DOE/PC/94117--T3

TCS

TAS COAL™ SYSTEMS

Leader in Coal Micronization

November 15, 1995

Department Control Center
Pittsburgh Energy Technology Center
U.S. Department of Energy
P.O. Box 10940, MS 921-118
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REF: Krakow Clean Fossil Fuels and Energy Efficiency Program.
Cooperative Agreement No. DE-FC22-94PC94117
Final Report - Budget Period I - Initial Site Investigation

Attached are three (3) copies of our Final Report - Budget Period I - Initial Site Investigation related to the referenced Project.

We apologize for the tardiness of this report. However, as the report reveals, we experienced a number of unanticipated and devastating project events, including the unexpected cancellation of our Project, by the Polish Military. This continues to leave our Project status in limbo.

We are planning a site visit to Krakow in early-December 1995 to determine the viability of a potential new project host and site. It's status should be known, and will be reported to USDOE, by early-January 1996. If the new project site is viable, we will submit a revised proposal prior to January 6, 1996, to extend our Budget Period I. This plan is predicated on various communiques which we have had with several USDOE officials involved in the program.

Thank you.

Sincerely yours,

Richard T Sheahan

Richard T. Sheahan
Vice President

RTS/ah
Enclosure, as described above

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1.0 EXECUTIVE SUMMARY

Micronized coal is coal micro-pulverized to a particle size consistency similar to a very fine talcum powder. Because of its micron-size particle distribution, micronized coal has unique combustion characteristics that are similar to those associated with oil. Reasons for the similarity to oil, is that micronized coal has: (a). high combustion reactivity, (b). lower ignition temperatures, (c). earlier combustion completion, and (d). minimum slagging or erosion effects.

Sulfur dioxide (SO₂) reductions during combustion with micronized coal is possible by co-micronizing limestone with coal. SO₂ air emissions are reduced due to a number of synergistic causes, including: a). lower flame temperatures realized by micronized coal, which is close to the optimum sulfur-calcium temperature spectrum, b). intimate mixing and contact between coal and limestone particles, c). accelerated calcination and sulfation reactions resulting from the small particle distribution of coal and limestone.

Nitrogen oxide reductions utilizing a TCS system result primarily from: (a). the reduced combustion temperature of a micronized coal flame, (b). lower excess air than other conventional coal combustion systems, and (c). staged combustion achieved with the proprietary TCS Low-NO_x burner.

Carbon monoxide reductions result because of the extremely high degree of carbon burnout achieved with micronized coal.

Original objective of this Project was to retrofit the Balice Boilerhouse with a TCS Coal Micronization System and Amerex baghouses to achieve higher combustion efficiencies and lower air emissions, including SO₂, NO_x, CO and particulate matter. The Balice Boilerhouse is located adjacent to the Krakow Airport and provides heating steam for the Polish Military Unit No. 1616, which is based in the vicinity of the Krakow airport. Original participants in this Project included:

- * TCS, Inc., Oakland, Maryland
- * Amerex, Inc.; Woodstock, Georgia
- * OPAM; Katowice, Poland
- * Polish Military Unit No. 1616; Krakow, Poland

In November 1994, a proposal was submitted to the Polish Military, which included an upgraded boilerhouse containing mostly new equipment, capable of burning coal in a very efficient manner, and able to meet the New 1997 Polish Air Emission Standards.

The expanded Project cost estimate of \$2,291,440 was greater than TCS's initial estimate of approximately \$1,600,000 made in January 1993 as part of its original USDOE proposal. However, the scope-of-supply also increased to include: (a). new boilers, instead of existing boilers, (b). sixty (60) percent greater boilerhouse heating capacity, and (c). requirements to meet New 1997 Polish Emission Standards, which were not known to TCS during the original USDOE proposal preparation.

A revised proposal was submitted to the Polish Military in March 1995; wherein, Polish supplied boilers were included. This action reduced the Project's cost to \$1,856,660. The revised cost would have required the Military to contribute \$937,000, or \$137,000 more than its originally agreed commitment of \$800,000.

In May 1995 the Polish Military announced it had decided to convert its boiler house to gas; thus, cancelling the TCS Project.

The balance of 1995 was spent considering alternative Project sites in Krakow for the application of the TCS coal micronization technology.

2.0 PROGRAM INTRODUCTION

The work to be performed is part of the equipment assessment program in the Support for Eastern European Democracy (SEED) Act of 1989 (P.L. 101-179). Following the guidance of this legislation, a U.S.-Poland Bilateral Steering Committee (BSC) was established to define the program. The BSC is directing a program of assistance to Poland that would reduce air pollution in Krakow, Poland from about 1,300 boiler houses that provide heat for industrial, commercial, and residential applications, plus about 100,000 small stoves for home heating. The 1,300 boiler houses and 100,000 home heating stoves in Krakow primarily utilize solid fossil fuels and have been collectively called "low emissions sources" because of their low stack heights and the consequent low elevation entry of flue gases into the ambient air.

In October 1991, a Memorandum of Understanding (MOU) was signed by the U.S. Department of Energy (USDOE) and the Ministry of Environmental Protection, Natural resources and Forestry of the Republic of Poland. The MOU is titled, "Collaboration on the Krakow Clean Fossil Fuels and Energy Efficiency Program, A Project of Elimination of Low Emission Sources in Krakow." This MOU describes the cooperation that is being undertaken by the governments of the United States and the Republic of Poland to accomplish this program. Funding for the program is being provided through the Agency for International Development (AID).

The purpose of the program is to encourage the formation of commercial ventures between U.S. and Polish firms to provide equipment and/or services to reduce pollution from low emission sources in Krakow, Poland. These commercial ventures may take the form of contracts, joint ventures, partnerships, or any other commercially feasible arrangements that accomplishes the purposes of the statute.

Project development support includes all activities that must be accomplished by U.S. organizations and their proposed team members before the enterprise can expect to receive revenues from its activities in Krakow. These activities may include efforts to determine how to establish a U.S.-owned business in Poland, identify the Polish regulations relevant to the proposed Project, conduct marketing studies, identify facilities and a labor force for the venture, and acquire a manufacturing

plant. The proposed activities may also include the construction and testing of equipment to be sold (e.g., furnaces) or to produce a fuel to be sold. The proposed activities may utilize Polish fuels, as appropriate, to confirm technical feasibility.

The assistance provided is through cost-shared cooperative agreements between the USDOE and U.S. companies. Participation of Polish firms through teaming arrangements with U.S. proposers, while not required, is strongly encouraged. Fifty percent minimum cost sharing is required.

The original work plan was to include the retrofit of the Balice Boilerhouse located in Krakow, Poland with a TCS Coal Micronization System and an Amerex baghouse to achieve higher combustion efficiencies and lower air emissions, including SO_x, NO_x, CO, and particulate matter. The Balice Boilerhouse is located adjacent to the Krakow Airport and provides heating steam for the Polish Military Unit No. 1616, which is based in the vicinity of the airport. Original participants in this Project included:

- * TCS, Inc., Oakland, Maryland
- * Amerex, Inc.; Woodstock, Georgia
- * OPAM; Katowice, Poland
- * Polish Military Unit No. 1616; Krakow, Poland

3.0 TASK ACCOMPLISHMENTS

General: The original Project scope of work envisioned that TCS coal micronization systems would be retrofitted to four (4) existing boilers at the Balice Boilerhouse. However, shortly after the Project's start-up in March 1994, the Polish Military announced that it desired and intended to decommission its existing four (4) boilers (due to old age and poor general condition) and replace them with two (2) new units. As such, the Project's scope of equipment supply and assessment expanded from use of the existing boilers, to requirements for implementing new units.

Likewise, at the same time, the Polish Military requested that results of the analysis be available by the end of September 1994, so that it could factor Project costs into the Military's fiscal year budget. This requirement necessitated compressing into six months, what was originally planned as a 12 month work effort.

At the end of September 1994, TCS submitted a request to the Polish Military that a time extension of two months be granted to allow a November 30, 1994 submission of a cost proposal for Budget Period Two, due to unanticipated Project delays. The extension was granted.

Also during September 1994, TCS became disenchanted with the performance of OPAM in its ability to provide the technical support necessary to complete the Project. During repeated TCS requests for necessary information and data, OPAM's response was unsatisfactory.

In response, TCS subcontracted S.E. Technologies, Inc. (SET) (Pittsburgh, Pennsylvania) to assist in progressing the Project.

SET's scope-of-work was limited to assisting TCS in developing a Project specification package that could be utilized by a designated Polish construction company (i.e., Elektrim, S.A.) to develop capital and operating costs during Budget Period I. Elektrim is an internationally oriented power engineering/construction company based in Warsaw, Poland. SET's capabilities to effectively assist TCS were very unique in two major areas, including:

- (1). SET is quite familiar with the TCS technology since it recently completed design of a micronized coal-fired heating plant for a State of Pennsylvania institutional facility in Clearfield County. The facility, with construction now complete, includes a TCS micronization system linked to Babcock & Wilcox boilers.
- (2). SET's principal-in-charge was Mr. Al Pasek, Vice President, SET. Mr. Pasek speaks fluent Polish, was born and raised in the Krakow region, is familiar with the Polish marketplace, and enjoys a personal and professional relationship with Elektrim.

In October 1994, SET (Mr. Al Pasek) accompanied TCS and USDOE personnel (Mr. Tom Feeley) on a site and Project status visit to Poland; wherein, the following items were successfully accomplished: (a). Electrim agreed to provide Project construction cost estimates by November 30, 1994 (which it did), and (b). it was decided by all key Project participants to utilize new Babcock & Wilcox boilers, predicated on the shortage of time for Polish manufacturers to acquire the necessary technical understanding to adequately respond to the requirements of micronized coal firing.

During the October 1994 trip to Poland, it was also determined during discussions, that OPAM had never really participated in the design nor implementation of a heating or power plant, which was contrary to statements and claims made by OPAM during the initial interviews by TCS and Amerex prior to the start of the Project. OPAM agreed to continue its participation in the Project and provide review comments during final preparations of the Project's Budget Period I results and cost preparations, prior to submittal to the Polish Military. Copies of the final Budget Period I material and requests for comments were submitted to OPAM; however, no response was ever received from OPAM and was never heard from again.

On November 30, 1994, a proposal was submitted to the Polish Military, which included an upgraded boilerhouse containing mostly new equipment, capable of burning coal in a very efficient manner, and able to meet the New 1997 Polish Air Emission Standards.

The expanded Project included: new Babcock & Wilcox boilers, TCS micronization system, Amerex fabric filters, Control Techtronics International combustion control system, and necessary balance of plant modifications.

The expanded Project cost estimate of \$2,290,000 was greater than TCS's initial estimate of approximately \$1,600,000 made in January 1993 as part of its original USDOE proposal. However, the scope-of-supply also increased to include: (a). new boilers, instead of existing boilers, (b). sixty (60) percent greater boilerhouse heating capacity, and (c). requirements to meet New 1997 Polish Emission Standards, which were not known to TCS during the original USDOE proposal preparation.

A December 1994 *communiqué* from Biuro Rozwoju Krakowa (Krakow Development Office) stated that the Polish Military was still interested in the Project; however, the proposed cost was too high. It was suggested that TCS consider the use of Polish manufactured boilers as an attempt to lower the Project's costs.

A revised proposal was submitted to the Polish Military in March 1995; wherein, Polish supplied boilers were included. This action reduced the Project's cost to \$1,860,000. The revised cost would have required the Military to contribute \$937,000, or \$137,000 more than its originally agreed commitment of \$800,000.

In its revised proposal, TCS emphasized that the added \$137,000 relates to a scope of supply that had expanded to include: (a). new boilers, instead of the existing as originally envisioned, (b). about 60 percent greater plant heating capacity, compared to the original proposal, and (c). capabilities to meet greater SOx reduction, compared to the original proposal.

Likewise, TCS indicated a cost saving comparison that indicated what the Military would spend on fuel costs if it decided to install new gas-fired boilers, rather than TCS's proposed coal Project.

According to POLINVEST fuel price estimates, based on the Military's heating demand, the 1997 (i.e., first full year of operation) gas cost would be \$472,000, compared to a coal cost of \$111,000. Likewise, the summated fuel costs for the first five years of operation would be \$2,600,000 for gas, and \$570,000 for coal, or a differential of over \$2 million.

If USDOE projections were used (which relate more to Western European pricing), the Military would experience an initial five year gas, vis-a-vis coal, cost differential of over \$2.5 million.

In its revised proposal, TCS expressed a difficulty in understanding how the Military could justify gas firing, in the context of gas: (a). being dramatically more expensive than coal, and (b). risking loss of local energy security by using foreign supplied gas.

A May 1995 BRK *communiqué*, announced that the Polish Military had decided to convert its boiler house to gas; thus, cancelling the TCS Project.

The balance of 1995 was spent considering alternative Project sites in Krakow for the application of the TCS coal micronization technology.

The following presents a task-by-task highlight of results that were achieved during the course of assessing the Polish Military Project site during Budget Period I.

Task 1: Coordination, DOE Liaison & Financial Management

TCS assumed Project participant responsibility for coordination, DOE liaison, and financial management.

Task 2: Project Reports

TCS assumed Project participant responsibility for preparation of reports and financial management.

Task 3: Project Site Criteria

This task involved verification of key operational and siting criteria at the Balice Boiler House. At the Project's start-up, TCS prepared and sent to OPAM a comprehensive list of required information that would describe: (a). operational data, (b). plant layout, and (c). configuration of existing equipment and building facilities. This included: typical daily and seasonal thermal load profiles, boiler mass-energy flow throughput, peak and average required coal flows, other material and mass balance data verification, existing instrumentation and control, and location drawings of existing equipment especially at points of interface with new equipment. OPAM procured this information, which was sent to TCS.

TCS also requested that OPAM procure technical information and drawings for: (a). existing boilers, and (b). proposed new boilers.

Information about existing boilers was requested so that TCS could assess requirements that would have been necessary if the Military had retained its existing boilers, as originally envisioned. Although requested of OPAM, it was unable to procure adequate drawings by citing the Military's reluctance to provide such material because: (a). they were not available, or (b). Military could not understand TCS's need since the boilers were scheduled for decommissioning.

OPAM sent technical information and drawings for new Polish manufactured boilers (i.e., Sefako TYPU KRM 2.5), which ostensibly were being considered as new units by the Military and were similar to the existing units. Upon review of these drawings, it became evident that the units were not the appropriate choice for application with the TCS technology. Upon notification of this fact, OPAM acknowledged: (a). it did not fully understand requirements of selecting boilers for application with the TCS technology, and (b). in fact, it was the Polish Military that had selected the Sefako boilers.

In view of these unacceptable events, TCS independently solicited technical and cost bids from three boiler suppliers, including: (1). Babcock & Wilcox (USA), (2). Sefako (Poland), and (3). Refako (Poland).

Task 4: Site Visits

At the end of April 1994, representatives of TCS, OPAM, and the Military conducted a site visit at the Balice Boilerhouse to review results of preliminary engineering analyses and equipment selection, in context with the actual facility and existing equipment location. There appeared to be no outstanding or major impediments to installation or construction.

At the end of October 1994, a second site visit was conducted to review the Project's progress. Several key decisions regarding its status was made, including: (a). Electrim, S.A.; Warsaw, Poland (a major Polish engineering construction company) agreed to provide Project construction cost estimates by November 30, 1994, and (b). it was decided by all key Project participants to utilize new Babcock & Wilcox boilers, predicated on the shortage of time for Polish manufacturers to acquire the necessary technical understanding to adequately respond to the requirements of micronized coal firing.

Task 5: Equipment Specification

This task analyzed criteria information from Task 3 and results of the Task 4 site visit to determine, on a preliminary basis, design and performance criteria for new equipment requirements, including::

1. TCS Ferrous/Non-Ferrous Metal Detection and Rejection System.
2. Limestone storage to utilize existing coal hoppers.
3. New screw conveyors to meter limestone feed, from the existing hoppers.
4. New screw conveyors to meter coal feed from existing hoppers.
5. TCS mills on existing firing floor in front of each new boiler.
6. New F.D. fans, equipped with variable speed motors. Also ducting from F.D. fans to TCS burners.
7. New Babcock & Wilcox FM-Series boilers.
8. Ducting from new boilers to new Amerex baghouses. Existing mechanical collectors will be abandoned.
9. New Amerex pulse-jet baghouse filters and contingent duct-injection system.
10. Removal of existing I.D. fans, and installation of new fans.
11. Breeching between Amerex baghouses, I.D. fans and stack.
12. New ash silo and interconnection ash transport lines.
13. New compressed air system, including compressor with cooling water lines, air dryer, air receiver, and interconnecting piping.
14. Foundations and supports for new equipment.
15. Internal plant sub-power systems to accommodate new equipment. New motor control centers, switchgear and conductors for new equipment.
16. New instrumentation and controls for: TCS mills and burners, Amerex baghouses, fuel and materials handling, combustion and boiler management control, emission monitoring, and all auxiliary systems and sub-systems.

Task 6: Control and Monitoring System

Because of the unique combustion nature of micronized coal (e.g., burns similarly to oil), it requires a unique control system that involves a hybrid of systems normally associated with gas-only, oil-only and coal-only firing. The integrity of this system is very important to ensure optimum equipment performance, but most importantly, to ensure personnel and equipment safety. The existing control system at the Military base is very rudimentary, manually driven, and oriented to coal-only firing. Purpose of this task was to design a control system that is fundamentally basic and relatively easy to manage. Mr. Bob Pocock, an independent consultant and President of Alternate Inputs, Inc., with over 30 years experience with Bailey Control Systems assisted TCS in designing the system, which formed the basis of TCS's Budget Period I cost proposal to the Military.

Task 7: Preliminary Engineering Design and Site Layout

This task involved the completion of sufficient engineering design and evaluation of all available Project site information, data, drawings and equipment specifications to prepare the Budget Period I cost estimate proposal for the Military.

Task 8: Laboratory Analysis of Candidate Coals

Purpose of this task was to conduct a screening analysis to identify coal to be used for the demonstration.

OPAM identified four (4) candidate coals; however, OPAM stressed the importance of utilizing one particular source, which is the coal currently being used by the Military. Specifications of the coal include:

Name:	Halemba	
Heat value:	22,650 kJ/kg	(9,740 BTU/lb)
Ash content:	21.7 %	
Sulfur content:	0.63 %	
Moisture content:	9.7 %	
Volatile matter:	33.0 %	
Hardgrove Index:	61	
Ash:	reduc/oxyg	reduc/oxyg
* sintering point	890/ 950 degC	(1630/1740 degF)
* initial deform.	1250/1370 degC	(2280/2500 degF)
* hemisphere temp.	1410/1480 degC	(2570/2700 degF)
* flow temp.	1440/1500 degC	(2625/2730 degF)

Ash analysis:

* P2O5	1.02
* SiO2	44.43
* Fe2O3	8.30
* Al2O3	34.93
* CaO	3.51
* MgO	2.35
* SO3	2.32
* K2O	2.17
* Na2O	0.97
* TiO2	-
* Mn3O4	-
* BaO	-

In the context of specifications for the other three coals presented by OPAM, the above Halemba coal appeared to be as likely a choice as could be, especially given the institutional issue of its current supply to and use by the Military.

Task 9: Laboratory Analysis of Candidate Limestones

The currently published 1997 Polish Air Emission Standards for new facilities burning pulverized hard coal indicate the following limits: (a). nitrogen oxides @ 170 g/GJ, (b). dust @ 130 g/GJ, and (c) sulfur dioxide @ 200 g/GJ.

Nitrogen Oxides (NO_x): TCS was advised that because of the extremely low level of indicated NO_x emission limits, it is certain this standard will be changed as time progresses closer to 1997. This is a reasonable assumption. To meet such a standard would require advanced control technologies that are not state-of-the-art for boilers in the size range for Balice.

Dust: The indicated dust emission limit is very reasonable and will be easily achieved by the Amerex fabric filter system.

Sulfur Dioxide (SO_x): The Military's current coal has a heat content of 22.7 MJ/kg and sulfur content of 0.63 percent. To meet the indicated limit of 200 g/GJ will require 63 percent desulfurization. This is a very restrictive requirement for boilers in the size range for Balice. TCS was advised that there is a reasonable chance that this standard may be relaxed as time progresses closer to 1997; however, it was not certain and could not be assumed.

Primary air emission concern for the Project was the capability of achieving the required percentage of desulfurization.

Limestone and coal can be mixed, and then co-micronized in a TCS system to achieve desulfurization during combustion.

Purpose of this task was to conduct a screening analysis, by laboratory testing, of at least four (4) limestones available in the Krakow region for consideration as candidate sorbents for the indicated combustion tests described below.

Chemical and physical data by itself does not reveal anything about the efficiency of a limestone as a sulfur sorbent. Results must be available from either: (a). laboratory tests, or (b). actual combustion test to rank-order limestones from "best" to "worse". To "rank-order" the limestones and determine which would be best for combustion tests, the preference is to conduct specific laboratory tests (e.g., thermogravimetric analysis - TGA, etc.) for a clear comparison of each stone. The resulting "best" stone would be selected as the candidate for subsequent combustion tests in the United States.

The physical and chemical characteristics of limestones vary significantly from source to source, depending on local geology and location. As a result, some limestones are excellent desulfurization agents; whereas, others are terrible. Therefore, as in any location of the world, to determine the desulfurization capabilities of limestones in the Krakow region, a series of tests are necessary.

TCS originally proposed to USDOE a two-step test process, including:

- (1). Conduct laboratory analyses on various Krakow limestones to "rank" them in order of their superiority as desulfurization agents. Table 1 indicates test results conducted by the Pennsylvania State University Coal Utilization Laboratory on four (4) Krakow limestones that show all materials are relatively good desulfurization agents; however, "1st" best of the group is Sitkowka Limestone and "2nd" best is a Carbide Residue.

Laboratory tests can only "rank-order" the limestones, they cannot indicate actual percentages of desulfurization by co-micronization.

- (2). Based on their "ranks", Sitkowka, and possibly the Carbide Residue, were to be sent to the TCS Combustion Test Facility; Oakland, Maryland, for actual combustion testing in a TCS system. This is the only way to accurately determine the specific percent of desulfurization by co-micronization of Sitkowka or other limestones.

Combustion tests were not completed due to the abandonment of the Project by the Polish Military.

TCS's original USDOE proposal indicated an objective of achieving 50 percent desulfurization at Balice by co-micronizing coal and limestone. This is reasonable based on USA experience, where results have ranged from 40 to 70 percent using a wide variety of different limestones.

However, until actual combustion tests are conducted, TCS was not certain 63 percent desulfurization is possible by co-micronization alone with Sitkowka or Carbide Residue.

Therefore, in its proposal to the Military, TCS proposed a contingency plan to ensure the Military is capable of meeting the currently published 1997 Polish Air Emission Standards (i.e., 63 percent desulfurization), including:

- (a). The Project planned and budgeted for a relatively inexpensive duct-injection system capable of achieving 15 to 20 percent desulfurization, if necessary, in addition to co-micronization.
- (b). Combustion tests were to be completed before start of construction.
- (c). If combustion tests showed co-micronization can yield 63 percent desulfurization with Sitkowka Limestone or Carbide Residue, the duct-injection system would not be necessary and would not be installed.
- (d). If combustion tests showed co-micronization cannot achieve 63 percent desulfurization with Sitkowka Limestone or Carbide Residue, the duct-injection system would be installed.

The duct injection system is a modular device that is very easy and quick to install either during construction, or retrofitted later. It is possible to delay its installation for a period of time, to determine if the New 1997 Air Standards will be, or will not be, relaxed for desulfurization.

Table 1: RESULTS OF LABORATORY ANALYSES OF LIMESTONES FROM KRAKOW REGION

In late-November 1994, Penn State completed the necessary analyses, which indicated the following results:

<u>LIMESTONE SOURCE</u>	<u>SITKOWKA</u>	<u>PLAZ</u>	<u>CARBIDE RESIDUE</u>	<u>CZERNA</u>
<u>Oxide</u>				
SiO ₂	0.40	6.76	2.30	2.60
Al ₂ O ₃	0.15	1.66	1.49	0.85
TiO ₂	0.01	0.07	0.05	0.04
Fe ₂ O ₃	0.08	0.85	0.39	0.36
MnO	0.44	0.04	0.01	0.04
CaO	56.80	43.10	70.10	53.20
MgO	< 0.02	5.72	0.12	1.62
Na ₂ O	< 0.02	< 0.02	< 0.02	< 0.02
K ₂ O	< 0.02	0.61	0.05	0.08
P ₂ O ₅	< 0.02	0.10	0.02	0.07
BaO	< 0.01	< 0.01	0.02	< 0.01
SrO	0.03	0.02	0.05	0.03
SO ₃	< 0.05	< 0.05	0.40	< 0.05
Loss on Ignition (LOI)	41.30	41.60	24.50	40.80
	-----	-----	-----	-----
TOTAL	99.30	100.50	99.50	99.70
Ca/S molar ratio	1.22	1.13	1.24	1.17
lb-Sorbent/lb Sulfur	3.8	4.6	3.1	3.9
Price (old-Z1 /ton)	30,000	225,000	70,000	70,000
Value added tax (VAT)	22%	22%	0%	7%

These results indicate, that on a relative ranking order reactivity-cost basis, the No. 1 ranked limestone is the Sitkowka; whereas, the No. 2 ranked material is the Carbide Residue.

Task 10: Combustion Tests

The purpose of this task was to conduct a series of combustion tests; wherein, sufficient quantities of the selected Polish coal was to be: (a). micronized and burned individually, and (b). co-micronized with varying quantities of the selected limestone and burned together, to determine: combustion efficiencies, carbon burnout, desulfurization capabilities, NO_x emissions and other criteria pollutants, ash analysis and other performance factors.

In the original Project's scope of work, it was envisioned that combustion tests would have been conducted at the Rochelle (Illinois) Municipal Utilities plant utilizing currently installed TCS and Amerex equipment and monitoring systems. However, the location for testing was changed to TCS's newly installed test facility in Oakland, Maryland for several reasons, including: (a). accelerated Project work effort to meet the Military's accelerated Project schedule would not correspond to Rochelle's boiler availability (i.e., only during Spring or Fall maintenance periods), and (b). smaller quantities of coal would be required at Oakland, thus saving expense and minimize environmental impacts.

It was planned that upon acceptance of TCS's November 30, 1994 proposal by the Polish Military, TCS would request shipment of sufficient samples of the Military's coal, in conjunction with the selected limestone.

This task was not completed due to the abandonment of the Project by the Polish Military.

If a new Project site is identified and committed prior to mid-January 1996, this task will be included in its implementation.

Task 11: Ash Constituent Analysis

The purpose of this task was to have identified the constituents in the resulting micronized coal ash produced during the aforementioned combustion tests.

This task was not completed due to the abandonment of the Project by the Polish Military.

If a new Project site is identified and committed prior to mid-January 1996, this task will be included in its implementation.

Task 12: USA Site Visit

This task originally planned to have a site visit by OPAM to witness the combustion tests at Oakland, Maryland.

If a new Project site is identified and committed prior to mid-January 1996, this task maybe included, depending on status of site owner.

Task 13: Finalize Equipment Specification and Modifications

Factoring in results of the combustion tests, this task was to result in the finalization of all new equipment design and performance specifications and establish key dimensions for new equipment and sub-systems, including: limestone storage silo and handling, material conveyor systems, surge bins, TCS mills, Babcock & Wilcox boilers and burners, Amerex baghouses, pneumatic puffer system, F.D. and I.D. fans, ash silo and ash handling system, control and monitoring systems, electrical starter and interconnect, other auxiliary subsystems. Likewise, this task will determine all necessary modification or changes required for existing equipment and support systems.

This task was sufficiently completed to form the basis of the Budget Period I cost proposal presented to the Military.

Task 14: Structural and Foundation Analysis

Purpose of this task was to assess current condition of the existing boilerhouse and determine extent of necessary new foundations and structural supports.

During the site visit to the Military's heating plant, particular attention was paid to the visual appearance of the existing structure around areas where new equipment was to be installed. The condition appeared solid indicating that no major problems would have been encountered during installation and construction.

Task 15: Design Plan

This task was to have resulted in final design drawings and equipment specifications, not for actual construction activities, but with sufficient detail to provide assurance that all technical and cost factors have been adequately considered and quantified to the extent that Project implementation could progress with a high level of confidence.

Most of this task was completed; however, not finalized due to the cancellation of the Project by the Military.

Task 16: Implementation and Installation Cost Estimates

The purpose of this task was to develop a Budget Period II implementation and installation cost estimate for the Project.

Table 1 presents the proposed Budget Period I cost estimate assuming the use of Babcock & Wilcox boilers.

Table 2 presents the proposed revised Budget Period I cost estimate assuming the use of Polish manufactured boilers.

Task 17: Start-up and Demonstration Operational Cost Estimates

The purpose of this task was to develop a Budget Period II start-up and demonstration operational cost estimate for the Project.

The heating demand profile for the Military Balice Boilerhouse, results in an equivalent annual thermal load equal to 15.14 billion Kcal/yr.

For orientation, based on an 84.7 percent boiler efficiency, 63 percent desulfurization at a reasonable 2.5:1 Ca/S molar ratio, the following indicates the estimated annual materials consumption for co-micronization alone.

<u>Item</u>	<u>Tons/Year</u>	<u>Estimated Cost</u> (old-Zl /ton)	<u>Annual Cost</u> (old-Zl x million /yr)
Coal	3,300	900,000	2,970
Limestone	180	72,000	13
Total annual cost:			2,983

For orientation, based on 50 percent desulfurization at 2.5:1 Ca/S molar ratio with co-micronization, and 15 percent desulfurization with duct injection, the following indicates estimated annual materials consumption:

<u>Item</u>	<u>Tons/Year</u>	<u>Estimated Cost</u> (old-Zl /ton)	<u>Annual Cost</u> (old-Zl x million/yr)
Coal	3,300	900,000	2,970
Limestone (co-micron)	180	72,000	13
Hydrated lime (injection)	6	1,500,000	9
Total annual cost:			2,992

Task 18: Interim Project Evaluation Report, Schedule and Implementation Plan

Intent of this task was to have provided an abbreviated interim report to be submitted by the end of September 1994 to the Polish Military. It's primarily focus was to be on the key decision making criteria necessary for the Military to understand the technical, commercial and economic aspects of implementing new boilers at its facility.

Because of the aforementioned problems in obtaining information on new boilers and conducting the combustion tests, TCS sent a letter dated September 7, 1994 to the Polish Military requesting an extension of about two months to allow time to complete work efforts necessary for the interim report. The Military granted an extension until November 30, 1994.

As indicated above, the Budget Period I cost proposal was submitted on November 30, 1994.

Task 19. Final Project Evaluation Report, Schedule and Implementation Plan

The purpose of this task was to prepare and submit a Final Project Evaluation Report that includes sufficient detail for an evaluation of the technical and commercial criteria to continue the Project into Budget Period II.

Portions of this task were completed and highlighted in this document; however, finalization was not completed due to the cancellation of the Project by the Military.

Table 1: BUDGET PERIOD I PROJECT SCOPE OF SUPPLY AND COST
(w/. B&W Boilers)

The following presents an itemized listing of the Project's scope of equipment supply and installation, utilizing Babcock & Wilcox boilers, with cost breakdown.

<u>A. U.S. SUPPLIED EQUIPMENT</u>	(US \$)
a. <u>TCS</u> : Two (2) metal detection/rejection systems, (2) Model CM24C TCS coal micronization mills (without motors), includes temperature, vibration, and oil flow sensors and controls, (1) CM24C TCS spare rotor assembly, (2) transport pipes (mill to burners), with valving, spare part package, shipping, field service/start-up.	\$388,000
b. <u>Babcock & Wilcox</u> : Two (2) Model FM 9-57 boilers; 3 Mwt, 175 degF at 0.79 MPa. Including economizers, micron-coal burners/oil lighter, FD fans, boiler trim, steam coil air heater, sootblowers, furnace floor "steam-puffer" system, spare part package, shipping, field service/start-up.	865,380
c. <u>Amerex</u> : Two (2) REX-Pulse Model RP-12-100 D4 pulse jet fabric filters, rated at 8,500 m3/hr at 175 degC, including by-pass system, insulation, valving and dampers, spare part package, shipping, field service/start-up.	89,860
d. <u>Amerex (Contingent Item)</u> : Dry sorbent duct injection system, including storage, feeders, blower, venturi, nozzles. This is contingent and may not be required pending results of limestone combustion testing, or status of 1997 Polish Air Emission Standards, as described in this proposal.	52,500
e. <u>Control Techtronics International</u> : Complete multi-loop combustion control system, including: distributive control panel, direct digital control capability, control valves, motor speed invertors, level control, temperature, pressure, flow instrumentation, system alarm annunciator, electric/ electronic field wiring and pneumatic piping. Burner management and flame safe-guard system for B&W burners. Shipping, installation, field service, start-up.	240,000
f. <u>SUBTOTAL: COST OF USA SUPPLIED EQUIPMENT:</u>	----- \$1,635,740
<u>B. POLISH SUPPLIED EQUIPMENT AND SERVICE</u>	
a. Project design, specification, and documentation.	\$87,000
b. Removal of existing boilers, mechanical collectors, induced draft fans, foundations and other unnecessary auxiliary components, as required.	14,100

c.	Two (2) electric motors for TCS mills; (2) I.D. fans, (2+2) coal and limestone feeders; ash handling system; air compressor and dryer; ash silo with separator/vent/and truck disposal; electrical equipment; air, steam, water, oil pipelines; water treatment modernization; start-up fuel oil installation; fire protection system; ventilation; thermal insulation of flue gas ducts and pipelines; painting and hoists.	201,300
d.	Erection: B&W boilers; TCS mills; Amerex fabric filters; air compressor; duct injection system; ash handling; all pipelines; fire protection system; ventilation; hoists; water treatment modernization; and thermal insulation and anti-corrosion protection.	88,300
e.	Civil engineering works, including: foundations for boiler and mill foundations (adaptation of existing structures), fabric filter and ash silo, fuel oil system, existing hoppers, adaptation of existing stack, anti-corrosion protection and painting.	44,000
f.	Organizing, managing, supervising, tenders for deliveries and services, commissioning, start-up, trial-runs.	104,000
g.	Commercial service of deliveries from USA.	65,000
h.	<u>SUBTOTAL:</u> COST OF POLISH SUPPLIED EQUIPMENT & SERVICES	----- \$603,700

C. TOTALS AND CONTINGENCIES

a.	Total equipment and installation:	\$2,239,440
b.	Contingencies	52,000
c.	Total Project cost:	----- \$2,291,440
d.	Less USDOE contribution from TCS contract:	- 800,000
e.	Less USDOE contribution from Control Techtronics contract:	- 120,000
f.	NET TOTAL PROJECT COST (Including USDOE contributions): To be financed by the Military [**].	----- \$1,371,440

[**] NOTE: Military originally agreed and was committed to pay \$800,000 predicated on original Project agreement.

TAXES: No border tax, no duty, no VAT is included, nor believed to be applicable to the Military.

Table 2: BUDGET PERIOD I PROJECT SCOPE OF SUPPLY AND COST
(w/. Polish Boilers)

The following presents an itemized listing of the Project's scope of equipment supply and installation, utilizing Polish Manufactured boilers, with cost breakdown.

A. <u>U.S. SUPPLIED EQUIPMENT</u>	(US \$)
a. <u>TCS</u> : Two (2) metal detection/rejection systems, (2) Model CM24C TCS coal micronization mills (without motors), includes temperature, vibration, and oil flow sensors and controls, (1) CM24C TCS spare rotor assembly, (2) transport pipes (mill to burners), with valving, spare part package, shipping, field service/start-up.	\$388,000
b. <u>Amerex</u> : Two (2) REX-Pulse Model RP-12-100 D4 pulse jet fabric filters, rated at 8,500 m3/hr at 175 degC, including by-pass system, insulation, valving and dampers, spare part package, shipping, field service/start-up.	89,860
c. <u>Amerex (Contingent Item)</u> : Dry sorbent duct injection system, including storage, feeders, blower, venturi, nozzles. This is contingent and may not be required pending results of limestone combustion testing, or status of 1997 Polish Air Emission Standards, as described in this proposal.	52,500
d. <u>Control Techtronics International</u> : Complete multi-loop combustion control system, including: distributive control panel, direct digital control capability, control valves, motor speed invertors, level control, temperature, pressure, flow instrumentation, system alarm annunciator, electric/ electronic field wiring and pneumatic piping. Burner management and flame safe-guard system for B&W burners. Shipping, installation, field service, start-up.	240,000
e. <u>SUBTOTAL: COST OF USA SUPPLIED EQUIPMENT:</u>	----- \$770,360
B. <u>POLISH SUPPLIED EQUIPMENT AND SERVICE</u>	
a. Project design, specification, and documentation.	\$87,000
b. Removal of existing boilers, mechanical collectors, induced draft fans, foundations and other unnecessary auxiliary components, as required.	14,100

c. <u>Boilers</u> : Two (2) Polish supplied water-tube boilers; 3 Mwt, 175 degF at 0.79 MPa. Including economizers, micron-coal burners/oil lighter, FD fans, boiler trim, steam coil air heater, sootblowers, furnace floor "steam-puffer" system, spare part package, shipping, field service/start-up.	470,600
d. Two (2) electric motors for TCS mills; (2) I.D. fans, (2+2) coal and limestone feeders; ash handling system; air compressor and dryer; ash silo with separator/vent/and truck disposal; electrical equipment; air, steam, water, oil pipelines; water treatment modernization; start-up fuel oil installation; fire protection system; ventilation; thermal insulation of flue gas ducts and pipelines; paining and hoists.	201,300
e. Erection: Polish boilers; TCS mills; Amerex fabric filters; air compressor; duct injection system; ash handling; all pipelines; fire protection system; ventilation; hoists; water treatment modernization; and thermal insulation and anti-corrosion protection.	88,300
f. Civil engineering works, including: foundations for boiler and mill foundations (adaptation of existing structures), fabric filter and ash silo, fuel oil system, existing hoppers, adaptation of existing stack, anti-corrosion protection and painting.	44,000
g. Organizing, managing, supervising, tenders for deliveries and services, commissioning, start-up, trial-runs.	104,000
h. Commercial service of deliveries from USA.	25,000
i. <u>SUBTOTAL</u> : COST OF POLISH SUPPLIED EQUIPMENT & SERVICES	<u>\$1,034,300</u>

C. TOTALS AND CONTINGENCIES

a. Total equipment and installation:	\$1,804,660
b. Contingencies	52,000
c. Total Project cost:	<u>\$1,856,660</u>
d. Less USDOE contribution from TCS contract:	- 800,000
e. Less USDOE contribution from Control Techtronics contract:	- 120,000
f. NET TOTAL PROJECT COST (Including USDOE contributions):	<u>\$936,660</u>
To be financed by the Military [**]	

[**] NOTE: Military originally agreed and was committed to pay \$800,000 predicated on original Project agreement; thus, basis of cash shortfall of \$136,660.

TAXES: No border tax, no duty, no VAT is included, nor believed to be applicable to the Military.