On-Site Incineration at the
Celanese Corporation Shelby Fiber Operations Superfund Site
Shelby, North Carolina

Incineration at the Celanese Superfund Site
Shelby, North Carolina

<table>
<tr>
<td>Site Name:
Celanese Superfund Site</td>
<td rowspan="2">Contaminants:
Ethylene glycol, volatile organic compounds, metals, polynuclear aromatic hydrocarbons, and phenol
• Trichloroethylene, benzene, phenols, lead, chromium, and antimony
• Maximum concentrations of ethylene glycol (12,000 mg/kg) antimony (3,000 mg/kg), lead (2,041 mg/kg) and chromium (40 mg/kg).</td>
<td>Period of Operation:
April 1991 to December 1991</td>
</tr>
<tr>
<td>Location:
Shelby, North Carolina</td>
<td>Cleanup Type:
Remedial action</td>
</tr>
<tr>
<td>Vendor:
Terry Elmaggar
GDC Engineering, Inc.
822 Neosho Avenue
Baton Rouge, LA 70802
(504) 383-8556</td>
<td rowspan="2">Technology:
On-Site Incineration
• Solids pretreated with screening and mixing with sawdust
• Incineration system consisting of rotary kiln and secondary combustion chamber (SCC)
• Soil residence time of 45 minutes, kiln temperature of 1,500°F; SCC temperature of 1,900°F
• Treated soil and sludge (incineration ash) discharged into a wet ash collection system</td>
<td>Cleanup Authority:
CERCLA and State: North Carolina
• ROD Date: 3/28/89
• PRP-Lead</td>
</tr>
<tr>
<td>SIC Code:
2824 (Manufacturing manmade organic fibers)</td>
<td>Point of Contact:
McKenzie Mallary
U.S. EPA Region 4
Atlanta Federal Center
100 Alabama Street
Atlanta, GA 30303-3104
(404) 562-8802</td>
</tr>
<tr>
<td>Waste Source:
Disposal of waste sludges</td>
<td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Sludge and Soil
• 4,660 tons of sludge and soil
• Moisture content: sludge - 25%</td>
</tr>
<tr>
<td>Purpose/Significance of Application:
Lowest volume incinerated for all of the case studies</td>
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<tr>
<td colspan="3">Regulatory Requirements/Cleanup Goals:
• Destruction and Removal Efficiency (DRE) of 99.99% for each constituent of concern as required by Resource Conservation and Recovery Act (RCRA) incinerator regulations in 40 CFR part 264, subpart O</td>
</tr>
<tr>
<td colspan="3">Results:
• Emissions and trial burn data indicate that all DRE and emission standards were met
• Analytical data of residuals indicate that cleanup goals were met</td>
</tr>
</table>

Incineration at the Celanese Superfund Site
Shelby, North Carolina

(Continued)

Description:
The site began operation in April 1960 and is still operating. Between 1960 and the early 1980s, plant wastes from the production of polyester raw-material were disposed of in burn pits and sludge was buried in trenches. Between 1970 and 1978, drums of waste chemicals and solvents were stored on site. A site investigation was conducted in 1981. A Record of Decision (ROD), signed in March 1989, specified on-site incineration as the remediation technology for the excavated sludge and soil. Site cleanup goals and DRE standards of 99.99% for constituents of concern were specified in the ROD.

On-site incineration began in April 1991. During its period of operation, the incinerator processed 4,660 tons of sludge and soil. The treatment system consisted of a rotary kiln and an SCC. An enclosed conveyor moved the soil and debris to the kiln for treatment. Treated ash from the incinerator was discharged to a wet ash collection system. The system used an air pollution control system that consisted of a baghouse and a packed-bed scrubber. Incineration achieved the soil cleanup goals specified in the ROD.

The total cost of the remedial action was approximately $5,800,000, including $3,925,000 in capital costs and $1,875,000 in operation and maintenance costs.

EXECUTIVE SUMMARY

This report presents cost and performance data for the application of on-site incineration at the Celanese Corporation Shelby Fiber Operations (Celanese) Superfund site in Shelby, North Carolina. A rotary kiln incinerator was operated from April 1991 through December 1991 as part of a remedial action. Contaminants of concern at the site were trichloroethylene (TCE), benzene, phenols, polynuclear aromatic hydrocarbons (PAHs), lead, chromium, ethylene glycol, and antimony.

The Celanese site is a polyester raw-material production facility that began operation in April 1960. Between 1960 and the early 1980s, various wastes were stored and disposed of on-site in unlined pits and trenches. In March 1988, a Record of Decision (ROD) for Operable Unit 1 (OU-1) was signed that required treatment of contaminated groundwater.

In March 1989, a ROD for OU-2 was signed. The remedial actions for OU-2 included the excavation and incineration of Glycol Recovery Unit (GRU) sludges and associated soil; and the excavation, solidification, and disposal of plastic chips, burn pit residuals, and stream sediments. The remainder of this report will address the incineration specified in OU-2, unless otherwise stated.

The ROD specified the excavation and incineration of approximately 1,500 cubic yards of GRU sludge plus an additional foot of soil below the sludge/soil interface. The ROD also specified incinerator requirements that included a destruction and removal efficiency (DRE) of 99.99% for each constituent of concern.

The selected incineration system consisted of a feed system; a rotary kiln; a secondary combustion chamber (SCC) and an air pollution control system (APCS) [2].

Before entering the feed system, waste sludge and soil were mixed with sawdust to facilitate materials handling. The mixture passed through a separator to remove any pieces of metal, then was conveyed to a weigh hopper, and finally to the kiln.

The kiln used at the Celanese site was lined with refractory brick. The rotary kiln volatilized and partially destroyed organic compounds from the contaminated material. Ash generated in the incinerator was collected in a wet ash collection system and conveyed out of the system for solidification and disposal, while exhaust gases were drawn into the SCC. The SCC provided further combustion of organics in the off-gases which were then quenched with water.

The APCS consisted of a baghouse and a packed-bed scrubber. Particulate removal occurred in the baghouse, and gas polishing and acid neutralization occurred in the scrubber.

During the nine months of operation, the incinerator processed 4,660 tons of GRU sludge and associated soil [2]. During excavation, several drums containing a tar-like substance were found. The drum contents also were incinerated. Treatment performance and emissions data collected during this application indicated that all performance standards and emissions requirements were met.

The actual cost for remediation using the incineration system was approximately $5,800,000, consisting of $3,925,000 in capital costs and $1,875,000 in operation and maintenance costs.

SITE INFORMATION

Identifying Information

Celanese Corporation Shelby Fiber Operations Superfund Site, Shelby, North Carolina

CERCLIS # NCD003446721

OU-2 ROD Date: March 28, 1989

Treatment Application

Type of action: Remedial (on-site incineration)

Period of incinerator operation: April 1991 - December 1991

Quantity of material treated during application: 4,660 tons of GRU sludge and associated soil incinerated

Background

Historical Activity that Generated Contamination at the Site: Manufacturing of polyester polymer resin and filament yarn

Corresponding SIC Code: 2824 (Organic Fibers)

Waste Management Practice That Contributed to Contamination: Storage and land disposal of wastes generated from the manufacturing process

Site History:

- The Celanese Corporation Superfund site is located on the 469-acre property of an operating polyester raw-material production facility in south central Cleveland County. The site began operation in April 1960.
- Between 1960 and the early 1980s, plant wastes were disposed of in burn pits and GRU sludge was buried in trenches. Between 1970 and 1978, drums of waste chemicals and solvents were stored on site.
- The primary contaminants of concern in the soil and sludges were ethylene glycol, volatile organic compounds (VOCs) including TCE and benzene, phenols, PAHs, and metals including lead, chromium, and antimony.
- A site investigation was conducted in 1981 and a Remedial Investigation (RI) was completed in June 1986. A Feasibility Study (FS) for OU-1 was completed in February 1988, and the FS for OU-2 was completed in April 1989.
- Remedial action related to the GRU sludge and associated soil (waste) began in January 1991 when the responsible party (RP) began excavating the waste. Beginning in April 1991, a rotary kiln incinerator was used to remediate the excavated waste.
- A period of optimization was followed by a mini-burn and then a trial burn. The mini-burn was conducted in April 1991 to provide enough data for tentative approval from EPA. The trial burn was conducted in June 1991.
- Approximately 4,660 tons of waste were processed between April 1991 and December 1991. By August of 1992, all remediation activities for OU-2 were complete.

SITE INFORMATION (CONT.)

Background (Cont.)

Regulatory Context:

- In June 1986, the Celanese Corporation site was placed on the National Priorities List (NPL).
- A ROD was signed in March 1989, specifying a remedial action that included excavation and on-site incineration to reduce the concentration of chemical contaminants at the site. Ground water remediation was addressed by OU-1, and source remediation was addressed by OU-2.
- The selected remedy was conducted under the provisions of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986 and the National Oil and Hazardous Substances Contingency Plan in 40 CFR part 300 [1].
- The DREs were set in accordance with Resource Conservation and Recovery Act (RCRA) incinerator regulations in 40 CFR part 264, subpart O.

Remedy Selection: On-site rotary kiln incineration was selected as the remedy for contaminated soil and sludge at the Celanese Superfund site based on the results of the RI/FS and long-term economic considerations.

Timeline

Table 1. Timeline [2]

Date	Activity
April 1960 - Ongoing	The facility on the Celanese site is in operation
1981	Initial site investigation
June 1986	Site placed on the NPL
June 1986 - April 1989	Remedial Investigation/Feasibility Study
March 28, 1989	Record of Decision for OU-2 signed
April 1991	Mini Burn
June 1991	Trial Burn
January 1991 - March 1992	GRU sludge and soil are excavated for incineration and/or solidification
April 1991 - December 1991	Rotary kiln incinerator operational
March 1992 - August 1992	Decontamination and demobilization of the incinerator

Site Logistics/Contacts

Site Management: RP-Lead

Oversight: EPA

Remedial Project Manager:
McKenzie Mallary
U.S. EPA Region 4
Atlanta Federal Center
100 Alabama Street, S.W.
Atlanta, GA 30303-3104
(404) 562-8802

Treatment System Vendor:
Terry Elmaggar
GDC Engineering, Inc.
822 Neosho Avenue
Baton Rouge, LA 70802
(504) 383-8556

MATRIX DESCRIPTION

Matrix Identification

Type of Matrix Processed Through the Treatment System:

- GRU sludges and associated soil were excavated. Metal was removed, solidified and disposed on site. The sludge and soil were mixed with sawdust prior to incineration.

Contaminant Characterization

Primary Contaminant Groups: Ethylene glycol, VOCs, metals, PAHs, and phenol.

- The contaminants of greatest concern were VOCs (including TCE and benzene), phenols, PAHs, lead, chromium, and antimony.
- Waste feed samples were collected and the concentrations of ethylene glycol and total antimony were measured. The average concentration of ethylene glycol was 1,740 mg/kg with a range of 43 to 12,000 mg/kg. The average concentration of antimony was 694 mg/kg with a range of 190 to 3,000 mg/kg [2]. The maximum GRU sludge concentrations for lead and chromium were 53 mg/kg and 40 mg/kg, respectively. The maximum concentration of lead in the soil was 2,041 mg/kg.

Matrix Characteristics Affecting Treatment Cost or Performance

The major matrix characteristics that most significantly affected cost or performance at the site and their measured values are presented in Table 2.

Table 2. Matrix Characteristics

Parameter	Value
Sludge Classification	Mixture of semi-viscous sludge and dry, hard material
Sludge Moisture Content	25%
Average Upper Heating Value of Sludge	5,400 BTU/lb

TREATMENT SYSTEM DESCRIPTION

Primary Treatment Technology

Rotary kiln incineration including:

- Rotary kiln;
- Secondary combustion chamber; and
- Quench duct.

Supplemental Treatment Technology

Pretreatment (solids): Mixed with sawdust and screened

Air pollution control system including:

- Baghouse; and
- Packed bed scrubber system.

Post-Treatment (water): Neutralization

TREATMENT SYSTEM DESCRIPTION (CONT.)

System Description and Operation

- The rotary kiln incineration system employed at the Celanese site consisted of two chambers (the kiln itself and a secondary combustion chamber) and an air pollution control system consisting of a baghouse and a packed-bed scrubber system.
- Overburden material at the site (those materials not collected for incineration and/or solidification) were removed and stockpiled. The GRU sludges and soil were mixed with sawdust in a pugmill to facilitate material handling. The waste feed was screened before being fed to the rotary kiln by a feed screw.
- The kiln had a length of 45 feet and an inner diameter of 6½ feet. The kiln was lined with refractory brick rotating on a slight incline (2 degrees).
- The kiln was rated at 20 MBTU/hr. The kiln rotated at a maximum rate of 0.98 revolutions per minute.
- Residual ash from the kiln was collected in a wet ash collection system and was solidified with 15 to 20 percent Portland cement and then used for backfill.
- Flue gases from the kiln were routed to the SCC for additional combustion of volatilized contaminants. The SCC operated at approximately 1,900°F and an average percent oxygen between 4 and 8 percent.
- The exhaust gas from the SCC was channeled through the quench duct and then to the system's baghouse. The design operating condition exit temperature for the baghouse was approximately 350°F.
- Combustion gases were drawn through the kiln system and baghouse by an induced draft fan (resulting in a constant negative pressure throughout the system) and were exhausted through a 69-foot reinforced concrete stack. Typical stack gas velocity was between 1,143 and 1,750 feet per second and the typical stack exit temperature was below 180°F.
- Scrubber water effluent was treated by an on-site neutralization system.

Table 3. Summary of Operating Parameters

Parameter	Value
Residence Time	45 minutes
System Throughput	2.3 tons/hour
Kiln Temperature	1,500°F

Cleanup Goals/Standards

- The required DRE was 99.99% for each constituent of concern.
- The OU-2 ROD originally established a remedial action that included excavation and incineration of approximately 1,500 cubic yards of GRU sludge plus an additional foot of soil below the sludge/ soil interface. Other wastes and sediments excavated on site were to be solidified and disposed of on site.
- Waste was excavated to the visual sludge/ soil interface and an attempt was made to excavate to an additional one foot below the sludge/soil interface [2].

TREATMENT SYSTEM DESCRIPTION (CONT.)

- Due to the hardness of the clay and bedrock beneath the GRU sludge, the removal of an additional one foot of soil was not always possible.

- Sampling was not performed in the excavated pits because the intent of the remediation was not to provide cleanclosure. The groundwater treatment system was expected to treat any remaining contaminants [2].

- Residual ash was solidified and disposed of on site. The maximum allowable ethylene glycol concentration for all material.

Treatment Performance and Compliance

- A trial burn conducted at the Celanese Corporation site was designed to operate the incineration system at conditions that would reflect worst-case destruction and removal of all constituents of concern.

- Tetrachloroethene was selected as the POHC for the Celanese Corporation site. Naphthalene was initially chosen as the POHC, but problems occurred with cross contamination. The calculated DRE for tetrachloroethene is shown in Table 4.

- The incinerator operated within the operating limits established during the trial burn, signifying that all cleanup requirements were met. The limits established for the AWFCOs are shown in Table 5. Information on the frequency of AWFCOs was not available. Trial burn and typical operating parameters are shown in Table 6.

- The residual ash was sampled and analyzed for ethylene glycol and toxicity characteristic leaching procedure metals.

- Workers were required to maintain level D protection through the remedial action.

Table 4. Average Destruction and Removal Efficiencies from Compliance Testing

Contaminant	Average Contaminant Feed Rate in Soil (g/hr)	Average Contaminant Rate in Stack Gas Emissions (g/hr)	Average Contaminant Rate in Residuals (g/hr)	DRE (%)
Tetrachloroethene	8,163	0.0415	NA	99.9995

Table 5. Automatic Waste Feed Cutoffs [2]

Parameter	Cutoff Limit
Minimum Secondary Combustion Chamber Oxygen	3.0% O_2
Maximum CO (rolling average)	50 ppm
Minimum Primary Combustion Chamber Temperature	1430°F
Minimum Secondary Combustion Chamber Temperature	1840°F
Minimum Scrubber pH	6.5
Maximum System Draft	-0.1 inch in w.c.
Minimum Baghouse Differential Pressure *	4.0 inch H_2O
Minimum Stack Velocity	1750 feet/min

w.c. = Water column
* Note: Limit for baghouse differential pressure not activated until 6 hours after incinerator start-up

TREATMENT SYSTEM DESCRIPTION (CONT.)

Table 6. Operating Parameters [2]

Parameter	Actual Value[a]	Trial Burn Value
Contaminated Soil Feed Rate	2.5 tons/hr	2.5 tons/hr
Primary Combustion Chamber Temperature	1,487°F	1,500°F
Secondary Combustion Chamber Temperature	1,880°F	1,850°F
Average percent oxygen in secondary chamber	5.07%	4.3% to 7.8%
Kiln draft average	-0.17 in w.c.	-0.19 to -0.21 in w.c.
Baghouse pressure drop average	4.76 in w.c.	2.75 to 7.24 in w.c.
CO emissions	NA	0.5 ppm to 3.4 ppm
Percent oxygen in stack	NA	11.7% to 13.0%
Percent carbon dioxide average	NA	4.8% to 6.8%
Scrubber pH	9.2	3.7 to 10.1

w.c. = Water column
[a]Proposed operating parameters based on the results of the trial burn.

Performance Data Available

- Verification sampling was not performed on excavated pits because clean closure was not the intent of the remediation for OU-2 [2].
- Initial contaminant concentrations are included in the RI/FS and the Treatability Study Investigation.
- For each day the incinerator was operating, one incinerator ash sample was analyzed for total ethylene glycol. Excluding mini-burn and trial burn samples, 137 samples were taken. Of the 137 samples taken, only three samples had ethylene glycol concentrations above the detection limit of 10 mg/kg. The concentrations of those samples were 31, 47, and 10 mg/kg [2].

Performance Data Quality

- The Quality Assurance/Quality Control (QA/QC) program used throughout the remedial action met the EPA and the State of North Carolina requirements. All QA auditing and monitoring were performed by SEC Donohue and RP personnel [2].

TREATMENT SYSTEM COST

Procurement Process

- The RP contracted with SEC Donohue to develop the remedial design and oversee the remedial work. The RP also retained GDC Engineering, Inc. to conduct the remedial work.

Cost Data

- The cost of incineration at the Celanese Corporation site was reported as $5,300,000. The capital costs for the incineration system were $3,425,000 and operations and maintenance (thermal treatment) costs totaled $1,875,000. A total of 4,660 tons of soil and sludge were incinerated. This corresponds to a total unit cost of $1,000 per ton, and a unit cost for thermal treatment of $410 per ton.

Table 7. Capital Costs [6]

WBS Number			Description	Cost
331	01	01	Mobilization of construction equipment and facilities	$100,000
331	01	02	Mobilization of personnel	$50,000
331	01	03	Submittals/implementation plans	$250,000
331	02	03	Air monitoring and sampling	
331	02	05	Sampling surface and groundwater	
331	02	06	Sampling soil and sediment	$300,000
331	02	09	Laboratory chemical analysis	
331	03	03	Earthwork (i.e., excavating, stock piling)	$500,000
331	03	05	Fencing	$25,000
			Incineration equipment	$2,000,000
			Trial burn	$100,000
			Set up/construct temporary facilities	$100,000
			Total Capital Costs	$3,425,000

Table 8. Operation and Maintenance Costs [6]

WBS Number		Description	Cost
342	14	Thermal treatment	
		• Labor	$750,000
		• Direct operating cost	$750,000
		• Permitting	$25,000
		• Overhead	$350,000
		Total Operation and Maintenance Costs	$1,875,000

Cost Data Quality

- Cost data was provided by Hoechst Celanese.

OBSERVATIONS AND LESSONS LEARNED

Cost Observations and Lessons Learned

- In relation to off-site incineration, on-site incineration is most economical with large volumes of waste. Because the amount incinerated at Celanese was comparatively not very large, off-site incineration would have been more economical.

Other Observations and Lessons Learned

- The initial estimate of 1,500 cubic yards of GRU sludge and 500 cubic yards of soil was exceeded. The treatment performance data indicate that the incinerator processed 4,549 tons of sludge, 111 tons of soil, and 1,200 tons of sawdust [2].
- Initially, clay in the waste feed was collecting on the walls of the kiln resulting in a reduction in throughput. This was remedied by mixing the waste with sawdust and optimizing the waste feed rate.
- Initially, problems occurred with naphthalene, the first POHC, cross contaminating the blanks. In response, naphthalene was replaced with tetrachloroethene.
- Weekly field reports identified difficulty with the feed screw as the cause of many AWFCOs. Other AWFCOs were caused by loss of burner flame in the kiln and SCC caused by a faulty relay, weigh cells around the line hopper failing to operate properly, and quench nozzles breaking. The actual number of AWFCOs was not included in these reports.

Public Involvement

- Citizens of the Earl/Shelby area expressed interest in the remediation of the Celanese Corporation site. The group, The United Neighbors for cleanup at Earl, was formed because of concerns about the quality of water in their area.
- At public meetings conducted by EPA, the community favored remedial action, but few citizens expressed a preference for a particular process [1].

REFERENCES

1. Superfund Record of Decision Operable Unit 2, Celanese Corporation Shelby Fiber Operations, Shelby, North Carolina, March 1989.
2. Remedial Action Report Operable Unit 2 Remedial Action, Celanese Shelby Fiber Operations Superfund Site, SEC Donohue, June 1993.
3. Personal communication with Susan Schrader, Tetra Tech EM, Inc., Denver, August 7, 1997.
4. Personal communication with Terry Elmaggar, GDC engineering, July 16, 1997.
5. Trial Burn Report Operable Unit 2 Hoechst Celanese, Westinghouse Environmental and Geotechnical Services, Inc., August 30, 1991.
6. Personal communication with Jeff Randolph. Hoechst Celanese, June 1997.