be retained for one month, after which it will be disposed off.~~

ANNEX "C"-2

Oyster Industries (Pvt.) Ltd. UNIDO Contract No. 99/246/VK

PERFORMANCE TEST REPORT

CONFIRMATORY TEST REPORTS OF INDEPENDENT LABORATORIES

STEEL TEST REPORTS

Sr. No. 00577

Telegraphic Address : LABTEST LAHORE
Telephone No. 5862154
5862153

GOVERNMENT OF PAKISTAN

CENTRAL TESTING LABORATORIES

FEROZEPUR ROAD, LAHORE—54600

Your Ref. No. SPO/KTP/326
Dated :- 22-5-2000.

Our Ref. No. CTL/4(304)/99-2000
Dated :- 25-5-2000.

TEST REPORT

Sample received from } The Sub Divisional Officer-II
Report issued to } Office of the Project Manager, Kasur Tannery Pollution Control Project, Tehsil Road, Kasur.

No. of samples Six (6).

Specification against which tested
As per test request.

Subject :- Testing of samples stated to be Tor Steel Bars 3/8" Dia.

The samples as received have been tested with the following test results:-

S.No.	Labs. Registration Nos.	Dia. (In).	Tensile Strength (Lbs/Sq").	Elongation(%) at break on 5.65 under root area G.L.	Bend Test at 180°
1.	PE/5085	0.374	91859	20.0	-------
2.	PE/5086	---	---	---	Satisfactory.
3.	PE/5087	0.376	95201	17.5	-------
4.	PE/5088	---	---	---	Satisfactory.
5.	PE/5089	0.375	90759	20.0	-------
6.	PE/5090	---	---	---	Satisfactory.

Note:- Please see terms & conditions overleaf.

SHAHID/

DEPUTY DIRECTOR INCHARGE
CENTRAL TESTING LABORATORIES
LAHORE
(577).

PCPPL—41 CTL—3-3-2000—2,000.

KASUR TANNERY POLLUTION CONTROL PROJECT
KTWMA KASUR
12" DIA. FRP PRESSURE PIPELINE

PROJECT NO. DG/PAK/93/006
UNIDO Contract No. 99/246/VK

OPERATION & MAINTENANCE MANUAL

MAY 15, 2000

OYSTER INDUSTRIES (PVT.) LTD.

19/1-L, D.H.A. (Defence Society)
Lahore-54792, Pakistan

Tel: (92-42) 573-1510
Fax: (92-42) 572-4503

INDEX

1.0 INTRODUCTION

The UNIDO Contract No. 99/246/VK, awarded to Oyster Industries (Pvt.) Ltd. for the turnkey construction of 12 inches diameter FRP Pressure Pipeline, is part of the overall **KASUR TANNERY POLLUTION CONTROL PROJECT.** This Pipeline will carry the discharge from the Dingarh Pumping Station to a concrete covered drain and will run through the already constructed concrete channel.

As there are no machines or complex equipment involved in this Pipeline, and the usage is continuous with remote chances of sludge deposition, operating instructions are brief. Therefore, a combined Operation & Maintenance Manual has been prepared, with emphasis on the material characteristics, preventive maintenance and repair techniques of the Pipeline. This is because most people are relatively unfamiliar with Fiberglass Reinforced Plastics (FRP).

This Operation & Maintenance Manual has been compiled to ensure that the Pipeline is used for its designed life with minimum problems. This is in compliance with Paragraphs 3.6, 5.3 and 6 of the Terms of Reference Annex "G", and Paragraph h) of Annex E of the above Contract. 10 copies of this manual are being submitted.

2.0 PURPOSE OF OPERATION & MAINTENANCE MANUAL

The purpose of this report is to:

1. Explain the Usage & Operational Procedures
2. Outline the Periodical Cleaning & required Preventive Maintenance
3. Acquaint the user with the basics of FRP technology
4. Explain the Pipe Manufacturing Method
5. Give details of the Jointing method used
6. Explain the Repair Techniques and the Materials required
7. Recompute the Pumping Requirements

3.0 USAGE & OPERATIONAL REQUIREMENTS

As the Pipeline is new, certain precautions are recommended when starting up for regular operations initially. The following procedure is recommended:

a) Leave the Pipeline full of water after the testing has been completed. The air release valve along with the pressure plate used in testing at the other end from the pumping station should be left in place.

b) When initially starting the pump with the sludge, care should be taken to fill the Pipeline slowly and expel all air in the Pipeline, which may have accumulated after weeks of nonuse.

c) This procedure of air release should be repeated whenever the Pipeline is not in use for any prolonged period of time.

d) Other than the above precautions, the Pipeline is adequately designed and no further precautions should be necessary, as we have been informed that the usage is continuous with remote chances of sludge deposition.

4.0 PREVENTIVE MAINTENANCE / PERIODICAL CLEANING

The Pipeline is meant to be maintenance-free for its designed life and sludge deposits are not expected. However, periodical cleaning is recommended annually for removal of any settled materials, which should not take more than a few hours. The method is as follows:

a) Have a source of water (quality of water is not important) available to purge the Pipeline. Recommended quantity is about 15,000 Liters for which mobile water tankers are easily available.

b) Stop the pump from pumping the tannery effluent.

c) Switch the intake of the pump from the effluent to the available water.

d) Pump the entire quantity of the water through the Pipeline.

e) Stop the pumping operation when water is seen to come out of the other end.

f) Switch the intake of the pump back to the effluent.

g) Start the pump again to pump the effluent.

With a Hazen Williams Factor of 150, the chances of blockage of this Pipeline are very remote. However, if this does occur even after regular periodical cleaning, a removable flanged pipe section of 3 meter length has been provided after approximately every 100 meter interval for maintenance purposes and removal of unlikely sludge deposits. This section should be removed and water at 4 Bar pressure should be pumped in the direction away from the pumping station. This will take care of any stubborn deposits.

5.0 BASICS OF FIBERGLASS REINFORCED PLASTICS (FRP)

5.01 INTRODUCTION

The nature of Fiberglass Reinforced Plastics (FRP)

FRP is a light, durable and astonishingly tough construction material that can be fabricated into all types of products, including pipes. It may be translucent, opaque or colored, flat or shaped, thin or thick. There is virtually no limit to the size of objects that can be made in FRP as single pieces. Single piece boat hulls of 80 meter length, tanks of 10 meter diameter and pipes of over 3 meter diameter and 12 meter length give an idea of the versatility of this material of construction.

FRP is unique amongst materials of construction in that the fabricator actually makes the material. Whether he is making sheeting, tanks, pipes, silos, boats, or prefabricated housing, the fabricator is not merely assembling pre-existing components; he is actually making the structural material *in situ*.

FRP is a composite of a resilient durable resin that impregnates an immensely strong fibrous glass. The resin determines the corrosion resistance of the composite and is usually an unsaturated polyester or epoxide resin. It is supplied in the form of a viscous syrup, which when suitably activated sets to a hard solid. The glass in FRP provides the strength and is usually in the form of very fine fibers. As concrete may be reinforced with steel

bars to form RCC, resins may be reinforced with glass fibers to form FRP. This is what the fabricator does.

Plastics

Plastics are man-made materials which can be molded into useful articles. All plastics are composed of macromolecules, i.e. large chain-like molecules consisting of many simple repeating units. These molecular chains are called *polymers*. Man-made polymers are called *synthetic resins* and are mostly made from chemicals derived from hydrocarbons (oil, gas, coal, etc.).

Fiberglass

Glass Fiber or *Fiberglass,* as it is commonly known, is made by rapidly drawing molten glass through platinum bushings and then cooling it. It is one of the strongest materials known and imparts the bulk of strength to FRP. It is non-combustible and chemically resistant.

Materials used in the UNIDO Kasur Pipeline

The resins used in the Pipeline constructed under the above contract are as follows:

Resins

Vinyl Ester Resin Primary Corrosion Barriers
Unsaturated Orthopthalic Polyester Resin as Secondary Corrosion Barriers, Backup and Top Coat.

Fiberglass

30 gm/sq mtr "C" Glass Veil and 300 gm/sq mtr Chopped Strand Mat as Primary Corrosion Barrier.
450 gm/sq mtr Chopped Strand Mat as Secondary Corrosion Barrier
2400 Tex Winding Roving as Pipe Strengthening Backup
800 gm/sq mtr Woven Roving for Joints Backup

5.02 GELATION & HARDENING

Storage Life

Liquid Vinyl Ester and Unsaturated Orthopthalic Polyester Resins are unstable. After several months of storage, they will set to a rubbery gel. This period is the *storage life* or *shelf life* of the resin at 25 Degrees C and varies from one type of resin to another. The storage life is considerably reduced at temperatures greater than 25 Degrees C.

The Vinyl Ester Resin used in this Pipeline has a storage life of 3 months, while the Unsaturated Orthopthalic Polyester Resin has a storage life of 5 months at 25 Degrees C.

Catalysts and Accelerators

In order to produce a laminate or product, a resin must be *cured.* This is the name given to the overall process of *gelation* and *hardening.* This is achieved either by the use of a *catalyst* combined with elevated temperatures, or at room temperatures by mixing a catalyst and *accelerator* into the resin.

Catalysts are dangerous formulations and should ***never*** be stored at temperatures above 23 Degrees C. The normal catalyst used in this Pipeline is 50% MEKP. The accelerator used in this Pipeline is 6% Cobalt Octoate. It is essential to choose the correct types of catalyst and accelerator, as well as to use the correct amount, if the optimum properties of the final cured laminate are to be obtained.

*Catalysts and accelerators must **never** be mixed directly with each other, as the reaction can be explosive. As a safety precaution, they must not be stored close to one another either.*

The Curing Reaction

The *cure* of the resins used in this Pipeline will begin as soon as a suitable catalyst is added. Without the addition of either an accelerator or heat, the rate of cure will be too slow for practical

purposes. Thus, the pipes used in this Pipeline were cured at elevated temperatures in an enclosed oven. The jointing at site was achieved by the use of accelerator.

There are three distinct phases in the curing reaction:

1. **Gel Time.** This is the period from the addition of the accelerator or heat to the setting of the resin to a soft gel. In other words, this is the working time that is available to complete the fabrication process.
2. **Hardening Time.** This is time for the setting of the resin to the point when the resin is hard enough to allow the product or pipe to be withdrawn from the mold or mandrel.
3. **Maturing Time.** This is the time required for the product to acquire its full hardness, chemical resistance and stability. Maturing for this pipe was done at elevated temperature for two hours and at room temperature for several days.

5.03 HAND LAMINATION

Hand Lamination was the process used to apply the Corrosion Barriers to the UNIDO pipes. A coat of the Vinyl Ester resin for the Primary Corrosion Barrier was liberally applied over the mandrel (pipe mold) initially. "C" Glass Veil was then pressed onto the mandrel and consolidated with a brush and all entrapped air in the Veil was released. A layer of Chopped Strand Mat (CSM) was then applied over the Veil and thoroughly impregnated with the same resin.

The Secondary Corrosion Barrier consisting of CSM was applied over the Primary Corrosion Barrier and allowed to partially cure using Unsaturated Orthopthalic Polyester Resin.

5.04 FILAMENT WINDING

The balance of the thickness of the pipe was built up by the process of *Filament Winding.* Filament winding consists of winding continuous filaments of glass (Winding Roving) on to a rotating mandrel, the Roving normally having first been passed

through a resin bath to thoroughly wet it. Several layers of Roving are applied until the required thickness is achieved.

Filament Winding is recognized as one the most economical and reliable conversion processes for the manufacture of cylindrical products. The process is principally used for the production of cylindrical tanks and vessels, chimneys, ducting, pipes and other products which must be capable of meeting critical performance requirements.

5.05 HEALTH & SAFETY

The handling of resins and ancillary materials, such as catalysts, presents several hazards which can be reduced to a minimum if proper precautionary measures are taken.

Storage

As mentioned earlier, the Vinyl Ester Resin used in this Pipeline has a storage life of 3 months, while the Unsaturated Orthopthalic Polyester Resin has a storage life of 5 months. As a general guide, the resin is usable as long as it remains a pourable liquid free from particles or lumps.

Vinyl Ester and Polyester Resins are flammable with a flashpoint of 35 Degrees C. Thus, it is advisable to store them at temperatures below 25 Degrees C.

Catalyst used is 50% Methyl Ethyl Ketone Peroxide and presents a special fire hazard. This has a low flashpoint of 28 Degrees C and must be kept in a separate area which is well ventilated. Care should be taken not to touch this material with bare hands.

Usage

Most resins contain a monermic styrene, which is a good grease solvent and can cause irritation to the skin. Use of impervious gloves is recommended. Hands should be washed with soap and water immediately after use. In sufficient quantities, styrene vapor is irritating to the eyes and reparatory passages. Work areas must therefore be well ventilated.

Catalysts are extremely irritating to the skin and can cause burns if not washed off immediately with plenty of warm water. Particular care must be taken with liquid catalysts to avoid splashing, spilling or contact with the eyes. Protective goggles must be worn as a necessary precaution. If catalysts or organic peroxides come into contact with the eyes, they can cause serious injury if not treated immediately. The affected eye should immediately be washed with plenty of clean water or normal saline solution (0.9% w/w NaCl) for at least 15 minutes. Under no circumstances should the eye be treated with oil or oily solutions since these aggravate the damaging effect of the peroxides. In all cases a doctor should be consulted as soon as possible after administering first aid.

Catalyst and accelerator must never be mixed directly with each other, or stored in the same vicinity, since they can react with explosive violence.

6.0 MATERIAL SPECIFICATIONS

A layer of resin rich "C" Glass Veil has been used in the Primary Corrosion Barrier. The next Primary Corrosion Barrier consists of 300 gms/sq mtr Chopped Strand Mat (CSM). The resin used in both the Primary Corrosion Barriers is Vinyl Ester Resin.

The Primary Corrosion Barriers have been backed up with two layers of 450 gms/sq mtr CSM utilising Unsaturated Polyester Orthopthalic Resin as a Secondary Corrosion Barrier. The balance of the thickness has been built up with Winding Roving, also utilizing Orthopthalic Resin. All FRP components have been sealed with a Top Coat of Orthopthalic Resin.

7.0 JOINT DETAILS

Two types of joints have been used in this Pipeline – **Flanged and Butt Joints.**

7.01 FLANGED JOINTS

Flanged Joints have a gasket between them. The Nuts and Bolts are Stainless Steel. Each Joint has 12 Nos. 7/8 inch Bolts. These Joints do not require any further elaboration, as they are a common form of jointing.

7.02 BUTT JOINTS

The strength of the Butt Joint is at least equal to the strength of the pipe itself. In the UNIDO Pipeline, the thickness of the joint has been kept greater than the pipe thickness. Whereas the pipe is of 8 mm nominal thickness, the Butt Joints are of 10.5 mm nominal thickness.

The first step in making a Butt Joint is perfect alignment of the faces of the two pipe sections to be jointed. Then the minute gaps between the faces of the two pipe sections are filled in with putty made from the same Vinyl Ester Resin (Hetron 922 or Derakane 411 or equivalent) as the Primary Corrosion Barrier. The putty is allowed to cure. The first layer over the putty is a band of "C" glass veil utilizing Vinyl Ester Resin.

This is followed by two layers of 450 gm/sq mtr CSM using Vinyl Ester Resin. Thereafter, successive layers of increasing thickness of alternating CSM 450 gm/sq mtr and Woven Roving 800 gm/sq mtr are applied using an Orthopthalic Resin (Scott Bader 405E or equivalent) until the desired thickness is achieved. The entire build-up is followed by a Top Coat using Orthopthalic Resin.

The widths and resins of all the layers of Fiberglass reinforcement are as follow:

No.	Type Of Reinforcement	Resin	Width
1.	"C" Glass Veil 30 gms/sq mtr	V. Ester	75 mm
2.	CSM 450 gm/sq mtr	V. Ester	75 mm
3.	CSM 450 gm/sq mtr	V. Ester	100 mm
4.	CSM 450 gm/sq mtr	Ortho Poly	100 mm
5.	Woven Roving gm/sq mtr	Ortho Poly	100 mm
6.	CSM 450 gm/sq mtr	Ortho Poly	125 mm
7.	Woven Roving gm/sq mtr	Ortho Poly	125 mm
8.	CSM 450 gm/sq mtr	Ortho Poly	150 mm
9.	Woven Roving gm/sq mtr	Ortho Poly	150 mm
10.	CSM 450 gm/sq mtr	Ortho Poly	175 mm
11.	Woven Roving gm/sq mtr	Ortho Poly	175 mm
12.	CSM 450 gm/sq mtr	Ortho Poly	175 mm
13.	Top Coat	Ortho Poly	200 mm

8.0 REPAIR TECHNIQUES

The repair procedure of the Pipeline in case of damage caused by accidental excavation or by willful destruction is the same as the application of the Butt Joint. It may be best to contact the Contractor for repairs initially. The premises of the Contractor are located only 15 minutes from the location of the Pipeline.

Initially, the Pipeline shall be under Warranty. After expiry of the Warranty, the Contractor can provide, at a nominal cost, complete kits of repair materials. The kits can be exchanged with the Contractor every three months to ensure availability of fresh materials at all times.

The kits will come complete with instructions.

9.0 RECOMPUTED PUMPING REQUIREMENTS

The pumping requirements were computed earlier in the Detailed Design Documentation to ensure that there would be no surprises at a later stage, when it would be too late to change the design parameters. The final calculations for the Pipeline as laid are reproduced below:

9.01 PUMP STATION CAPACITY & FLOW DATA

Pump Type	KSB KRTF 150-315/264 UG
Pump Capacity	105.6 liters/sec at 14.0 m Head
Peak Flow	130 liters/sec (Assumed) at Vel =1.82m/sec
Design Flow	*(As per pump capacity)* 105.6 liters/sec (Assumed) at Vel=1.5 m/sec
Pipe Length	537 m (including bends, fittings etc.)
Level Difference	4.5 m

9.02 HEAD LOSS CALCULATIONS

The Pipeline has been analyzed for the anticipated working conditions and also for the peak flow taking into account the actual length of the Pipeline, which can occur in case higher capacity pumps are installed in the Dingarh Pump Station.

9.02.1 Head Loss Calculations at Working Flow

Hazen Williams Coefficient "C"	150
Flow	106 liters/sec
Head loss/meter	0.0055
Total head loss	2.95 m
Head loss for fittings & valves	0.60 m
Level difference	4.50 m
Pump installation below ground	4.00 m
Total Head Required	**12.05 m**

9.02.2 Head Loss Calculations at Peak Flow

Hazen Williams Coefficient "C"	150
Flow	130 liters/sec
Head loss/meter	0.0081
Total head loss	4.35 m
Head loss for fittings & valves	0.80 m
Level difference	4.50 m
Pump installation below ground	4.00 m
Total Head Required	**13.65 m**

KASUR TANNERY POLLUTION CONTROL PROJECT
KTWMA KASUR
12" DIA. FRP PRESSURE PIPELINE

PROJECT NO. DG/PAK/93/006
UNIDO Contract No. 99/246/VK

DETAILED DESIGN DOCUMENTATION

MARCH 6, 2000

OYSTER INDUSTRIES (PVT) LTD.
19/1-L, D.H.A. (Defence Society)
Lahore-54792, Pakistan
Tel: (92-42) 573-1510
Fax: (92-42) 572-4503

Oyster Industries (Pvt.) Ltd. UNIDO Contract No. 99/246/VK

DETAILED DESIGN DOCUMENTATION

INDEX

1.0 INTRODUCTION & LOCATION

The UNIDO Contract No. 99/246/VK, awarded to Oyster Industries (Pvt.) Ltd. for the turnkey construction of 12 inches diameter FRP Pressure Pipeline, is part of the overall **KASUR TANNERY POLLUTION CONTROL PROJECT.** This Pipeline will carry the discharge from the Dingarh Sewage Pump Station to a concrete covered drain. The Pipeline will run through the already constructed concrete channel.

The present Phase II of the overall project concentrates on constructing and starting up the operation of CTEPTP and TSWDS, establishing an effluent treatment laboratory and improving working conditions in the tanneries.

The Pipeline Project is located in the town of Kasur. Kasur is a district having a gross area of 981,702 acres located about 55 km southeast of Lahore, in the province of Punjab. The pipeline passes through a cluster of tanneries at a gradually rising gradient. The location map is attached as **FRP/01**.

2.0 PURPOSE OF DETAILED DESIGN REPORT

The purpose of this report is to define:

- the scope of engineering services
- establish and confirm design criteria of components
- layout of the pipeline including plan and longitudinal profiles
- pressure head loss calculations
- technical information for the FRP pipeline
- testing and maintenance procedures
- connection and jointing details

This information will form the basis for the Operation and Maintenance Manual, which will be prepared on completion of the Project.

3.0 CONTRACTORS SCOPE OF WORK

The detailed design and tender documents (consisting also geodetic survey data and as-built drawings for existing objects) prepared by IN-CONSULT serve as the basis for all civil engineering activities, including the installation of the pressure pipeline as part of the Pucca Drain. Place for the pressure pipeline is available in form of a filled concrete channel (although cleaning and perhaps minor corrections might be required to accommodate the pipeline itself). The *Contractor* will have to provide the following services which will limit his Scope of Work:

3.1. *Study/review* the detailed design documents prepared by IN CONSULT. The general layout of the sewage system and location data for the pressure pipeline were supplied in form of an AutoCAD drawing on a floppy disc along with the tender documents by UNIDO.

3.2. *Prepare a detailed design documentation* for the entire pipeline - including connections to the existing pipes at both ends - having the following specifications:

Diameter:	300mm (12") nominal
Wall thickness:	8 mm
Estimated length:	540 m (including bends, fittings etc.)
Material:	Fiberglass Reinforced Plastic (FRP) Pipe resistant to tannery effluent (pH 8 – 10).

3.3. *Clean* and *repair* (where required) the already laid concrete channel in which the pressure pipeline will be placed.

3.4 *Buildup the pipeline,* connect it to the Dingarh pumping station and the follow-up pipeline, *check* reliability of joints and fittings, provide a certificate issued by an independent laboratory on the quality and anticipated performance of the pipeline.

3.5 Provide appropriate *sand filling* in the channel, as well as *concrete slab cover* over the channel where required.

3.6. Prepare an *Operational and Maintenance Manual* on the entire pipeline and provide instructions on the use and preventive maintenance, as well as re-compute pumping power requirements.

3.7. Prepare a *Final Report* on work done and lessons learned in the construction of the pipeline and recommend measures to overcome problems in future projects.

4.0 PIPELINE SYSTEM COMPONENTS

The Project involves the following System Components starting from the Pumping Station end:

- Connection with the Dingarh Pump Station Main Discharge Header.
- 12 inches diameter FRP Pipeline and Flanges.
- Maintenance Sections for Pipeline.
- Concrete Cover Slabs with Sulfate Resistant Cement and Grade 60 Steel.

5.0 PUMP STATION CAPACITY & FLOW DATA

Pump Type	KSB KRTF 150-315/264 UG
Pump Capacity	105.6 liters/sec at 14.0 m Head
Peak Flow	130 liters/sec (Assumed) at Vel =1.82m/sec
Design Flow (As per pump capacity)	105.6 liters/sec (Assumed) at Vel=1.5 m/sec
Flow Type	24 Hrs Continuous.
Sewage	Untreated Tannery Waste Effluent (pH 8-10)
Approx. Pipe Length	600 m (including bends, fittings etc.)
Level Difference	4.5 m
Hazen Williams Coefficient "C"	150
Effluent Min Temp	12^0 C
Effluent Max Temp	28^0 C

6.0 FRP MATERIALS & CONSTRUCTION DETAILS

A layer of resin rich "C" Glass Veil shall be used in the Primary Corrosion Barrier. The next Primary Corrosion Barrier shall consist of Chopped Strand Mat (CSM). The resin used in both the Primary Corrosion Barriers shall be Vinyl Ester resin.

The Primary Corrosion Barriers shall be backed up with two layers of CSM utilising Orthopthalic resin as a Secondary Corrosion Barrier. The balance of the thickness shall be built up with Winding Roving, also utilizing Orthopthalic resin. All FRP components shall be sealed with a suitable Top Coat. Details can also be seen in the Construction Drawing **FRP/03.**

7.0 LAYING & JOINTING

The Pipeline shall be laid in the already constructed concrete 150 mm of compacted sand bedding. After testing, the trench will be completely filled with sand, which will again be watered and compacted.

Concrete cover slabs will be placed over the filled trench so that they are fully supported on the sand bed. Although light vehicular loading is not expected in the concrete channel area, this sand support will enable the slabs to sustain light loads in unforeseen situations.

The Concrete Cover Slab and Laying Details are attached as **FRP/05.**

Pipes will be joined together with Butt Wrapped Joints. The Joints will be capable of withstanding the same operating/test pressure and external loads as the Pipe itself.

Flanges for testing and removal of pipe sections will be provided after every 50 meter intervals as shown in **FRP/02.** A removable flanged pipe section of 3 meter length shall be provided after every 100 meter interval for maintenance purposes and removal of sludge deposits.

The pipes will be transported and placed with utmost care so as not to damage any pipe section.

At places where unbalanced thrust is expected to occur on pipes due to change of direction of flow, concrete thrust blocks will be provided to transfer the thrust onto the concrete channel.

8.0 MAINTENANCE PIPE SECTIONS

The pipeline, after commissioning, may require periodic maintenance tasks such as flushing with clean water, removal of sludge and other settled materials. Therefore, a removable flanged pipe section of 3 meter length shall be provided after every 100 meter interval for maintenance purposes and removal of sludge deposits.

9.0 TESTING

INITIAL TESTS

In addition to the normal pressure tests outlined below, the following initial tests shall be performed on test sections of the pipe:

	TYPE OF TEST	SAMPLE LENGTH	MINIMUM VALUE
a.	Diametrical Collapse Test	300 mm	400 KGS
b.	Axial Tension Test	600 mm	8,000 KGS
c.	Axial Compression Test	300 mm	8,000 KGS

WORKING PRESSURE

The pipeline will receive discharge from submersible non-clogging pumps manufactured by KSB (KRTF 150-315/264 UG). These pumps are designed to operate at a 106 liters/sec with a maximum pressure of 14 m (1.35 bar). Public Health Department (Punjab) and textbooks on pressure testing require pipelines to be tested at 1.5 times the working pressure, i.e., 2.03 bars.

TEST PRESSURE

As specified in the Terms of Reference (TOR), the pipeline will be subjected to a hydraulic test pressure of 6 bars, which is approximately 4.5 times the working pressure.

LENGTH OF TEST SECTION

The length of each test section will be 100 m, starting from the sections at the high level end.

BACKFILLING BEFORE THE TEST

The pipes comprising the test sections will be anchored by partially backfilling the trench to at least 300 mm above the crown of pipes. The joints shall remain uncovered for visual inspection during the test.

FILLING OF THE TEST SECTION

The section of the pipeline to be tested shall be filled with water at a rate sufficiently slow to ensure that all air is expelled. The water will be introduced at the lower end of the test section. The rate of filling will be based on a flow velocity of 0.05 m/sec.

TEST PROCEDURE

The hydraulic pressure in the test section will be raised to the working pressure (1.35 bars) and kept static for 6 hours. On successful retaining of the working pressure, the pressure in the pipe will be raised to the test pressure (6.0 bar) and maintained for one hour.

FINAL TEST

After the Pipeline has been completely laid, the pipes will be subjected to a final pressure test of 6.0 bars. The duration of the test will be determined by the time required to carry out a visual inspection of the closure joints between the previously tested individual test sections.

10.0 HEAD LOSS CALCULATIONS

The Pipeline is analyzed for the anticipated working conditions and also for the peak flow, which can occur in case higher capacity pumps are installed in the Dingarh Pump Station.

Design Formula	Hazen Williams
Hazen Williams Coefficient " C "	150

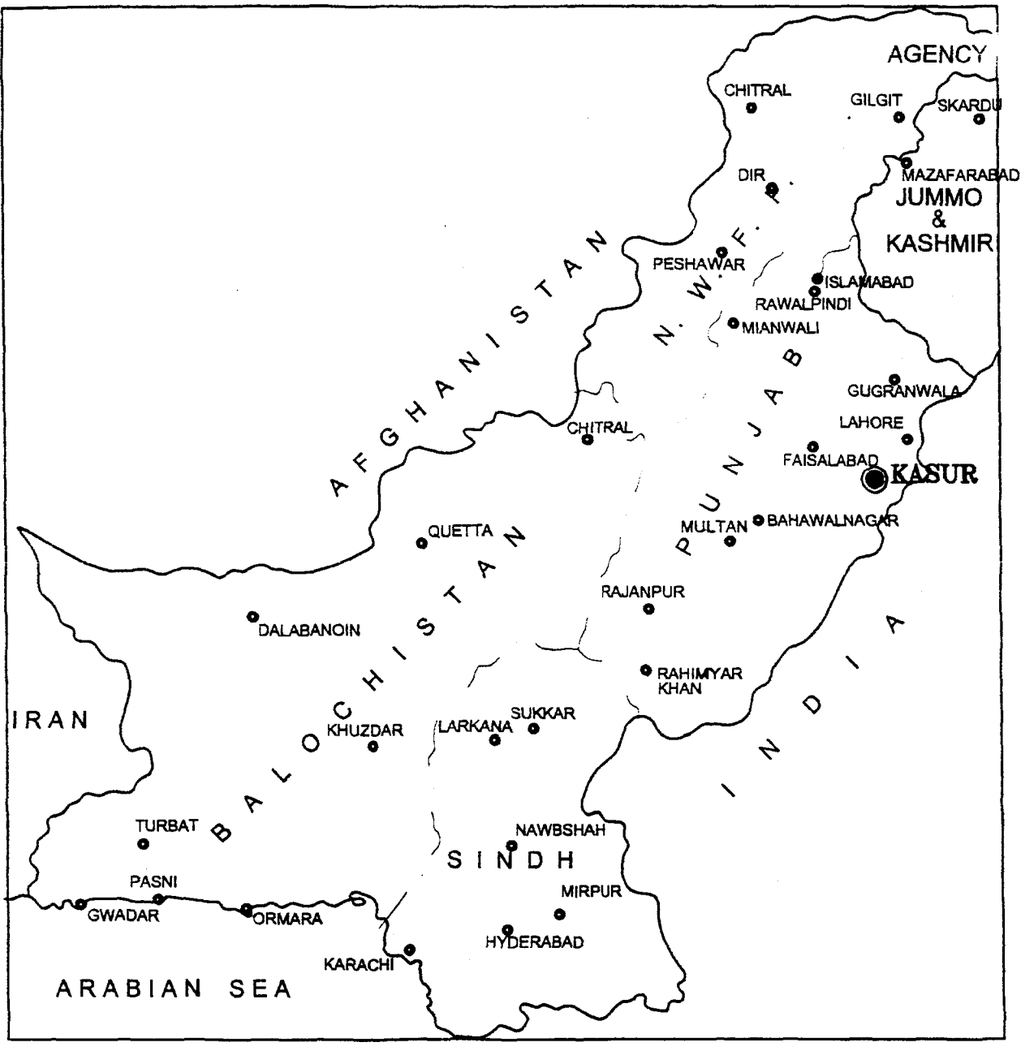
10.1 HEAD LOSS CALCULATIONS AT WORKING FLOW

Flow	106 liters/sec
Head loss/meter	0.0055
Total head loss	3.33 m
Head loss for fittings & valves	1.00 m
Level difference	4.50 m
Pump installation below ground	4.00 m
Total Head Required	**12.83 m**

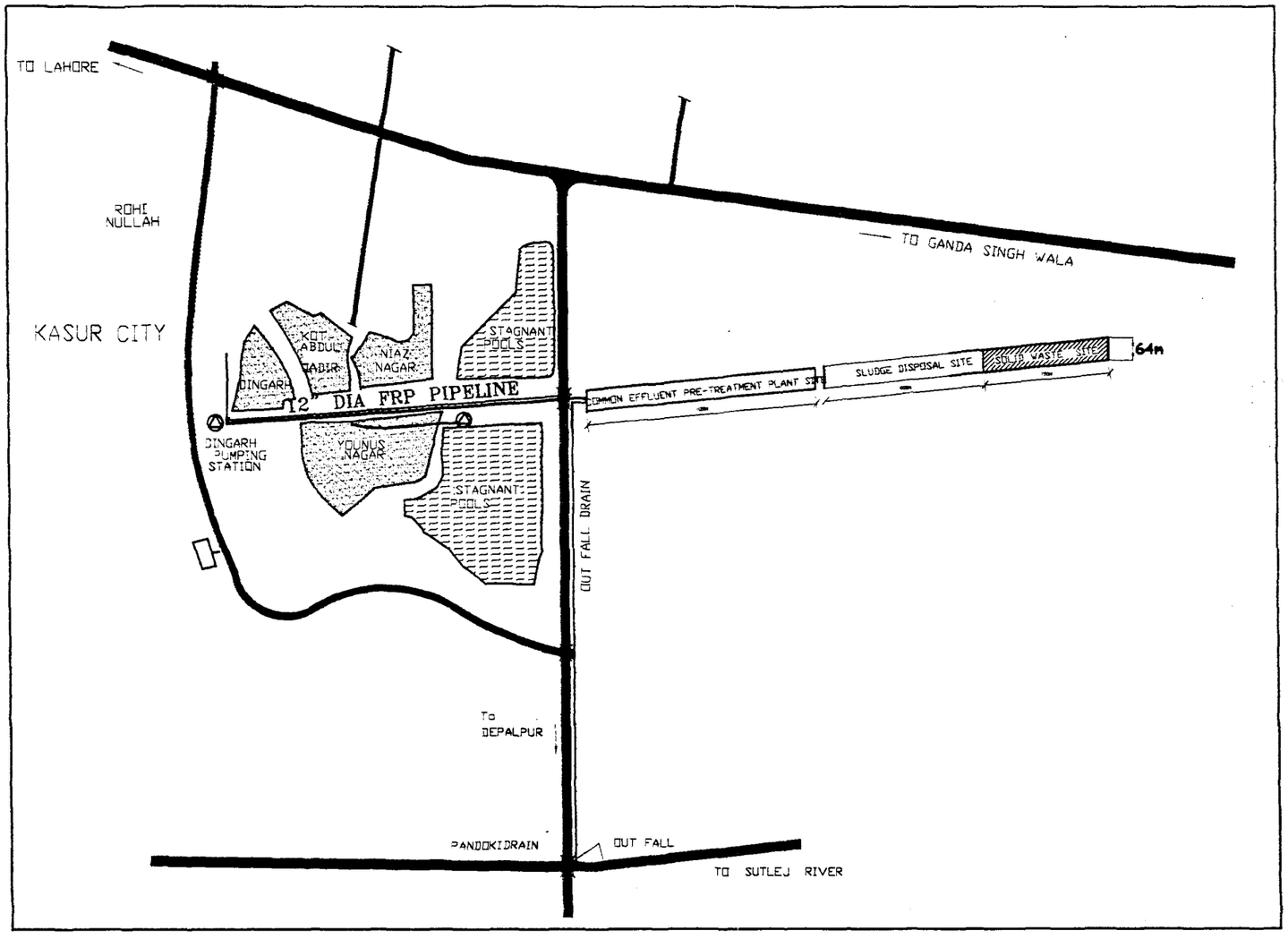
10.2 HEAD LOSS CALCULATIONS AT PEAK FLOW

Flow	130 liters/sec
Head loss/meter	0.0081
Total head loss	4.86 m
Head loss for fittings & valves	1.20 m
Level difference	4.50 m
Pump installation below ground	4.00 m
Total Head Required	**14.56 m**

MAP OF PAKISTAN



GENERAL PROJECT LAYOUT



UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

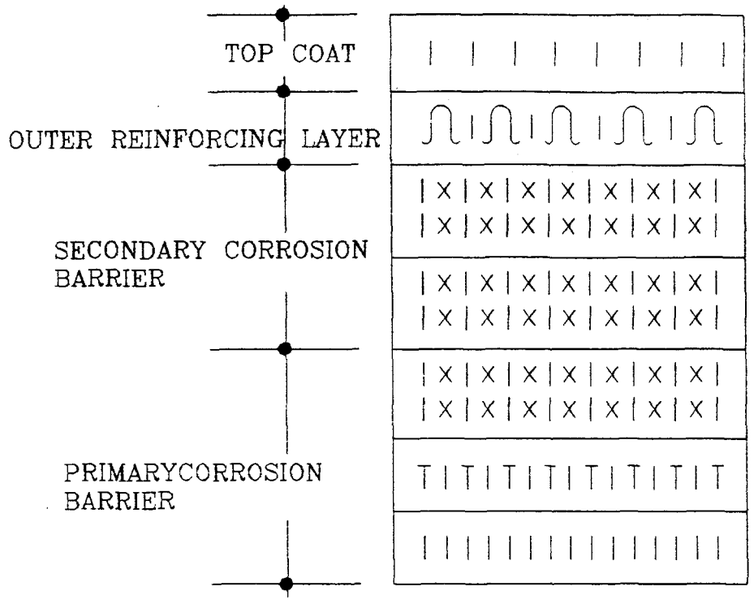
UNIDO CONTRACT NO.99/246/VK

PROJECT No. DG/PAK/93/006
KASUR TANNERY POLLUTION CONTROL PROJECT
KTWMA– KASUR
12" DIA. FRP PRESSURE PIPELINE

LOCATION PLAN
12" DIA FRP PRESSURE PIPELINE PROJECT

OYSTER INDUSTRIES (PVT) LTD.
19/1-L, D.H.A. (Defence Society)
Lahore-54792, Pakistan
Tel: (042) 5731510 - 5731511
Fax: (92-42) 5724503, 5721525

SCALE: NTS.	APPROVED:	DATE: JUNE 2000
CHECKED:	DRAWN: AQIB	DRG. NO. FRP/01



TOP COAT WITH ORTHOPTHALIC RESIN

CIRCUMFERENTIAL WINDING WITH ORTHOPTHALIC RESIN

CSM LAYER WITH ORTHOPTHALIC RESIN

CSM LAYER WITH ORTHOPTHALIC RESIN

CSM LAYER WITH CORROSION RESISTANT VINYL ESTER RESIN

CORROSION RESISTANT VINYL ESTER RESIN ENRICHED "C" GLASS VEIL LAYER

CORROSION RESISTANT VINYL ESTER RESIN RESIN COAT

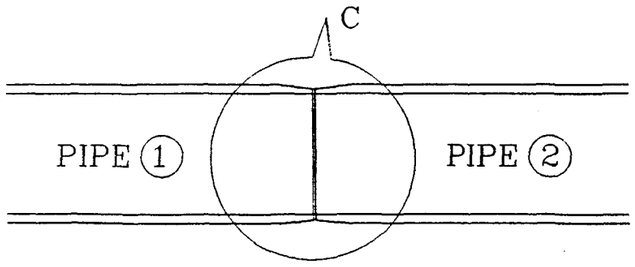
CIRCUMFERENTIAL GLASS (WINDING ROVING) LAYER

X RANDOM GLASS (CHOPPED STRAND MAT) LAYER

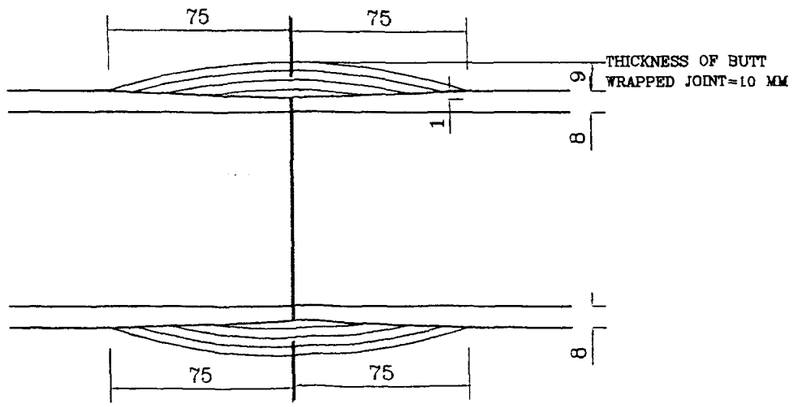
T "C" GLASS VEIL LAYER

RESIN

CONSTRUCTION DETAIL OF 12" DIA FRP PIPE



BUTT WRAP JOINT DETAIL



DETAIL C

NOTES:

1- FOR PLAN AND LOGITUDNAL PROFILE SEE DRAWING NO. FRP/02

REV.	DESCRIPTION	BY	DATE

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

UNIDO CONTRACT NO.99/246/VK

PROJECT No. DG/PAK/93/006
KASUR TANNERY POLLUTION CONTROL PROJECT
KTWMA- KASUR
12" DIA. FRP PRESSURE PIPELINE

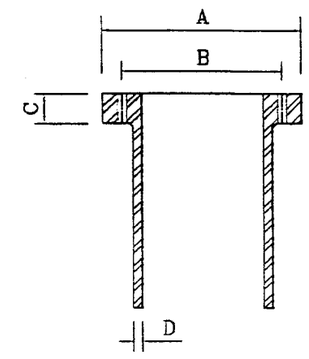
PIPELINE DETAILS-SHEET-1

OYSTER INDUSTRIES (PVT) LTD.
19/1-L, D.H.A. (Defence Society)
Lahore-54792, Pakistan
Tel: (042) 5731510 - 5731511
Fax: (92-42) 5724503, 5721525

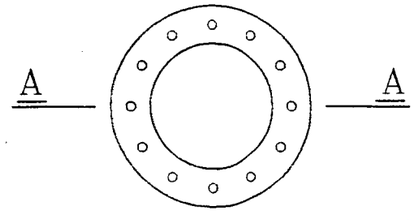
SCALE: NTS.	APPROVED:	DATE: MARCH 2000
CHECKED:	DRAWN: AQIB	DRG. NO. FRP/03

FLANGE DETAILS

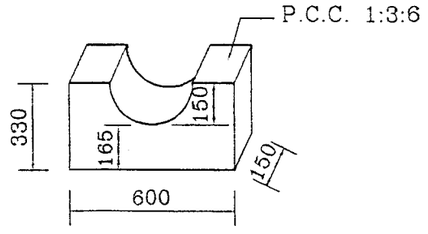
PIPE SIZE mm.	D THICKNESS OF FLANGE NECK mm.	A DIAMETER OF FLANGE mm.	C FLANGE THICKNESS mm.	B DIAMETER OF BOLT CIRCLE mm.	BOLTS		DIAMETER OF BOLT HOLES mm.
					NOS	DIAMETER mm.	
304.8	8	482.6	36.5	431.8	12	22	25.4



SEC. A-A



PLAN



PIPE SUPPORT SADDLES
(WHERE REQUIRED)

NOTES:

1- FOR PLAN AND LOGITUDNAL PROFILE
SEE DRAWING NO. FRP/02

REV.	DESCRIPTION	BY	DATE

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
UNIDO CONTRACT NO.99/246/VK

PROJECT No. DG/PAK/93/006
KASUR TANNERY POLLUTION CONTROL PROJECT
KTWMA- KASUR
12 DIA. FRP PRESSURE PIPELINE

PIPELINE DETAILS-SHEET-2

OYSTER INDUSTRIES (PVT) LTD.
19/1-L, D.H.A. (Defence Society)
Lahore-54792, Pakistan
Tel: (042) 5721510 - 5731511
Fax: (92-42) 5724503, 5721525

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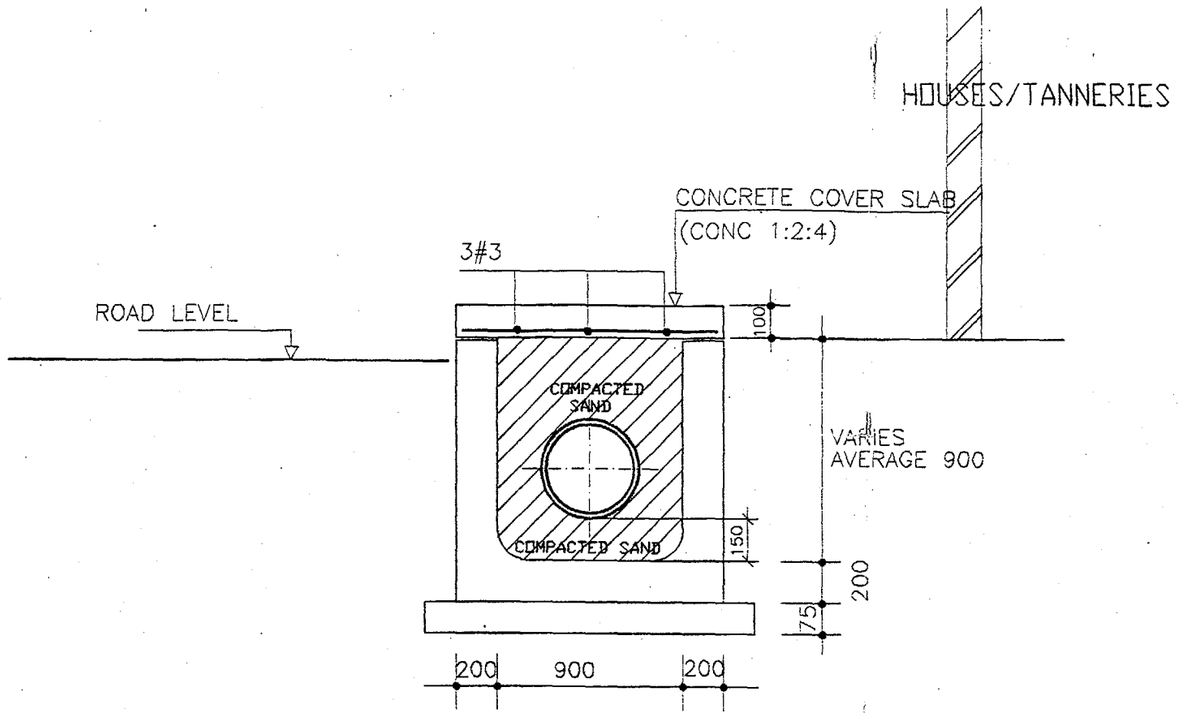
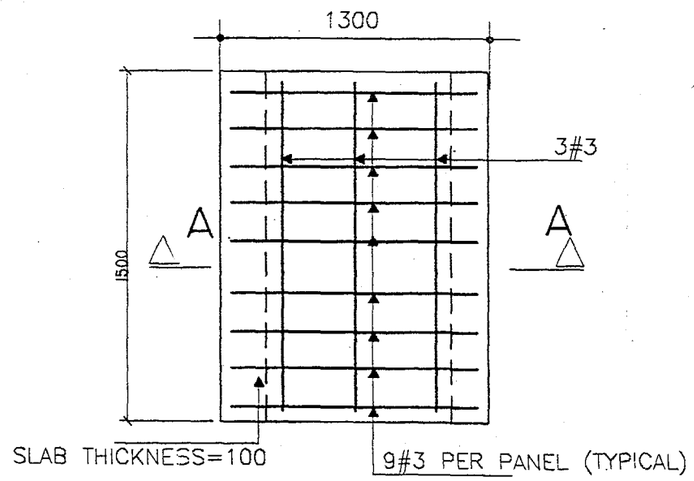
CHECKED:	DRAWN: AQIB	DRG. NO. FRP/04



TYPICAL SECTION OF DRAIN



CONCRETE COVER SLAB

NOTES:

1- FOR PLAN AND LONGITUDNAL PROFILE SEE DRAWING NO. FRP/02.
2- USE CONCRETE OF 3000 PSI CYLINDERICAL CRUSHING STRENGTH.
3- STEEL SHOULD BE OF GRADE 60 OF MIN. YIELD STRENGTH fy =60,000 psi.
4- CONCRETE COVER TO MAIN BARS SHALL BE 3/4 INCHES.
5- SULPHATE RESISTANT CEMENT SHALL BE USED.

REV.	DESCRIPTION	BY	DATE

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
UNIDO CONTRACT NO.99/246/VK

PROJECT No. DG/PAK/93/006
KASUR TANNERY POLLUTION CONTROL PROJECT
KTWMA- KASUR
12" DIA. FRP PRESSURE PIPELINE

CONCRETE COVER SLAB &
PIPE LAYING DETAILS

OYSTER INDUSTRIES (PVT) LTD.
19/1-L, D.H.A. (Defence Society)
Lahore-54792, Pakistan
Tel: (042) 5731510 - 5731511
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SCALE: NTS.	APPROVED:	DATE: JUNE 2000
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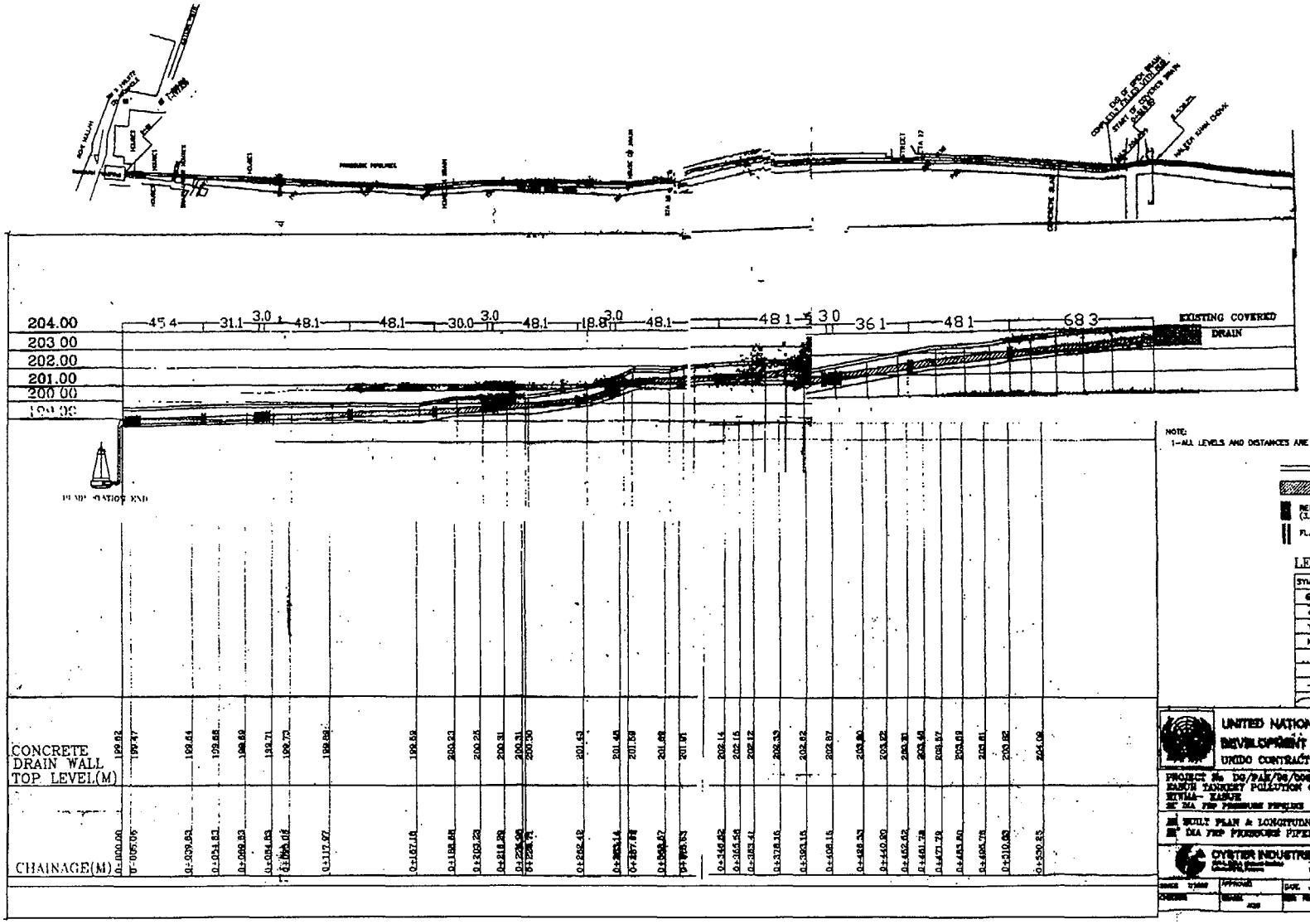
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3.0
48.1
48.1
30.0
3.0
48.1
18.8
3.0
48.1
481
530
361
481
683
EXISTING COVERED DRAIN
PUMP STATION END
CONCRETE DRAIN WALL TOP LEVEL.(M)
CHAINAGE(M)
NOTE:
1-ALL LEVELS AND DISTANCES ARE IN METRES.
CONCRETE COVER (PROPOSED)
FRP PIPE(300 mm)
REMOVABLE SECTIONS (3.0 M)
FLANGED CONNECTION
LEGEND
SYMBOL
DESCRIPTION
MAN HOLE
TREE
HAND PUMP
TUBE WELL
RAINGAUGE STATION
SPOT LEVEL
ELECTRIC POLE
CONTOUR
UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
UNIDO CONTRACT NO 98/148/YK
PROJECT No DG/PAK/98/006
KASUR TANNERY POLLUTION CONTROL PROJECT
KEVLA- KASUR
BUILT PLAN & LONGITUDINAL PROFILE
DIA FRP PRESSURE PIPELINE ROUTE
CYSTER INDUSTRIES (PVT) LTD
PRPM07

22398
(2 of 2)

KASUR TANNERY POLLUTION CONTROL PROJECT
KTWMA KASUR
12" DIA. FRP PRESSURE PIPELINE

PROJECT NO. DG/PAK/93/006
UNIDO Contract No. 99/246/VK

OPERATION & MAINTENANCE MANUAL

MAY 15, 2000

OYSTER INDUSTRIES (PVT.) LTD.

19/1-L, D.H.A. (Defence Society)
Lahore-54792, Pakistan

Tel: (92-42) 573-1510
Fax: (92-42) 572-4503

INDEX

1.0 INTRODUCTION

The UNIDO Contract No. 99/246/VK, awarded to Oyster Industries (Pvt.) Ltd. for the turnkey construction of 12 inches diameter FRP Pressure Pipeline, is part of the overall **KASUR TANNERY POLLUTION CONTROL PROJECT.** This Pipeline will carry the discharge from the Dingarh Pumping Station to a concrete covered drain and will run through the already constructed concrete channel.

As there are no machines or complex equipment involved in this Pipeline, and the usage is continuous with remote chances of sludge deposition, operating instructions are brief. Therefore, a combined Operation & Maintenance Manual has been prepared, with emphasis on the material characteristics, preventive maintenance and repair techniques of the Pipeline. This is because most people are relatively unfamiliar with Fiberglass Reinforced Plastics (FRP).

This Operation & Maintenance Manual has been compiled to ensure that the Pipeline is used for its designed life with minimum problems. This is in compliance with Paragraphs 3.6, 5.3 and 6 of the Terms of Reference Annex "G", and Paragraph h) of Annex E of the above Contract. 10 copies of this manual are being submitted.

2.0 PURPOSE OF OPERATION & MAINTENANCE MANUAL

The purpose of this report is to:

1. Explain the Usage & Operational Procedures
2. Outline the Periodical Cleaning & required Preventive Maintenance
3. Acquaint the user with the basics of FRP technology
4. Explain the Pipe Manufacturing Method
5. Give details of the Jointing method used
6. Explain the Repair Techniques and the Materials required
7. Recompute the Pumping Requirements

3.0 USAGE & OPERATIONAL REQUIREMENTS

As the Pipeline is new, certain precautions are recommended when starting up for regular operations initially. The following procedure is recommended:

a) Leave the Pipeline full of water after the testing has been completed. The air release valve along with the pressure plate used in testing at the other end from the pumping station should be left in place.

b) When initially starting the pump with the sludge, care should be taken to fill the Pipeline slowly and expel all air in the Pipeline, which may have accumulated after weeks of nonuse.

c) This procedure of air release should be repeated whenever the Pipeline is not in use for any prolonged period of time.

d) Other than the above precautions, the Pipeline is adequately designed and no further precautions should be necessary, as we have been informed that the usage is continuous with remote chances of sludge deposition.

4.0 PREVENTIVE MAINTENANCE / PERIODICAL CLEANING

The Pipeline is meant to be maintenance-free for its designed life and sludge deposits are not expected. However, periodical cleaning is recommended annually for removal of any settled materials, which should not take more than a few hours. The method is as follows:

a) Have a source of water (quality of water is not important) available to purge the Pipeline. Recommended quantity is about 15,000 Liters for which mobile water tankers are easily available.

b) Stop the pump from pumping the tannery effluent.

c) Switch the intake of the pump from the effluent to the available water.

d) Pump the entire quantity of the water through the Pipeline.

e) Stop the pumping operation when water is seen to come out of the other end.

f) Switch the intake of the pump back to the effluent.

g) Start the pump again to pump the effluent.

With a Hazen Williams Factor of 150, the chances of blockage of this Pipeline are very remote. However, if this does occur even after regular periodical cleaning, a removable flanged pipe section of 3 meter length has been provided after approximately every 100 meter interval for maintenance purposes and removal of unlikely sludge deposits. This section should be removed and water at 4 Bar pressure should be pumped in the direction away from the pumping station. This will take care of any stubborn deposits.

5.0 BASICS OF FIBERGLASS REINFORCED PLASTICS (FRP)

5.01 INTRODUCTION

The nature of Fiberglass Reinforced Plastics (FRP)

FRP is a light, durable and astonishingly tough construction material that can be fabricated into all types of products, including pipes. It may be translucent, opaque or colored, flat or shaped, thin or thick. There is virtually no limit to the size of objects that can be made in FRP as single pieces. Single piece boat hulls of 80 meter length, tanks of 10 meter diameter and pipes of over 3 meter diameter and 12 meter length give an idea of the versatility of this material of construction.

FRP is unique amongst materials of construction in that the fabricator actually makes the material. Whether he is making sheeting, tanks, pipes, silos, boats, or prefabricated housing, the fabricator is not merely assembling pre-existing components; he is actually making the structural material *in situ.*

FRP is a composite of a resilient durable resin that impregnates an immensely strong fibrous glass. The resin determines the corrosion resistance of the composite and is usually an unsaturated polyester or epoxide resin. It is supplied in the form of a viscous syrup, which when suitably activated sets to a hard solid. The glass in FRP provides the strength and is usually in the form of very fine fibers. As concrete may be reinforced with steel

bars to form RCC, resins may be reinforced with glass fibers to form FRP. This is what the fabricator does.

Plastics

Plastics are man-made materials which can be molded into useful articles. All plastics are composed of macromolecules, i.e. large chain-like molecules consisting of many simple repeating units. These molecular chains are called *polymers*. Man-made polymers are called *synthetic resins* and are mostly made from chemicals derived from hydrocarbons (oil, gas, coal, etc.).

Fiberglass

Glass Fiber or *Fiberglass,* as it is commonly known, is made by rapidly drawing molten glass through platinum bushings and then cooling it. It is one of the strongest materials known and imparts the bulk of strength to FRP. It is non-combustible and chemically resistant.

Materials used in the UNIDO Kasur Pipeline

The resins used in the Pipeline constructed under the above contract are as follows:

Resins

Vinyl Ester Resin Primary Corrosion Barriers
Unsaturated Orthopthalic Polyester Resin as Secondary Corrosion Barriers, Backup and Top Coat.

Fiberglass

30 gm/sq mtr "C" Glass Veil and 300 gm/sq mtr Chopped Strand Mat as Primary Corrosion Barrier.
450 gm/sq mtr Chopped Strand Mat as Secondary Corrosion Barrier
2400 Tex Winding Roving as Pipe Strengthening Backup
800 gm/sq mtr Woven Roving for Joints Backup

5.02 GELATION & HARDENING

Storage Life

Liquid Vinyl Ester and Unsaturated Orthopthalic Polyester Resins are unstable. After several months of storage, they will set to a rubbery gel. This period is the *storage life* or *shelf life* of the resin at 25 Degrees C and varies from one type of resin to another. The storage life is considerably reduced at temperatures greater than 25 Degrees C.

The Vinyl Ester Resin used in this Pipeline has a storage life of 3 months, while the Unsaturated Orthopthalic Polyester Resin has a storage life of 5 months at 25 Degrees C.

Catalysts and Accelerators

In order to produce a laminate or product, a resin must be *cured.* This is the name given to the overall process of *gelation* and *hardening.* This is achieved either by the use of a *catalyst* combined with elevated temperatures, or at room temperatures by mixing a catalyst and *accelerator* into the resin.

Catalysts are dangerous formulations and should ***never*** be stored at temperatures above 23 Degrees C. The normal catalyst used in this Pipeline is 50% MEKP. The accelerator used in this Pipeline is 6% Cobalt Octoate. It is essential to choose the correct types of catalyst and accelerator, as well as to use the correct amount, if the optimum properties of the final cured laminate are to be obtained.

Catalysts and accelerators must ***never*** *be mixed directly with each other, as the reaction can be explosive. As a safety precaution, they must not be stored close to one another either.*

The Curing Reaction

The *cure* of the resins used in this Pipeline will begin as soon as a suitable catalyst is added. Without the addition of either an accelerator or heat, the rate of cure will be too slow for practical

purposes. Thus, the pipes used in this Pipeline were cured at elevated temperatures in an enclosed oven. The jointing at site was achieved by the use of accelerator.

There are three distinct phases in the curing reaction:

1. **Gel Time.** This is the period from the addition of the accelerator or heat to the setting of the resin to a soft gel. In other words, this is the working time that is available to complete the fabrication process.
2. **Hardening Time.** This is time for the setting of the resin to the point when the resin is hard enough to allow the product or pipe to be withdrawn from the mold or mandrel.
3. **Maturing Time.** This is the time required for the product to acquire its full hardness, chemical resistance and stability. Maturing for this pipe was done at elevated temperature for two hours and at room temperature for several days.

5.03 HAND LAMINATION

Hand Lamination was the process used to apply the Corrosion Barriers to the UNIDO pipes. A coat of the Vinyl Ester resin for the Primary Corrosion Barrier was liberally applied over the mandrel (pipe mold) initially. "C" Glass Veil was then pressed onto the mandrel and consolidated with a brush and all entrapped air in the Veil was released. A layer of Chopped Strand Mat (CSM) was then applied over the Veil and thoroughly impregnated with the same resin.

The Secondary Corrosion Barrier consisting of CSM was applied over the Primary Corrosion Barrier and allowed to partially cure using Unsaturated Orthopthalic Polyester Resin.

5.04 FILAMENT WINDING

The balance of the thickness of the pipe was built up by the process of *Filament Winding.* Filament winding consists of winding continuous filaments of glass (Winding Roving) on to a rotating mandrel, the Roving normally having first been passed

through a resin bath to thoroughly wet it. Several layers of Roving are applied until the required thickness is achieved.

Filament Winding is recognized as one the most economical and reliable conversion processes for the manufacture of cylindrical products. The process is principally used for the production of cylindrical tanks and vessels, chimneys, ducting, pipes and other products which must be capable of meeting critical performance requirements.

5.05 HEALTH & SAFETY

The handling of resins and ancillary materials, such as catalysts, presents several hazards which can be reduced to a minimum if proper precautionary measures are taken.

Storage

As mentioned earlier, the Vinyl Ester Resin used in this Pipeline has a storage life of 3 months, while the Unsaturated Orthopthalic Polyester Resin has a storage life of 5 months. As a general guide, the resin is usable as long as it remains a pourable liquid free from particles or lumps.

Vinyl Ester and Polyester Resins are flammable with a flashpoint of 35 Degrees C. Thus, it is advisable to store them at temperatures below 25 Degrees C.

Catalyst used is 50% Methyl Ethyl Ketone Peroxide and presents a special fire hazard. This has a low flashpoint of 28 Degrees C and must be kept in a separate area which is well ventilated. Care should be taken not to touch this material with bare hands.

Usage

Most resins contain a monermic styrene, which is a good grease solvent and can cause irritation to the skin. Use of impervious gloves is recommended. Hands should be washed with soap and water immediately after use. In sufficient quantities, styrene vapor is irritating to the eyes and reparatory passages. Work areas must therefore be well ventilated.

Catalysts are extremely irritating to the skin and can cause burns if not washed off immediately with plenty of warm water. Particular care must be taken with liquid catalysts to avoid splashing, spilling or contact with the eyes. Protective goggles must be worn as a necessary precaution. If catalysts or organic peroxides come into contact with the eyes, they can cause serious injury if not treated immediately. The affected eye should immediately be washed with plenty of clean water or normal saline solution (0.9% w/w NaCl) for at least 15 minutes. Under no circumstances should the eye be treated with oil or oily solutions since these aggravate the damaging effect of the peroxides. In all cases a doctor should be consulted as soon as possible after administering first aid.

Catalyst and accelerator must never be mixed directly with each other, or stored in the same vicinity, since they can react with explosive violence.

6.0 MATERIAL SPECIFICATIONS

A layer of resin rich "C" Glass Veil has been used in the Primary Corrosion Barrier. The next Primary Corrosion Barrier consists of 300 gms/sq mtr Chopped Strand Mat (CSM). The resin used in both the Primary Corrosion Barriers is Vinyl Ester Resin.

The Primary Corrosion Barriers have been backed up with two layers of 450 gms/sq mtr CSM utilising Unsaturated Polyester Orthopthalic Resin as a Secondary Corrosion Barrier. The balance of the thickness has been built up with Winding Roving, also utilizing Orthopthalic Resin. All FRP components have been sealed with a Top Coat of Orthopthalic Resin.

7.0 JOINT DETAILS

Two types of joints have been used in this Pipeline – **Flanged and Butt Joints.**

7.01 FLANGED JOINTS

Flanged Joints have a gasket between them. The Nuts and Bolts are Stainless Steel. Each Joint has 12 Nos. 7/8 inch Bolts. These Joints do not require any further elaboration, as they are a common form of jointing.

7.02 BUTT JOINTS

The strength of the Butt Joint is at least equal to the strength of the pipe itself. In the UNIDO Pipeline, the thickness of the joint has been kept greater than the pipe thickness. Whereas the pipe is of 8 mm nominal thickness, the Butt Joints are of 10.5 mm nominal thickness.

The first step in making a Butt Joint is perfect alignment of the faces of the two pipe sections to be jointed. Then the minute gaps between the faces of the two pipe sections are filled in with putty made from the same Vinyl Ester Resin (Hetron 922 or Derakane 411 or equivalent) as the Primary Corrosion Barrier. The putty is allowed to cure. The first layer over the putty is a band of "C" glass veil utilizing Vinyl Ester Resin.

This is followed by two layers of 450 gm/sq mtr CSM using Vinyl Ester Resin. Thereafter, successive layers of increasing thickness of alternating CSM 450 gm/sq mtr and Woven Roving 800 gm/sq mtr are applied using an Orthopthalic Resin (Scott Bader 405E or equivalent) until the desired thickness is achieved. The entire build-up is followed by a Top Coat using Orthopthalic Resin.

The widths and resins of all the layers of Fiberglass reinforcement are as follow:

No.	Type Of Reinforcement	Resin	Width
1.	"C" Glass Veil 30 gms/sq mtr	V. Ester	75 mm
2.	CSM 450 gm/sq mtr	V. Ester	75 mm
3.	CSM 450 gm/sq mtr	V. Ester	100 mm
4.	CSM 450 gm/sq mtr	Ortho Poly	100 mm
5.	Woven Roving gm/sq mtr	Ortho Poly	100 mm
6.	CSM 450 gm/sq mtr	Ortho Poly	125 mm
7.	Woven Roving gm/sq mtr	Ortho Poly	125 mm
8.	CSM 450 gm/sq mtr	Ortho Poly	150 mm
9.	Woven Roving gm/sq mtr	Ortho Poly	150 mm
10.	CSM 450 gm/sq mtr	Ortho Poly	175 mm
11.	Woven Roving gm/sq mtr	Ortho Poly	175 mm
12.	CSM 450 gm/sq mtr	Ortho Poly	175 mm
13.	Top Coat	Ortho Poly	200 mm

8.0 REPAIR TECHNIQUES

The repair procedure of the Pipeline in case of damage caused by accidental excavation or by willful destruction is the same as the application of the Butt Joint. It may be best to contact the Contractor for repairs initially. The premises of the Contractor are located only 15 minutes from the location of the Pipeline.

Initially, the Pipeline shall be under Warranty. After expiry of the Warranty, the Contractor can provide, at a nominal cost, complete kits of repair materials. The kits can be exchanged with the Contractor every three months to ensure availability of fresh materials at all times.

The kits will come complete with instructions.

9.0 RECOMPUTED PUMPING REQUIREMENTS

The pumping requirements were computed earlier in the Detailed Design Documentation to ensure that there would be no surprises at a later stage, when it would be too late to change the design parameters. The final calculations for the Pipeline as laid are reproduced below:

9.01 PUMP STATION CAPACITY & FLOW DATA

Pump Type	KSB KRTF 150-315/264 UG
Pump Capacity	105.6 liters/sec at 14.0 m Head
Peak Flow	130 liters/sec (Assumed) at Vel =1.82m/sec
Design Flow	*(As per pump capacity)* 105.6 liters/sec (Assumed) at Vel=1.5 m/sec
Pipe Length	537 m (including bends, fittings etc.)
Level Difference	4.5 m

9.02 HEAD LOSS CALCULATIONS

The Pipeline has been analyzed for the anticipated working conditions and also for the peak flow taking into account the actual length of the Pipeline, which can occur in case higher capacity pumps are installed in the Dingarh Pump Station.

9.02.1 Head Loss Calculations at Working Flow

Hazen Williams Coefficient "C"	150
Flow	106 liters/sec
Head loss/meter	0.0055
Total head loss	2.95 m
Head loss for fittings & valves	0.60 m
Level difference	4.50 m
Pump installation below ground	4.00 m
Total Head Required	**12.05 m**

9.02.2 Head Loss Calculations at Peak Flow

Hazen Williams Coefficient "C"	150
Flow	130 liters/sec
Head loss/meter	0.0081
Total head loss	4.35 m
Head loss for fittings & valves	0.80 m
Level difference	4.50 m
Pump installation below ground	4.00 m
Total Head Required	**13.65 m**