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WORLD ENVIRONMENT CENTER

ADDENDUM TO
TRIP REPORT OF JULY 1995 ENTITLED

"ENVIRONMENTAL AND WASTE MINIMIZATION ASSESSMENT VISIT TO JUHOSLOVENSKE CELULOZKY A PAPIERNE"

STUROVO, SLOVAK REPUBLIC

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I. INTRODUCTION

In June of 1995, Dr. Hans E. Wörster, pro bono specialist, Fletcher Challenge Canada Ltd., visited the Juhoslovenski Celulozky a Papierne A.S. - Papermill (JCP) located in the town of Sturovo in Southern Slovakia, on the Danube River. The objective of this visit was to conduct an environmental assessment of the JCP plant and identify opportunities for pollution reduction and waste minimization.

In July 1995, WEC issued Dr. Worster's trip report of his visit to JCP. After receiving additional information about JCP from the plant, Dr. Worster submitted the following addendum to his July report.

II. EXECUTIVE SUMMARY

This report is an addendum to the trip report entitled "Environmental and Waste Minimization Assessment to Juhoslovenske Celulozky A Papierne (JCP) Sturovo, Slovak Republic, June 26 to 30, 1995," prepared by H.E. Wörster, Technical Director Pulp & Paper, Fletcher Challenge Canada, in early July 1995.

Since the time period allowed for the visit was too short to collect sufficient detailed information on JCP's effluent treatment system, this information was sent to Dr. Wörster after his return to Canada by JCP's Manager of the Environmental Protection Department.

This report contains an analysis of the operation of JCP's existing activated sludge effluent treatment system, considerations toward expansion of the existing system to meet future discharge limits, and recommendations on the components of an expanded system.

The data confirm that removal of the biological oxygen demand (BOD_5) in the activated sludge system is low compared to similar systems operated elsewhere. JCP's biological treatment plan is underdesigned for the mill's effluent volume.

Calculations based on JCP's test data suggest the following:

- BOD_5 loading exceeds that of well performing similar systems;
- the ratio of BOD_5 load to the quantity of sludge containing the active microorganisms (which remove BOD_5) is at the high end or above that of well performing systems;
- the high ratio is at least partly caused by the poor settling sludge recycled from the secondary clarifiers.

A comprehensive monitoring program is recommended to better understand the reasons for the relatively poor performance of the system and to generate input data for upgrading and expanding it.

The limited information currently available suggests that, for meeting future stricter effluent discharge regulations, all mill effluent should be treated in an extended activated sludge system. Obviously, the system needs to be well designed and it would have to be operated efficiently on the basis of more extensive testing than conducted currently. Also, important components of the expanded system should include a spill collection basin, an efficient equalization basin, and automatic on-line test and control equipment.

In-plant steps such as improved NSSC pulp washing and spill containment in the chemical regeneration plant should be part of the overall strategy directed toward meeting future stricter effluent discharge limits.

II. CONCLUSIONS AND RECOMMENDATIONS

1. Exiting Activated Sludge System

JCP's test results of 1994 and the first half of 1995 indicate low BOD_5 removal efficiencies for the existing activated sludge effluent treatment system. The overall BOD_5 input of 1,273.6 tonnes to the activated sludge system and an output of 580.3 tonnes in 1994 indicate a removal efficiency of only 54.5%. Similarly, in the first six months of 1995, BOD_5 input and output were 756.7 and 241 tonnes respectively, giving a removal efficiency of only 68.2%. Efficiently operated activated sludge systems provide 85 to 95% BOD_5 removal efficiency. The question arises as to why the BOD_5 removal efficiency is so low at JCP.

Insufficient data is available to explain the low efficiency. Old test data indicated relatively low concentrations of dissolved oxygen (DO) in the activated sludge system itself. Since oxygen solubility decreases with increasing temperature, control of temperature may also be important and temperature measurements should be combined with DO testing. Effluent cooling ahead of the activated sludge systems is practiced in many mills to protect the microorganisms and increase oxygen solubility.

Also, performance details of the aerators are important. Supplier data on oxygen transfer (kg/d) and operating recommendations on preferred liquid depth and aerator blade immersion should be checked to ensure that sufficient oxygen is made available.

The so-called food to microorganism ratio (F/M), which is essentially the ratio of BOD_5 to the mixed liquor suspended solids (MLSS), has to be within a certain range for efficient BOD_5 removal. The MLSS originate from the recycle stream pumped from the secondary clarifiers for mixing with the untreated effluent immediately ahead of the activated sludge basin. Verbal information obtained during the visit to JCP from June 26 - 30, 1995, indicated approximately 4 to 6 grams of MLSS per liter of recycled effluent and a recycle ratio of 1.5.

Calculation of the major design operating parameters from JCP's average data gives the following results compared to extended aeration systems with 18 to 24 hours hydraulic retention time, which provide 75% to 90% BOD_5 removal efficiency.

TIME PERIOD	1994	JAN - JUNE 1995	GOOD SYSTEMS
MLSS, mg/l	3000	3000	3000 - 6000
F/M, kg BOD/kg MLSS	0.21	0.15	0.05 - 0.15
Volumetric Loading, kg BOD_5/m^3	0.86	0.45	0.16 - 0.40

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These data show that, at JCP, on the average the MLSS concentration in the activated sludge system was at the low end and the F/M was at the high end and above the range of systems that are performing well. Also, the volumetric BOD_5 loading was significantly above the common range in 1994 and slightly above it in the first half of 1995. In plant steps such as better NSSC pulp washing and spill collection in the chemical regeneration area would reduce the BOD5 loading. This reduction in BOD loading would also lower the F/M and thus should lead to higher BOD_5 reduction efficiencies.

Alternatively, an increase in the MLSS concentration would also result in lower F/M. However, this would require better settling, i.e. a lower settled volume index (SVi) of the MLSS in the recycle from the secondary clarifier. The high SVi of the recycle at JCP (150 to 200 ml/g compared to 80 ml/g for good settling) is probably mainly due to very high portion of filamentous bacteria in the sludge. Growth of filamentous bacteria is favored by:

- low dissolved oxygen concentration, especially in combination with high F/M;
- presence of readily degradable BOD_5 such as starch, e.g. from OCC waste;
- high sulfide concentration, i.e. from sodium sulfide containing spills and hydrogen sulfide contain condensate from the chemical regeneration system;
- nutrient deficiency;
- low pH.

From the above, it follows that more information is needed to understand the main reason for the relatively low BOD_5 reduction efficiency. To this end, a monitoring program around the activated sludge system is recommended. It includes some of the testing already being conducted. A list of the proposed monitoring program is given in Table 1.

TABLE 1

PROPOSED MONITORING FOR THE ACTIVATED SLUDGE PLANT

MONITORING/TESTING	FREQUENCY
Influent flow	1/day
Dissolved oxygen (DO)	2/day
Temperature	2/day
pH	1/day
Nutrient flow	1/day
Sludge volume index (SVI)	1/day

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MLSS/MLVSS[1]	1/day
Secondary clarifier DO	2/day
Return activated sludge flow	1/day
Microscopic exam of MLSS	1/day
Oxygen uptake rate	2/week
Settling Velocity of MLSS	2/week
Waste activated sludge volume	1/day
1. MLSS/MLVSS - Mixed liquor suspended solids and volatile suspended solids	

Data established over a period of several weeks of representative mill operation should then provide the information required for upgrading of the existing activated sludge system.

At this time, every effort should be made to reduce spills in the NSSC pulping and regeneration area in order to reduce the volumetric BOD_5 loading to the activated sludge system. This reduction would result in a lower F/M, which in turn should increase the BOD5 removal efficiency and, obviously, also the BOD_5 content of the effluent discharged into the Danube River.

2. Considerations Towards Additional Biological Effluent Treatment Facilities

Calculations based on JCP's data of 1994 and the first half of 1995 indicate average volumetric BOD_5 loadings of 0.40 and 0.55 kg/m^3 of the total effluent respectively from <u>all</u> mill departments. To reach the BOD_5 limit of 50 mg/liter required by 1 January 2005, the BOD_5 removal efficiency would have to be 87.5% and 91% respectively on the average. This removal efficiency can be reached with well designed and well operated activated sludge systems. Nevertheless, it is expected that a significant reduction of the volumetric BOD_5 loading will be accomplished by improved NSSC pulp washing and spill collection in the chemical regeneration area. However, data are not yet available to calculate the impact of these in-plant steps on BOD_5 reduction.

At a MLSS concentration of 3000 mg/liter (e.g. at a recycle ratio of 1.5) in the activated sludge tank, the F/M would be 0.06 and 0.08 for the 1994 and the first half of 1995 untreated effluent flow rates and BOD loadings respectively. These F/Ms are well within the range of the extended aeration mode of activated sludge effluent treatment technology with hydraulic retention times of 18 to 24 hours in the aeration basin.

The above F/M data serve only as an example. Obviously, somewhat different results would be obtained with other MLSS concentrations in the activated sludge tank. Different M/F would

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easily be possible, e.g. with other recycle ratios than the 1.5 ratio assumed above. However, the general conclusion would probably be that extended aeration would be suitable.

Calculations based on JCP's indicate data average COD concentrations of 686 to 878 mg/l for the total effluent volume from all departments in 1994 and the first half of 1995 respectively. At 68% COD reduction, which can be accomplished in a well designed and well operated activated sludge system, the above COD loading should result in final effluent with approximately 220 to 280 mg/l. This COD concentration range would be close to and somewhat above the 250 mg./l limit that will be enforced on 1 January 2005. However, improvements in NSSC pulp washing and spill collection and spill recycle in the chemical regeneration plant should reduce the COD discharges significantly.

JCP's data made available to Dr. Wörster on total suspended solids contents of the untreated department effluents are incomplete in that no test results were provided for the effluent from Plant III. JCP's average test data for 1994 indicate 110 mg TSS/l and 1,798.3 tonnes/year for the effluent discharged into the Danube from the manufacturing facilities. These discharges are too high compared to the 1 January 2005 limits of 50 mg/l and 1,250 tonnes/year. The available numbers do not indicate how much of the TSS is fiber and other solid material and how much is biomass from the activated sludge system. Therefore, in the absence of this information, it can only be recommended that primary sedimentation and the SVi of sludge from the existing activated sludge system be improved and that a new/expanded biological treatment system be designed and operated in such a manner that well settling sludge is generated.

3. Components of an Efficient Activated Sludge System

The major components of an efficient activated sludge system regardless of its rate are:

- primary clarification of all mill department effluents containing fibrous and other solid materials;

- an equalization basin for mixing of all effluents. Twelve hour retention time is recommended to minimize variations in BOD_5, COD, pH and temperature, etc. caused by inconsistencies of the manufacturing processes. If the potential for odor release exits, e.g. due to the presence of sulfides, the basin should be covered and the air space under the cover should be vented through charcoal filters to eliminate odors and other objectionable gas emissions such as VOC;

- emergency and spill collection basin for storage and for metering high BOD_5/COD or toxic effluents (identified by high conductivity, very dark color or high turbidity) to the equalization basin at such a rate that the microorganisms of the activated sludge system are not affected adversely;

- pH control and nutrient addition to provide satisfactory conditions for the biological processes in the activated sludge basin;

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- temperature control to avoid high temperatures at which the microorganisms' efficiency would suffer; cooling towers or heat exchangers may be necessary depending on the maximum temperature and flow rate of individual mill department effluents;

- activated sludge (biological) basins with efficient properly positioned aerators

- secondary clarifiers for good settling of sludge from the biological treatment and pumps for feeding some of the settled sludge back to the inlet of the activated sludge system for control of the microorganism population and of the F/M;

- thickening of excess sludge from the secondary clarifiers with filters and presses before disposal of the sludge, e.g. in a landfill;

- automatic on-line test and control equipment, e.g. conductivity meters to identify high BOD_5 effluent from the NSSC pulp mill and the chemical regeneration area or from other areas of the mill.

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