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WEC™

WORLD ENVIRONMENT CENTER

FINAL REPORT

TO

BORSODCHEM RT.

KAZINCBARCIKA, HUNGARY

WASTE MINIMIZATION DEMONSTRATION PROJECT

WORLD ENVIRONMENT CENTER
419 PARK AVENUE SOUTH, SUITE 1800
NEW YORK, NEW YORK 10016

JULY 1995

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File

TABLE OF CONTENTS

		Page
I.	Introduction	1
II.	Executive Summary	2 - 4
III.	Envirometrics Systems Final Report	5
IV.	Borsodchem Rt. Report	6
	Attachment No. 1 Vendor Literature: TMO2D Oxygen Analyzer & Thermoparamagnetic Oxygen Sensor	

I. INTRODUCTION

Under the technical assistance program for Central and Eastern European countries funded by the United States Agency for International Development, the World Environment Center (WEC) team conducted a reconnaissance visit in April 1994 to a plastics and chemicals manufacturing plant, Borsodchem Rt., located in Kazincbarcika, Hungary.

During that visit, the feasibility of a Waste Minimization Demonstration Project (WMDP) was established and three potential projects were identified. The first concerned the reduction of vinyl chloride monomer (VCM) emissions from the polyvinyl chloride (PVC) manufacturing facilities; the second pertained to reduction of vent gas air emissions from the waste gas incinerator at VCM facilities and the third was related to reduction of mercury losses at the chlor-alkali plant. The results of this visit were reported in Trip Report #1.

During a follow-up trip (August 1994), the project finally selected was the one concerning reduction of VCM emissions at the PVC plant. Findings and conclusions from that trip were presented in Trip Report #2.

The start-up of the WMDP took place during WEC team's visit in December 1994. At the same time, the monitoring equipment was calibrated and plant personnel were trained in its usage.

Following installation of oxygen monitoring equipment and tests performed for about three (3) months, it was concluded that recovery of VCM is practical and can become standard production procedure.

The purpose of the June 2, 1995 WEC team's visit was to formally close this waste minimization demonstration project.

I. EXECUTIVE SUMMARY

Among its other various activities, World Environment Center's (WEC's) technical assistance to industrial plants in Hungary to reduce environmental pollution includes a Waste Minimization Program. Under this program, Waste Minimization Demonstration Projects (WMDP) sponsored by WEC were performed at three (3) large enterprises. The purpose of these projects was to demonstrate to the industry the attractiveness of the waste minimization concept and to disseminate this effective pollution prevention strategy among other Hungarian enterprises.

One of the plants where a WMDP was performed was Borsodchem Rt., the largest chemical complex in Hungary. The project was initiated in April 1994, when WEC's team during a reconnaissance visit together with the plant management, established the feasibility of such projects. At that time, three (3) facilities for potential projects were identified:

No. 1 PVC plant - recapture of vinyl chloride monomer (VCM) released into the air from steam stripper column;

No. 2 VCM plant - reduction of vent gas air emission from the waste gas incinerator, containing chlorine, hydrogen chloride and hydrocarbons; and

No. 3 Chlor-alkali plant - reduction of mercury losses.

The most attractive prospect from an environmental and financial point of view was No. 1. It was estimated that, when implemented, this project could reduce VCM (carcinogenic!) emissions into the air by about 300 tons/year and yield approximately $150,000/year in feed stock savings.

Project No. 2, if implemented, could eliminate the release of approximately 20 tons/year of excess chlorine, hydrogen chloride and other chlorinated hydrocarbon gases into the air and generate about $100,000/year profit from sale of additional hydrochloric acid.

Project No. 3, although financially least attractive, when implemented would prevent about 0.5 ton/year of mercury from entering into the environment and generate about $2,000/year savings.

Final selection of the project was contingent on securing reliable monitoring equipment, which could be purchased by WEC with available funds.

During a follow-up visit by WEC's team in August 1994, a final determination was made on the selection of facilities for the WMDP. It was decided that the project

will focus on reduction of vinyl chloride monomer (VCM) air emissions at the polyvinyl chloride (PVC) plant.

VCM is a gas that is potentially explosive and causes liver cancer (known as angiosarcoma), a bone condition (acro-osteolysis), a narrowing of the blood vessels (Raynaud's phenomenon), and hardening of the skin (scleroderma). Approximately 300 tons/year of this gas were discharged causing air pollution and a loss of raw material. The reason for this situation was the plant's concern that under certain conditions recycling of VCM can cause an explosion which may occur when oxygen contents exceed maximum limits. Dependable monitoring of the oxygen content presented technical problems due to the high moisture contained in VCM gas.

To assure successful completion of the project, Borsodchem Rt. has established a Waste Minimization Team consisting of five people from various departments, who were responsible for implementation of this WMDP.

For this project, WEC has provided monitoring equipment which included a thermoparamagnetic oxygen analyzer and complete sample conditioning system purchased from Panametrics Company at a cost of $11,280. The equipment was delivered to the plant in mid-November 1994 and plant personnel were trained on its use and maintenance.

Following installation of the equipment and after about two (2) months of tests and adjustments, as of this writing Borsodchem Rt. is recovering nearly **100%** of VCM gases previously wasted. It was concluded that about **240 tons/year** of VCM can be recovered, thus generating savings of **$144,000/year.** The payback period was about one (1) month.

Borsodchem Rt.'s management and WEC consider this demonstration project to be highly successful. In addition to environmental and financial dividends, it demonstrated to the management of one of the largest enterprises in Hungary and also to other companies the attractiveness of the **waste minimization concept** in combating environmental pollution. Also, it served as a catalyst for culture change among operators, who saw first-hand the link between environmental and operational improvements. The degree of understanding and cooperation which WEC received at this plant is an assurance that Borsodchem Rt. will be the "flagship" in Hungary for the dissemination to other companies of this effective pollution prevention strategy.

The results of WEC's Waste Minimization Demonstration Project at Borsodchem Rt. can be summarized as follows:

- Reduced air pollution by preventing **240 tons/year** of a cancer-causing gas from entering the atmosphere;
- Reduced health hazard to workers and to neighboring inhabitants;
- Improved relations with adjacent community by making substantial reduction in air pollution;
- Saving of raw material valued at **$144,000/year.**
- Improved production efficiency.
- Improved energy conservation;
- Induced plant managers to adopt permanent waste minimization policy; and
- Established a forum for demonstrating benefits of the waste minimization program for Hungary's enterprises.

The project was formally closed on June 2, 1995.

For more information and details, refer to the enclosed Envirometrics Systems, Inc. "Final Report".

III. ENVIROMETRICS SYSTEMS, INC.
FINAL REPORT

Envirometrics Systems, Inc.

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Final Report
Waste Minimization Demonstration Project
Borsodchem Rt., Kazincbarcika, Hungary

INTRODUCTION

World Environment Center (WEC) and Borsodchem Rt., Kazincbarcika, Hungary (Borsodchem) have conducted a Waste Minimization Demonstration Project (WMDP) to reduce air emission of vinyl chloride monomer (VCM) gas from steam stripping columns located in the polyvinyl chloride (PVC) manufacturing plant operated by Borsodchem. This project was the result of a reconnaissance visit made by a project team of WEC to Borsodchem in April 1994 to identify waste minimization opportunities, as well as a follow-up visit in August 1994 to develop a WMDP for the most feasible opportunities. At the same time, WEC made a decision to purchase and supply the process monitoring equipment required for the project. A Memorandum of Understanding (MOU) to conduct the WMDP was then signed by the two organizations. The process monitoring equipment selected for the project, an oxygen analyzer and gas sample conditioning system, was then received by Borsodchem and installed near the steam stripping columns to monitor the VCM gas being emitted to the air. A visit was then made by WEC's project team in December 1994 to participate in the start-up of this equipment. The project team also included a technical representative of Panametrics, Inc, which had supplied the equipment. During this visit, plant personnel at Borsodchem were trained in the final calibration and use of the oxygen analyzer. At the same time, a waste minimization team (WM Team) was formed by Borsodchem to implement the WMDP. It was also decided that Borsodchem will initially monitor the performance of the oxygen analyzer for data quality and need for additional calibration of the instrument. Borsodchem then made arrangements for weekly data on the process and oxygen monitoring to be sent to WEC for review. This procedure was followed by Borsodchem for approximately six weeks (until February 16, 1995). Simultaneously, the WM Team made the plant modifications required to reduce and control the oxygen content of the VCM gas. Then, Borsodchem reported their satisfaction with the performance of the oxygen analyzer and the results of the efforts made by the WM Team to reduce oxygen content of VCM gas. A decision was then made by Borsodchem to start recycling of VCM whenever its oxygen content was below predetermined limits.

Borsodchem completed the WMDP in March 1995 after monitoring the recycling of VCM gas emitted by both the steam stripping columns installed on-site for a month (February 16 through March 15, 1995). These trials were successful and resulted in the actual recycling of nearly 80% of the VCM gas which would have been emitted to the air otherwise. These results were then presented by Borsodchem in a report dated March 31, 1995 to WEC which is given as an attachment to this final report of WEC's consultant - Envirometrics Systems, Inc. - on the project. Besides discussing the initial process monitoring data and final results of the WMDP as reported by Borsodchem, the following report has provided a few conclusions and recommendations on the general practice of using instruments in process control and waste minimization. The following report is also designed to provide a brief review of the entire project. Therefore, this report starts with a brief description of the selection of a waste minimization opportunity for the project. Then, the report addresses the selection of process monitoring equipment to support the WMDP. Finally, the WMDP itself has been discussed at some length prior to summarizing the conclusions and recommendations of the project. A brochure describing the principle and features of the equipment supplied by WEC is also included as an attachment to this report.

More complete details of the project are given in the earlier reports which were submitted by WEC (Interim Reports # 1 dated June 1994, Interim Report # 2 dated November 1995 & Interim Report # 3 dated January 1995).

Selection of a Waste Minimization Opportunity

At least three highly beneficial waste minimization opportunities were identified at Borsodchem during the reconnaissance visit of the WEC project team in April 1994, primarily due to the active interest in waste minimization shown by all professionals in the company. Being a large chemicals manufacturing facility, almost every major "non-product" stream found at Borsodchem can result in significant cost savings and benefits to the environment and health if properly recycled, recovered or reused. It was, therefore, difficult at the end of the reconnaissance visit to select one of the three waste minimization opportunities identified for the WMDP. The final selection of the waste minimization opportunity was therefore made only in the follow-up visit in August 1994, after investigating each opportunity and getting a better understanding of the availability of equipment and level of effort involved in demonstrating waste minimization in each case.

The final selection of a waste minimization opportunity for the WMDP - recycling of VCM gas being lost to the air at the PVC plant - was also driven by management decisions which had been made recently to install additional steam stripping columns at the facility to meet with increased standards for residual vinyl chloride in the PVC resin sold in the international market as well as the increased demand for manufacturing PVC. Due to the planned increase in level of steam stripping operations, the maximum expected rate of emission of VCM gas to the air would have increased from 40 to 75 kilograms per hour. A concept design had therefore been prepared by Borsodchem for monitoring the oxygen content of the VCM gas to enable its recycling when the WEC project team visited the plant in August 1994. Borsodchem had also made an effort to commission a repaired oxygen analyzer for use at the facility, and was considering the feasibility of using a suitable programmable logic controller (PLC) with the oxygen analyzer to monitor VCM recycling operations in the future. Once a suitable gas monitoring system is found and installed, it was believed that Borsodchem had adequate familiarity with the PVC manufacturing plant and operations to be able to minimize the leakage of air into the system which was responsible for the oxygen content of the VCM gas being high and prevented its recycling. After considering the availability of instruments for the purpose, as well as Borsodchem's initiative to improve its operations, WEC decided that the WMDP will be focussed on demonstrating the opportunity of recycling VCM at the PVC manufacturing plant.

Selection of Equipment for the WMDP

Five quotations were obtained from U.S.-based manufacturers of process instruments for the application proposed for the WMDP. Three of these instruments used the fact that the magnetic susceptibility of oxygen is approximately 100 times greater than most common gases. Oxygen was therefore being detected in these instruments by creating a magnetic field in the instrument and attracting oxygen preferably towards the field. The designs for creating a magnetic field in the proposed instruments using this principle were different, however. Two of the instruments considered for this application used the magnetodynamic field, known as the "dumbbell type", whereas the third instrument used a thermoparamagnetic field or wind generating type. Although both types of magnetic fields have been used successfully to monitor oxygen content in different industrial applications, previous experience of Borsodchem in using the "dumbbell type" magnetic field, as well as other attractive features of the instrument using thermoparamagnetic field (price and safety), enabled the selection of the latter type of instrument for the WMDP. The design of the gas sampling system offered with this instrument was also found to include attractive features.

Implementation of WMDP

As noted above, Borsodchem commenced the WMDP after the oxygen analyzer and gas sample conditioning system were started-up in December 1994. Prior to recycling the VCM gas from the steam stripping columns to the manufacturing process, however, Borsodchem monitored the performance of the instrument for several weeks. WEC received these monitoring data on a weekly basis for review. These data indicated that an improvement in the readings was taking place and that Borsodchem was increasing its familiarity with the equipment. After receiving the first and fifth week's data, however, WEC's consultant and representatives of Panametrics, Inc. discussed the data and communicated to Borsodchem the need to confirm data quality, check calibration, follow operating instructions for the gas sampling system and document the actions being taken or planned by the WM team to reduce the oxygen content of the VCM gas stream. Borsodchem continued with the monitoring of the instrument for a few more weeks when it confirmed that the instrument's readings were reliable. Borsodchem had also been reducing the oxygen content of the VCM gas at the same time, and developed an action plan to reduce it further. It was known that air leakages to the system occurred at specific units, such as the screen below the polymerization reactors to receive the PVC resin. Slurry tanks used for storing the resin prior to steam stripping were also kept open to atmosphere. Steam stripping was also conducted at vacuum which could result in increased oxygen content. The WM team was known to be familiar with these problems and the needed corrective action . Borsodchem started recycling VCM gases from February 16, 1995.

As shown by the attached report of Borsodchem on the results of recycling VCM gas to the gas holder prior to further purification, the WMDP prevented nearly 80% of the gas from being released to the air from steam stripping columns. Prior to the WMDP, control valves were installed in the pipes carrying the gas streams and connected to the electronic output from the oxygen analyzer. Daily records were then maintained for one month of the period of time when the blowdown control valve on each steam stripping column was kept open. This information was then used to record the quantities of VCM gas recycled and vented. As shown in the tables prepared by Borsodchem, blowdown has occurred from 0 to 15 hours per day in steam stripping column 'B'. However, the average daily blowdown of gas from this column was only 4 hours. Borsodchem expected the results of recycling rate to improve to 95% as soon as plant modifications at the slurry tanks were completed. This appears to have been verified by the data collected during most of April 1995.

ESI

Conclusions and Recommendations

A summary of the conclusions and recommendations to date resulting from the WMDP at Borsodchem is given below :

1. The project has demonstrated that it is feasible to successfully recycle to the process nearly all the VCM gas which is removed from PVC resins by steam stripping at Borsodchem. This demonstration will enable Borsodchem to prevent the future emission to the air of significant quantities of a gas which is known to be a carcinogen.

2. The recycling of the VCM gas being emitted at present will also reduce the cost of raw materials used in manufacturing PVC resin. Borsodchem has estimated in its report on the results of WMDP that the payback period of waste minimization in this project is less than 1 month based on an assumption that the cost of implementation included only the cost of the instrument purchased by WEC. It is recommended that Borsodchem revise this estimate after calculating the true cost of implementation by taking into consideration at least the cost of plant modifications required to install the new gas recycling system (control valves, electrical connections, piping, additional instruments, etc.) and to prevent air leakages to the existing process equipment. Now that the WMDP has been successful, it is recommended that Borsodchem determine the upper limit of additional capital investment needed to achieve safe recycling and to make it a permanent feature of plant operations.

3. Borsodchem has reported that the recycled gas was found to be of acceptable quality in comparison with the previous contents of the gasholder at the plant. It is recommended that Borsodchem estimate the changes in the quality of the recycled VCM gas which may occur if a third steam stripping column is installed to further decrease the quantities of VCM residuals in the PVC resin manufactured at the plant. Based on the results of this estimate, it is suggested that Borsodchem consider the alternatives to increasing the capacity of steam stripping at the plant to meet with international standards on PVC resin quality.

4. It is finally recommended that Borsodchem consider the purchase of an oxygen analyzer dedicated for the VCM gas emitted from each steam stripping column to achieve increased safety and reliability of the existing monitoring system. It is also recommended that Borsodchem determine the need for additional training in calibration and operation of the Panametrics analyzer and gas sampling system to assure data quality and performance.

Project Summary

The WMDP at Borsodchem required a capital investment of approximately $11,000 in process monitoring equipment (a thermoparamagnetic oxygen analyzer and a gas sample conditioning system) and has demonstrated the possibility of recycling nearly 100% of the VCM gas (a recognized carcinogenic material) which had been emitted to the air from steam stripping of the PVC resin being manufactured at the plant in Kazincbarcika, Hungary.

Based on the current level of production of PVC resin at the plant and the operation of both the existing steam stripping columns at current levels of performance, the potential for recycling VCM gas (at 100% recovery) has been estimated to be 300 metric tons per year. During the WMDP, the actual rate of recovery of VCM which was demonstrated from February 16, 1995 to March 15, 1995 was reported to be 80%. At that time, the quantity of gas recovered was estimated to be 240 metric tons per year. However, the rate of recovery has been found to be nearly 100% during the demonstration which was conducted in most of April 1995 after modifying the auxiliary equipment prior to the steam stripping columns (such as the slurry tanks receiving the PVC resin from polymerization reactors) to prevent the leakage of air to the manufacturing systems. The potential for recovering VCM will increase further in quantity with increased levels of production of PVC resin at the plant and / or increased levels of performance of steam stripping operations.

The WMDP has resulted in significant economic and environmental / health benefits to Borsodchem, as well as several other less tangible benefits, which are outlined below :

Environmental / Health Benefits. As noted above, the total reduction in the air emission of VCM gas under current levels of production and performance of the operations at Borsodchem is estimated to be 300 metric tons per year. The hourly rate of emission of the gas, based on 8,000 hours of operation per year, may be estimated to be 37.5 kilograms per hour. This rate of air emission would have been higher (40 kilograms per hour) at the existing maximum production capacity of the plant. At the increased levels of production Borsodchem is planning to operate in the near future, the potential emission of VCM gas has been estimated to be as high as 75 kilograms per hour. Prevention of air emission of a carcinogenic gas like VCM has resulted in the reduction of health risks in Kazincbarcika.

Economic Benefits. As noted in the final report, a reasonable estimate of the economic benefits may be based on the cost - $ 600 per metric ton - at which VCM gas is available for manufacturing PVC resin at Borsodchem. By assuming that Borsodchem manufactures 300 metric tons of PVC resin next year at a rate of recovery of VCM gas of 95%, the cost benefits in purchase of VCM gas is estimated to be 171,000 per year. The period for paying back the capital investment ($11,000) involved in the purchase of the process monitoring equipment for the WMDP can therefore be estimated as less than 1 month.

Other Benefits. Several other less tangible, but important, benefits have resulted from the WMDP conducted by Borsodchem. First, the WMDP appears to have been a catalyst for increased efforts to be made by the management of the company to achieve more waste minimization in the immediate future. Borsodchem has prepared a waste minimization program at the end of participation in the WMDP, a workshop on waste minimization in Hungary and a study tour of industries and management services in the United States. Second, the WMDP has paved the way for Borsodchem to increase and accelerate their participation in the international market for PVC resins which has established standards for the residual content of vinyl chloride in the product. Borsodchem can now consider the installation of a third steam stripping column to achieve these standards, as well as reduce the concentration of vinyl chloride in the wastewater from the plant and fugitive emissions. If the market demand grows sufficiently, Borsodchem will also be able to consider plant expansion without a corresponding increase in air emission of VCM gas. Last, but not the least, the WMDP has prepared Borsodchem to comply better with future environmental regulations and minimize the impact of regulatory enforcement on their operations.

Acknowledgement

Envirometrics Systems, Inc, (ESI) thanks Dr. Bohdan Aftanas, Project Manager at WEC, for this opportunity to work in the WMDP from identification of waste minimization opportunities through concept development and design to ultimate implementation of the project. ESI would also like to acknowledge the fact that the success of this project has been mainly due to the interest shown and the active participation in the project of the management of Borsodchem, including Messrs. Laszlo Szentmiklossy (Deputy General Director), Zoltan Bordas (Director of PVC Manufacturing Plant) and Zsombor Rajkai (Deputy Director of PVC Manufacturing Plant). We would also like to thank all other members of the waste minimization team at Borsodchem who worked in this project.

IV. BORSODCHEM RT. REPORT

Y3/95.

HUNGARY
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PF.: 208

BORSODCHEM Rt.

TELEFON. 00-36-48-310050
TELEX: 084-242, 64-238
TELEFAX. 00-36-48-311157

95 MAR 34 AM 7:35

PVC FACTORY

TELEFAX MESSAGE

TO : WORLD ENVIRONMENT CENTER
ENVIROMETRICS SYSTEM INC.

FROM : Zsombor Rajkai

ATTN : Mr.B.T.AFTANAS
Mr.R.K.RAGAVAN

DATE : 31.03.1995.

FAX Nr: 00-1-703-502-9160
00-1-212-683-4745

Nr of pages: 7.

Ref: Valuation of waste minimization program

Dear Sirs,

Please find attached valuation of waste minimization program carried out in Polimer plant II of Borsodchem Rt.

Kind regards,

Zoltán Bordás
director of PVC

Zsombor Rajkai
deputy director of
PVC Factory

14

WASTE MINIMIZATION PROGRAM

This project was technically and financially sponsored by the WEC, New York.

INTRODUCTION

In August 1994. an agreement was signed by World Environment Center and BorsodChem Rt, consisting a demonstration plan in topic of reducing of waste VC-gas in Polimer II plant at BorsodChem Rt.

SHORT DESCRIPTION OF THE PROCESS

BorsodChem Rt produces PVC-resin by suspension technology /see:Figure 1./.
The suspension polymerisation is carried out in the polymerisation unit up to 89-91 % of VCM conversion rate. At the end of polymerisation the reaction is stopped by inhibitor and unconverted VCM is removed by heating up the slurry using vacuum.
Slurry is discharged from reactors into slurry tanks.

Remaining, unconverted VCM is to be removed from the slurry. It is carried out by strippers. Capacity of one of the strippers:21000 kg/h slurry, and this slurry contains up to 7000 kg PVC-resin, and approximatelly 18 kg unconverted VCM.

./.

This VCM-gas could be reused after purification, if its oxygen content is less than 3 %.
Due to lack of reliable oxygen analyser this VCM-gas was exhausted to the air, polluting the environment.

SOLUTION OF VCM LOSSES PROBLEM

Continuosly analysing the oxygen content of this waste gas, under 3 % limit the gas can be reused, going to the gasholder and the purification unit. Above 3 % limit it has to go to the air.
/see:Figure 2./

IMPLEMENTATION

Environmetrics System Inc. as a consultant of WEC sent to BorsodChem Rt five of offers for oxygen analyser usable in this circumstances. Experts of BorsodChem Rt chose PANAMETRICS TMO2 type of oxygen analyser, that was built in.

RESULTS AND VALUATION

After building the instrument in we tested the new system till 16-th of February, and some possibilities of air-inlet were stopped.
Since 16-th of February this gas has being reused. In quality parameters of recovered VCM can not be found any deviation comparing to quality in former time.

./.

Efficiency this method can be seen in table Nr.1.and 2. During this four weeks in average approximatelly 80 % of VCM gas has been recycled. We will carry out a modification in the slurry tank system and. expectedly the efficiency of the waste gas recovery will be min.95%.

The price of the instrument was 10470 USD
Recovered VCM: quantity min 240 t/year
/calculating with 80 % of eff./
value of recovered VCM appr. 144000 USD

Total savings: appr. 133530 USD
Payback period: appr. 1 month.

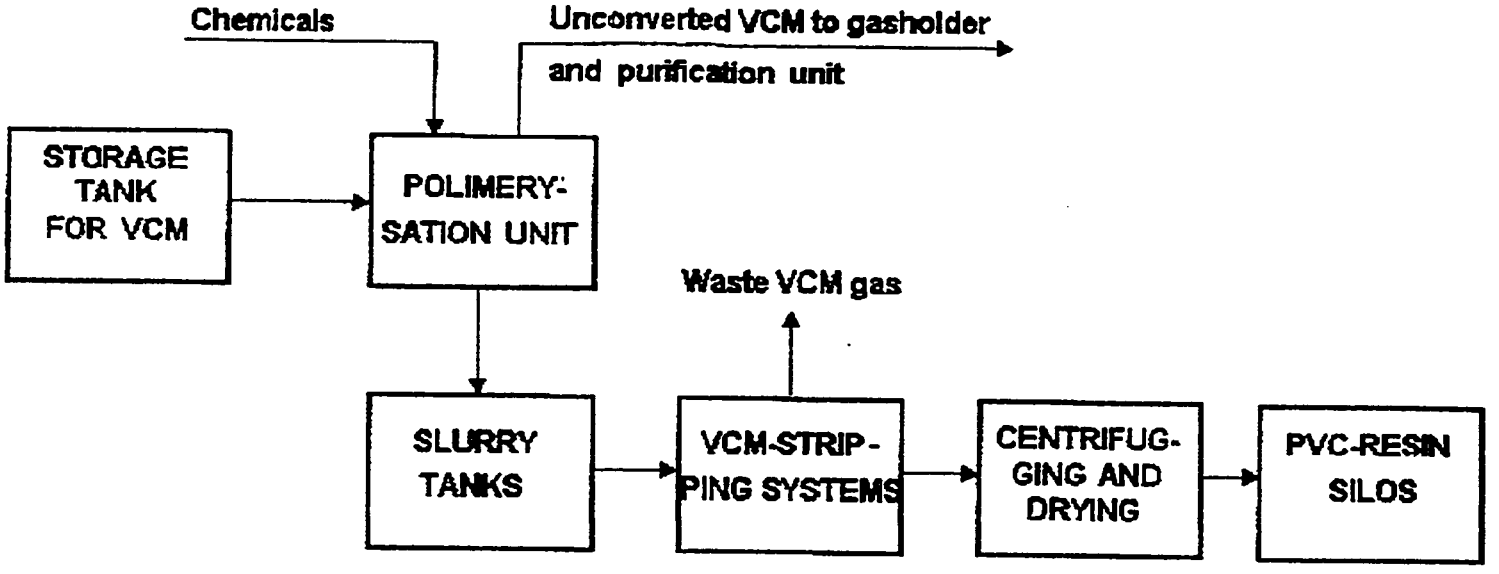


FIGURE 1.

Block diagram of suspension polimerisation of VCM at BorsodChem Rt.

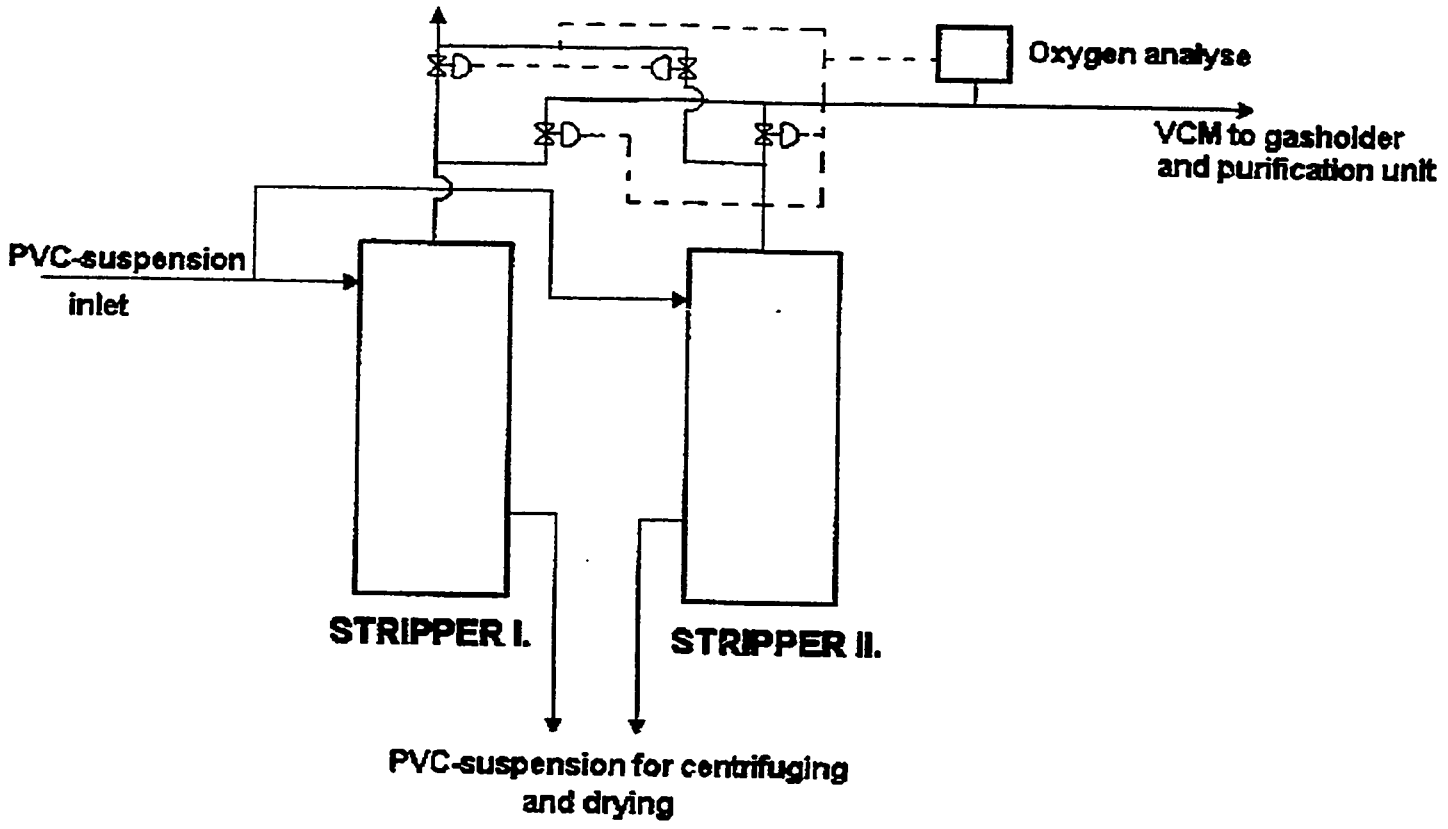


FIGURE 2.

Block diagram of stripping system at BorsodChem Rt.

LEFB11.XLS

STRIPPER "B" BLOW DOWN AND RECOVERING OF VCM 16.02-15.03. 1995.

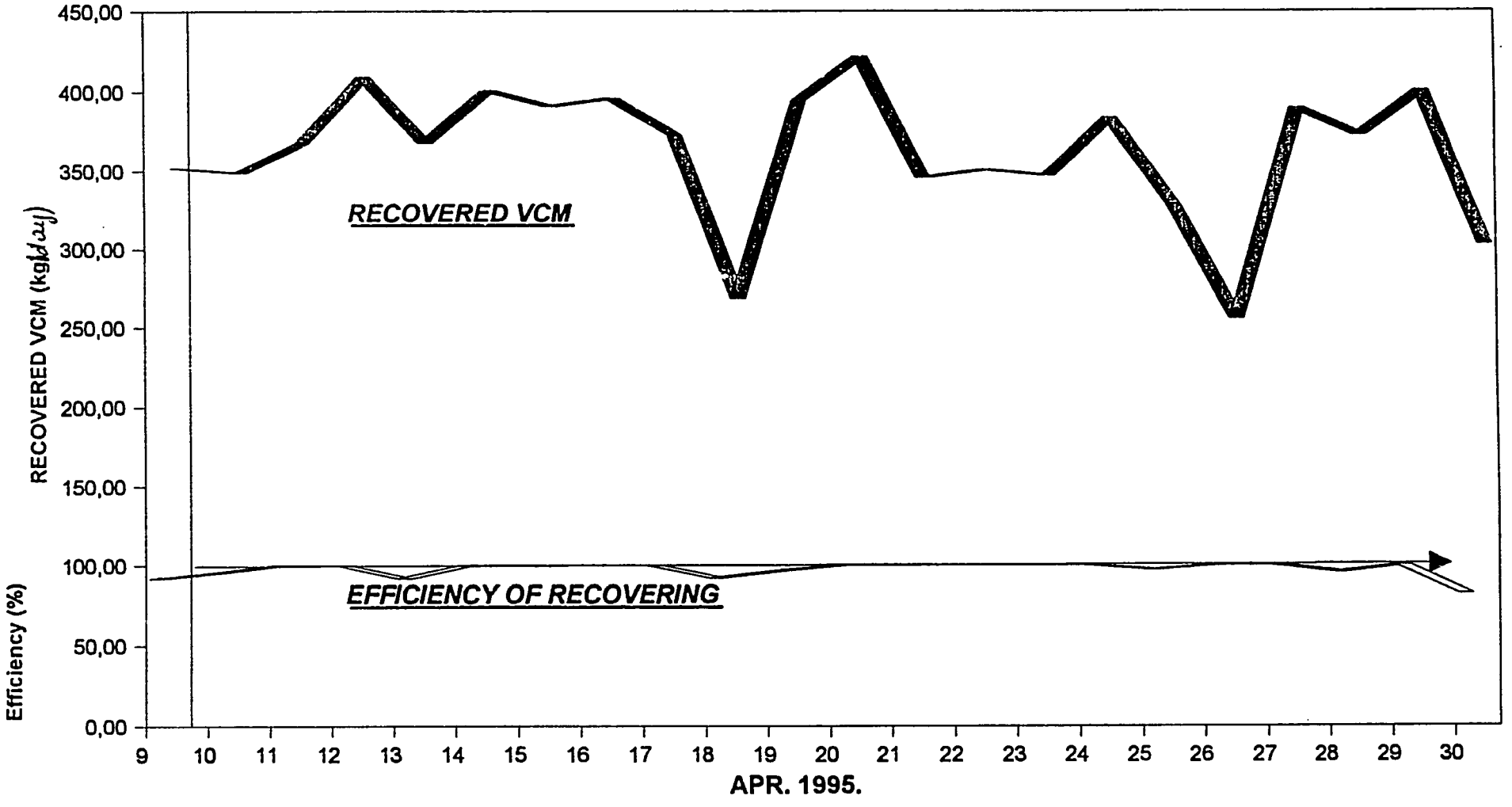
DATE (feb)	16	17	18	19	20	21	22	23	24	25	26	27	28		
BLOW DOWN (hrs)	1	7	5	15	4	3	2	6	1	1	0	1	10		
BLOWN DOWN VCM (kg)	18	129	67	240	72	42	30	100	17	18	0	17	170		
RECOVERED VCM (kg)	386	265	116	33	106	242	342	162	404	414	406	361	235		
DATE (mar)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
BLOW DOWN (hrs)	7	1	1	1	0	0	0	5	3	2	8	6	13	1	8
BLOWN DOWN VCM (kg)	123	14	18	19	0	0	0	83	45	32	138	98	226	17	146
RECOVERED VCM (kg)	269	347	257	380	421	382	166	283	332	177	177	234	134	402	177

LEFA11.XLS

STRIPPER "A" BLOW DOWN AND RECOVERING OF VCM 16.02.-15.03. 1995															
DATE (day)	16	17	18	19	20	21	22	23	24	25	26	27	28		
BLOW DOWN (kg/day)	0	6	15	19	17	5	1	1	1	0	0	3	10		
BLOWN DOWN VCM (kg)	0	95	362	333	295	89	16	17	17	0	0	44	326		
RECOVERED VCM (kg)	156	126	18	85	54	17	64	17	371	425	403	77	101		
DATE (month)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
BLOW DOWN (kg/day)	4	1	9	3	0	0	3	6	3	4	7	6	14	1	12
BLOWN DOWN VCM (kg)	71	17	152	53	0	0	53	103	50	50	121	86	217	17	223
RECOVERED VCM (kg)	70	224	107	0	123	361	376	313	366	298	190	260	108	395	165

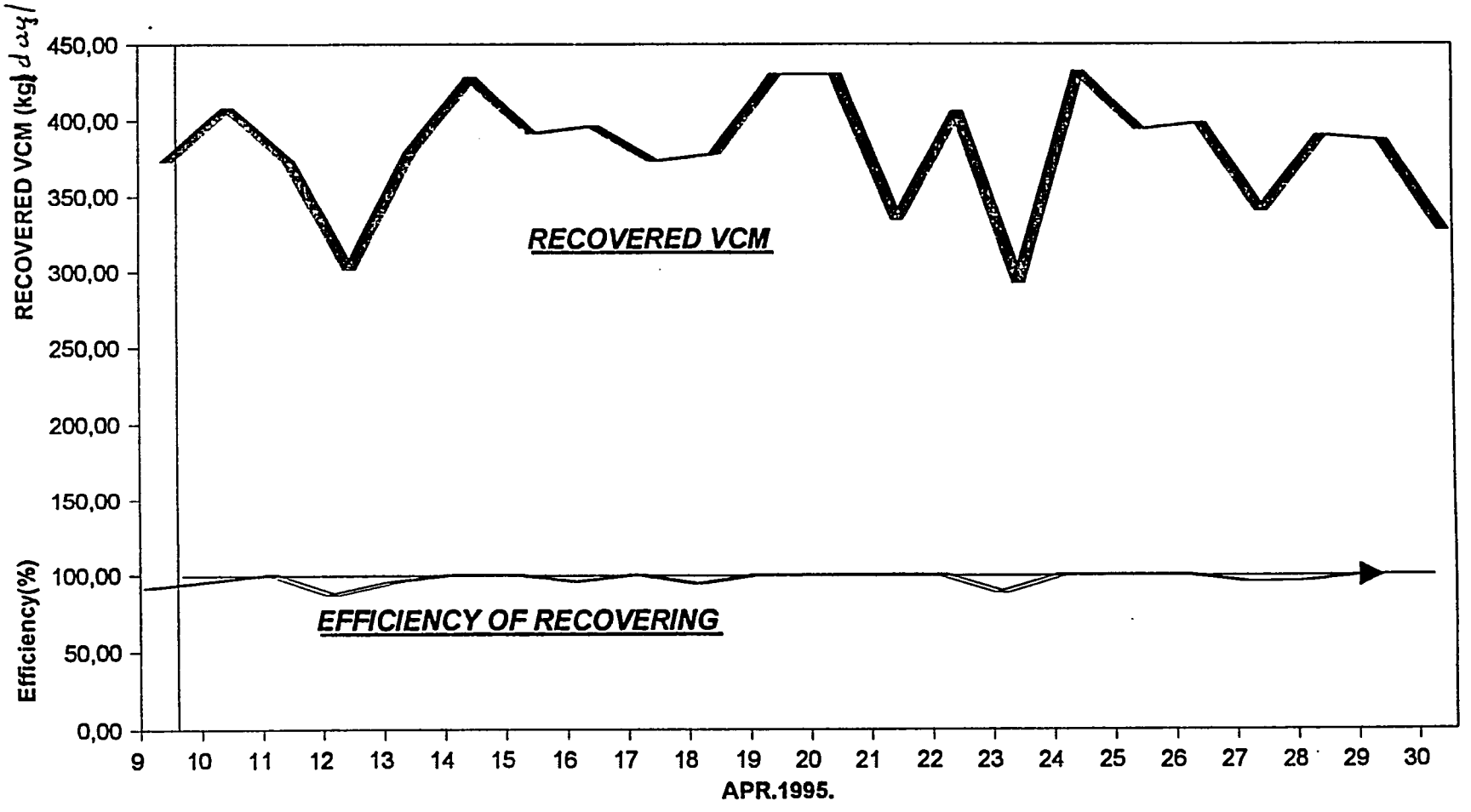
TABLE 2.

STRIPPER "A" RECOVERING AND EFFICIENCY OF RECOVERING OF VCM APR. 1995.



22

STRIPPER "B" RECOVERING AND EFFICIENCY OF RECOVERING OF VCM APR.1995.



23

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PVC FACTORY

TELEFAX MESSAGE

TO : WEC

ATTN : Dr. BOHDAN T.AFTANAS

FAX Nr: 00-1-212-6835053

FROM : Zsombor Rajkai

DATE : 18.05.1995.

Nr of pages: 1.

Ref: Oxygen analyser in BorsodChem Rt

Dear Mr Aftanas,

Please find below costs connected to oxygenanaliser built in stripper lines of PVC-suspension in Polimer II. Plant of BorsodChem Rt.

Costs of material

Pipeline:	- carbon steel:	200 m	200.000	HUF
	- stainless steel:	24 m	128.000	"
Pay of labour:	- welding:	48 hours	57.600	"
	- locksmith:	8 "	8.800	"
	- mechanician:	16 "	20.800	"
	- electrician:	6 "	7.800	"
	- cleaning works:	32 "	35.200	"
	- other maintenance works:	48 "	52.800	"
			511.000	HUF
		appr.	4.065	USD

Best regards

Zsombor Rajkai

1995 MAY 18 PM 6:50

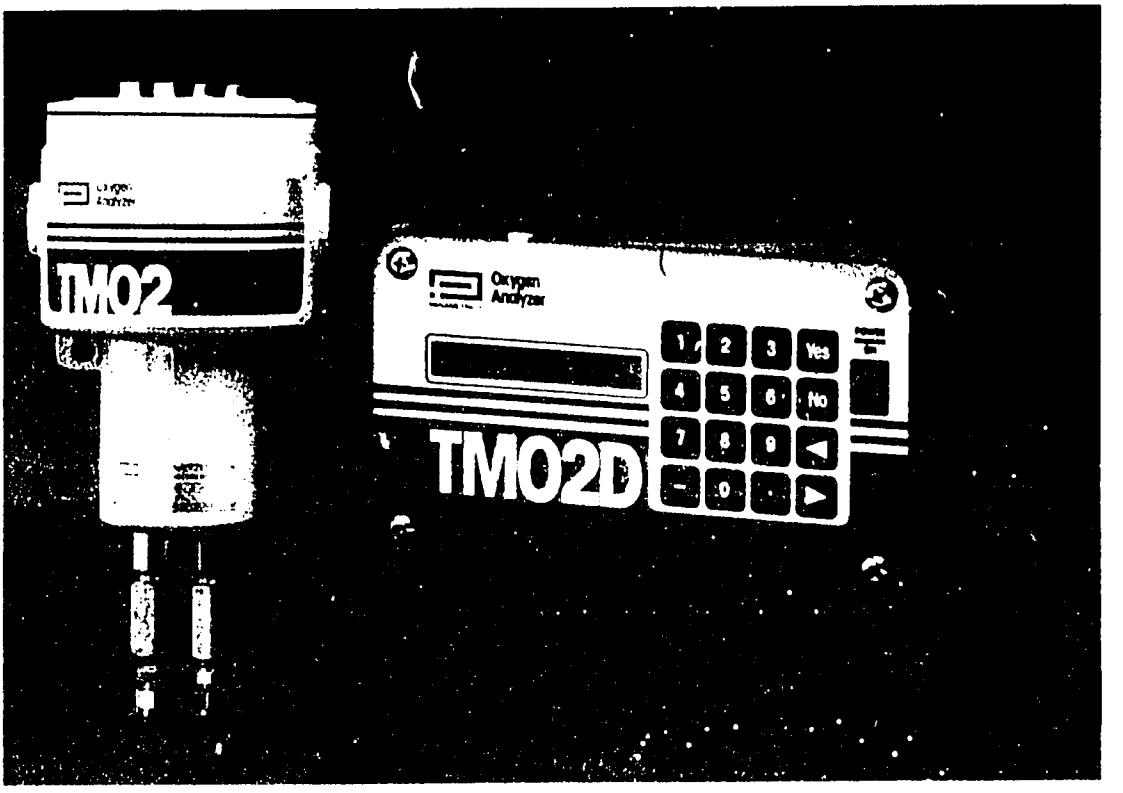
ATTACHMENT I.

VENDOR LITERATURE: TMO2D
OXYGEN ANALYZER & THERMOPARAMAGNETIC OXYGEN SENSOR

PANAMETRICS

TMO2D OXYGEN ANALYZER

& Thermoparamagnetic Oxygen Sensor



- Measures oxygen concentration from ppm to 100% in gases
- Rugged, reliable, trouble-free operation
- Unequaled stability for less frequent calibration
- Fast response to track rapid changes
- Background gas compensation
- Active autocalibration
- Wide variety of ranges to meet specific needs
- Pressure compensation for high oxygen concentration

A New Dimension in Oxygen Measurement

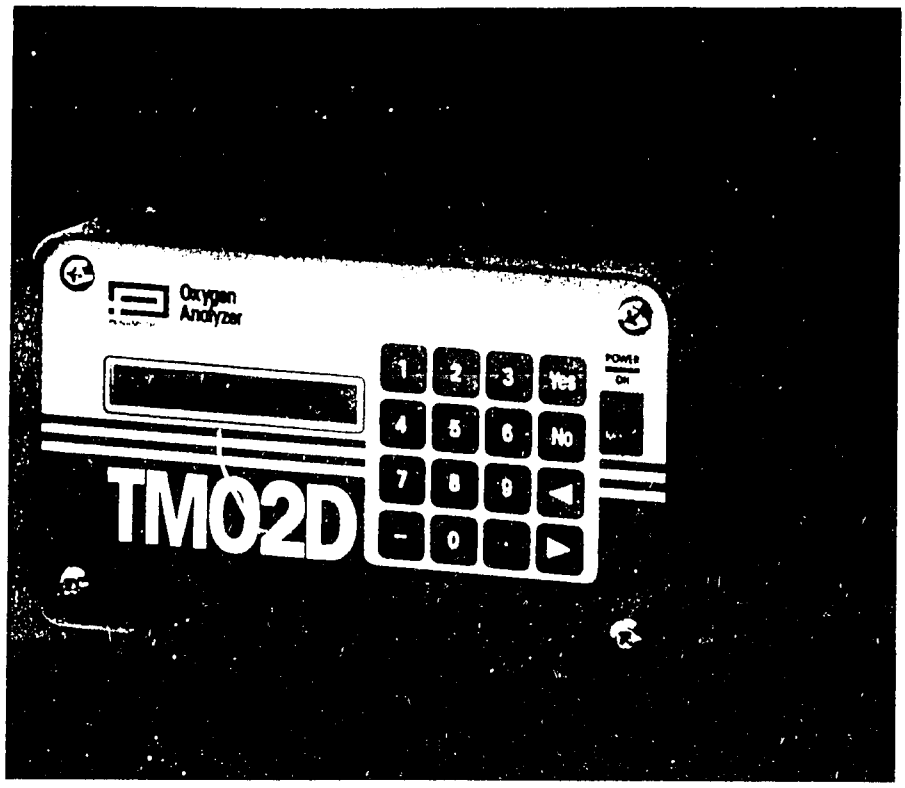
Panametrics has combined the proven technology of its TMO2 Oxygen Transmitter, and the power of microprocessor-based TMO2D Electronics, to create the TMO2D Oxygen Analyzer. The resulting system features enhanced performance and a long list of new user benefits.

Measuring oxygen concentration in gases based on its paramagnetic properties has long been recognized as accurate and reliable. This principle is used in three types of oxygen sensors: magnetodynamic (dumbbell type); traditional thermoparamagnetic (wind generating type); and the advanced thermoparamagnetic TMO2 oxygen transmitter from Panametrics.

Like other wind-generating types, the TMO2 Oxygen Transmitter has no moving parts, so it's rugged, reliable, and insensitive to shock and vibration.

But, the TMO2 Transmitter improves on the traditional thermoparamagnetic design by using cooler-running, double-glass coated thermistors in place of troublesome, hot wire filaments to provide the most stable oxygen sensor available. It is also much less affected by variations in position (level) than other analyzers.

And, the TMO2 Transmitter's unique "bridge-within-a-bridge" circuitry is teamed with microprocessor based TMO2D Electronics to provide automatic compensation for variation in both magnetic and thermal properties of the background gas — a feature not offered on dumbbell or traditional wind generating analyzers.



The microprocessor-based TMO2D electronics unit features two line backlit LCD, full keypad and menu-driven software to provide easy access to a variety of features including user selectable oxygen range, recorder output range, alarm settings and autocalibration.

A Long List of Benefits

The TMO2D minimizes user attention. Many oxygen analyzers require weekly and even daily attention. The TMO2D has no moving parts, and uses cool-running thermistors, resulting in rugged, reliable, trouble-free operation, and unequaled stability with zero and span drift of less than 1% per month. In addition, the TMO2 Transmitter and TMO2D Electronics combine to produce fast response, with a system time constant of only four seconds.

For accuracy and safety, the TMO2D corrects for variation in background gas properties which can cause measurement errors, and often results in the understatement of oxygen concentration by other analyzers. In addition, due to its dual chamber design, the system is much less sensitive to process stream contamination, and sample flow rate variation. To maintain accuracy, particularly when measuring high oxygen concentrations, the sensor is temperature controlled, and pressure compensated.

Long-term, hands-off performance is provided by active autocalibration. When recalibration is needed, TMO2D's optional autocalibration feature does more than just sound an alarm. The TMO2D electronics unit controls valves to admit zero and span gases to the TMO2 transmitter. Then, TMO2D software compares readings with factory calibration data and makes any necessary corrections — automatically — so manual recalibration frequency can be reduced to as little as once per year.

A wide variety of ranges is provided to meet your needs. The TMO2 Transmitter is available in six measurement ranges. This, combined with easy access to zero suppression and user selectable recorder output range provided by TMO2D's membrane keypad and menu-driven software, allows you to zoom-in on the specific oxygen range for your application.

For installation flexibility, the TMO2 Transmitter can be located up to 1000 feet (300 meters) from the TMO2D Electronics, and with the addition of flame arresters is approved to CENELEC EEx d II C T6 for use in hazardous areas. When service is required, the transmitter can be removed from its housing and replaced in seconds, without breaking process connections.

KEY BENEFITS

- Rugged, reliable, trouble-free operation
- Unequaled stability for less frequent calibration
- Fast response to track rapidly changing processes
- Background gas compensation for improved accuracy & safety
- Active autocalibration for long-term performance
- Wide variety of ranges to meet your specific needs
- Pressure compensation for high oxygen concentration applications
- Unaffected by variations in ambient temperature
- Less sensitive to sample contamination & flow rate variation
- Flexible installation
- Suitable for use in hazardous areas
- Easily serviceable transmitter

APPLICATIONS

At Panametrics, we've been providing dependable, advanced analytical instruments to government and industry for over 30 years. The TMO2D can be found across a broad spectrum of applications including:

- **General Industry**
  plant safety inerting
- **Steel Industry**
  blast furnace off gas
- **Heat Treating Industry**
  carburizing and annealing ovens
- **Chemical Industry**
  reactor feed gases
- **Petrochemical Industry**
  catalytic regeneration, flare gas and other hydrocarbon gases
- **Biochemical/Pharmaceutical**
  fermentation processes composting operations
- **Gas Production Industry**
  air separation process
- **Laboratories**
  laboratory ambient air
- **Hospitals**
  oxygen supply systems

Complete application data is available from your Panametrics representative or any Panametrics office worldwide.

HOW IT WORKS

Basic Principle

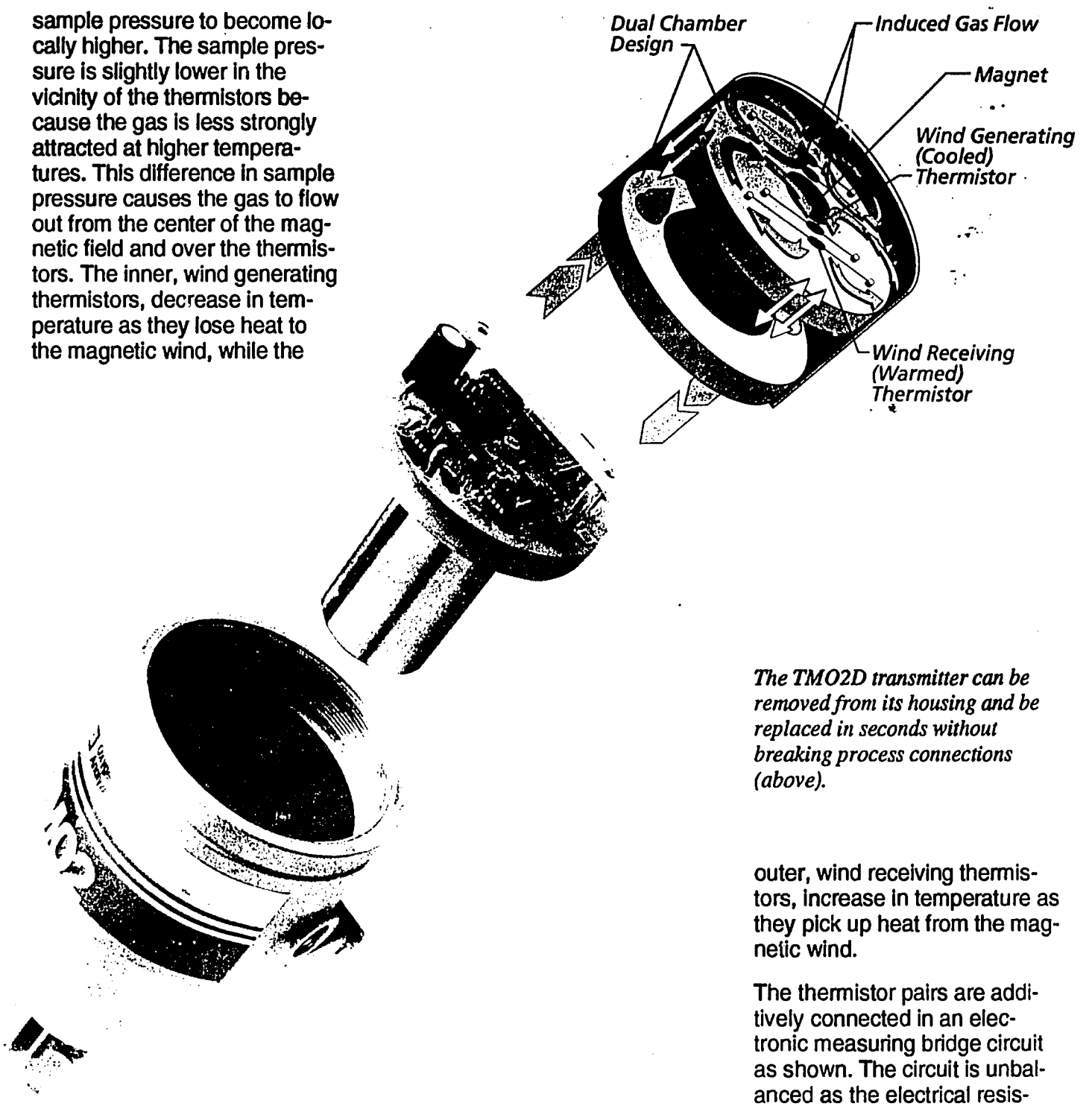
Since its magnetic susceptibility is approximately 100 times greater than most common gases, oxygen can be easily distinguished from other gases based on its attraction into a magnetic field. The magnetic susceptibility of oxygen varies with temperature — more strongly attracted at low temperatures, and less at high temperatures. Therefore, by carefully combining a magnetic field gradient and a temperature gradient within the TMO2 transmitter measuring cell, an oxygen-containing gas can be made to flow, creating "magnetic wind." The intensity of this induced flow depends on the concentration of oxygen in the sample.

TMO2 Transmitter: Oxygen measurement bridge

In the TMO2 transmitter measuring cell, permanent magnets are used to create a magnetic field. The temperature within the measuring cell is controlled to a constant 45°C to maintain thermal equilibrium. The cell also contains two pairs of thermistors, with one thermistor of each pair located within the magnetic field. Since the thermistors are electrically heated, a temperature gradient is created within the magnetic field.

When a small sample of oxygen-containing gas diffuses into the measuring cell, it is attracted to the field, causing the

sample pressure to become locally higher. The sample pressure is slightly lower in the vicinity of the thermistors because the gas is less strongly attracted at higher temperatures. This difference in sample pressure causes the gas to flow out from the center of the magnetic field and over the thermistors. The inner, wind generating thermistors, decrease in temperature as they lose heat to the magnetic wind, while the



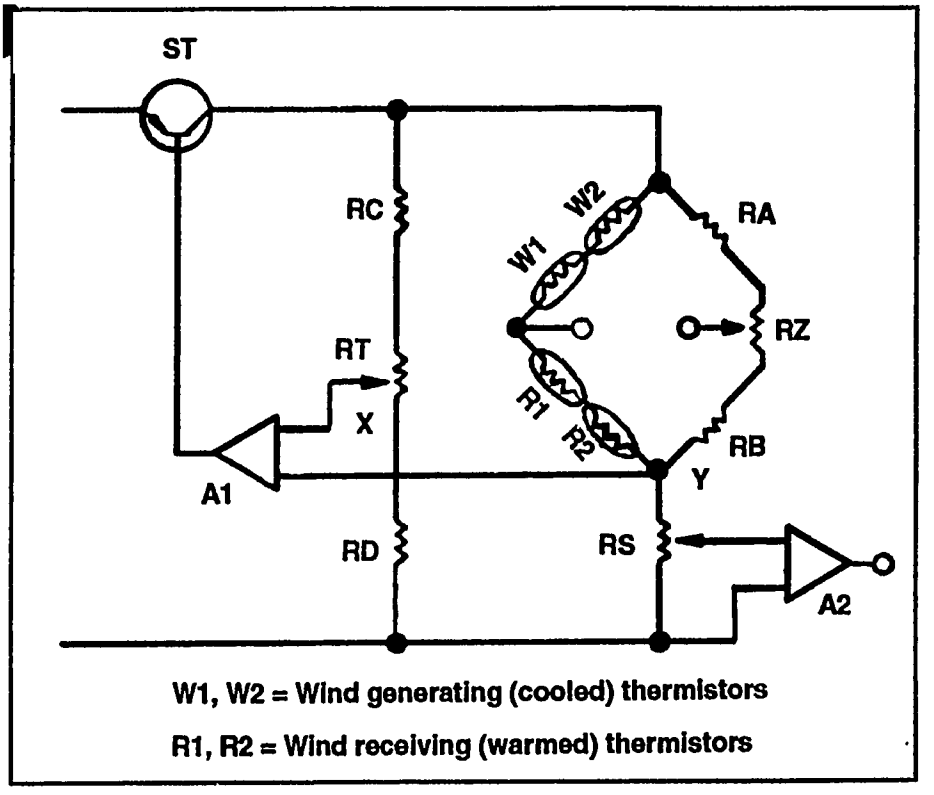
The TMO2D transmitter can be removed from its housing and be replaced in seconds without breaking process connections (above).

outer, wind receiving thermistors, increase in temperature as they pick up heat from the magnetic wind.

The thermistor pairs are additively connected in an electronic measuring bridge circuit as shown. The circuit is unbalanced as the electrical resistance of the thermistors change with temperature.

The circuit imbalance causes a voltage to appear across the bridge which is proportional to the oxygen concentration in the gas being measured.

Dual chamber oxygen measuring cell. The magnetically-induced flow of oxygen containing gas cools the wind-generating thermistors and warms the wind receiving thermistors (above).



TMO2 Transmitter schematic: The oxygen bridge is one arm of yet another compensation bridge, which maintains the oxygen bridge at a constant temperature when background gas composition changes.

TMO2 Transmitter: Compensation Bridge

As the background gases which make up the balance of an oxygen-containing mixture change, the magnetic and thermal properties of the sample gas change. This will affect the response of any magnetic oxygen analyzer if left uncompensated.

For this reason, the TMO2 transmitter features a unique "bridge-within-a-bridge circuit." The oxygen measuring bridge described above is one arm of yet another compensation bridge, which maintains the oxygen bridge at a constant temperature when background gas composition changes.

TMO2D Electronics: Microprocessor-Based Compensation for Variations In Background Gas Composition

By sensing the compensation bridge current necessary to restore oxygen bridge temperature, a signal is obtained which is transmitted to the TMO2D electronics. The TMO2D then performs microprocessor-based background gas compensation for both magnetic and thermal properties. This allows the TMO2D to be more accurate than uncompensated magnetic oxygen analyzers in the majority of applications.

TMO2 OXYGEN TRANSMITTER SPECIFICATIONS

Measuring Ranges:

0 to 1% O_2
0 to 2% O_2
0 to 5% O_2
0 to 10% O_2
0 to 25% O_2
0 to 100% O_2

Measurement Resolution:

0.01% O_2

Accuracy:

1% of span

Linearity:

0.1% of span

Repeatability:

0.2% of span

Stability:

Zero and span, 0.8% of span/month (0 to 2% O_2 range and higher), 1.5% of span/month (0 to 1% O_2 range)

Ambient Temperature Influence:

Negligible if transmitter is heated at least 5°C above highest ambient temperature

Transmitter Temperature:

Controlled to 45°C

Atmospheric Pressure Influence:

0.2% of span per mm Hg (optional pressure compensation available)

Sample Flow Rate Influence:

Less than 1% of span with 50 to 1000 cc/minute, no flame arresters (0.1 to 2 SCFH)

Line Voltage Influence:

Negligible

Ambient Requirements:

Relative Humidity
0 to 100% (non-condensing)

Temperature
– 20° to 40°C; Higher temperatures available

Sample Requirements:

Flow
50 to 1000 cc/m (0.1 to 2 SCFH)

Pressure
20 psig maximum

Power Requirements:

24 VDC, 1A maximum, powered by TMO2D Electronics

Electrical Output:

0/4 to 20 mA to TMO2D electronics

Transmitter/Electronics Separation:

1000 feet (300 meters) maximum; Shielded cable not required

Physical Characteristics:

Dimensions (height x width x depth)
9.25 x 5.625 x 6 inches (23.5 x 14.3 x 15.2 cm)

Weight
9.5 pounds (4.3 kg)

Connections
1/2 inch NPTF (electrical conduit), 1/4 inch NPTF (sample inlet & outlet)

Area Classification:

Explosion-proof/weatherproof INIEX Cert. # 90C.103.882 to CENELEC EEx d IIC T6

U.S. Coast Guard approval (file # 16703/33-154) for vapor control systems for the transfer of vapors of benzene, crude oil and gasoline blends per 33 CFR Part 154.824 (g)

TMO2D ELECTRONICS SPECIFICATIONS

Display:

2-line x 24 character backlit LCD

Accuracy:

0.1% of span (electronics only)

TMO2D Oxygen Analyzer System Response:

4 seconds for 63% of a step change in oxygen

Ambient Temperature Influence:

0.001% Full Scale/°C

Temperature:

Operating
0° to 50°C

Storage
– 20° to 70°C

Recorder Outputs:

Standard
Single, non-isolated 0/4 to 20 mA, 12-bit resolution, field selectable/programmable 600 ohm maximum load

Optional
Dual, isolated 0/4 to 20 mA, 10-bit resolution, field programmable

Alarms:

Standard
2 Form C alarms, SPDT 2A maximum @ 117 VAC field selectable/programmable, set point resolution 0.01% O_2, dead band 0.05% of span

Optional
2 hermetically sealed relays for Division 2 hazardous area locations
2 standard or hermetically sealed relays for automatic calibration

Digital Output:

RS232 serial port

Power Requirements:

100/120/220/240 VAC ±10%, 50/60 Hz, 35 watts, provides 24 VDC, 1A maximum power to TMO2 oxygen transmitter

Electrical Input:

0/4 to 20 mA from TMO2 oxygen transmitter

Physical Characteristics:

Dimensions (height x width x depth)
Rack Mount 5.25 x 19 x 9.25 inches (133 x 483 x 235 mm)
Bench Mount 5.25 x 9 x 9.25 inches (133 x 229 x 235 mm)
Panel Mount 5.25 x 9 x 9.25 inches (133 x 229 x 235 mm)

Weight
Rack Mount 5.4 pounds (2.4 kg)
Bench Mount 7.4 pounds (3.4 kg)
Panel Mount 4.7 pounds (2.1 kg)

Area Classification:

Weatherproof

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