# cement-lock®
# Technology

**DEMONSTRATION PROJECT FOR**
**DECONTAMINATION OF**
**DREDGED ESTUARINE SEDIMENT**

## ESTIMATED ENVIRONMENTAL IMPACT OF THE PILOT-SCALE DEMONSTRATION PROJECT

**Prepared by:**

**ENDESCO Services, Inc.**
**ENDESCO Clean Harbors, L.L.C.**
**Gas Technology Institute**
**Des Plaines, Illinois 60018-1804**

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## INTRODUCTION

The Cement-Lock® Technology, developed by the ENDESCO Clean Harbors, L.L.C., ENDESCO Services, Inc., and the Gas Technology Institute (GTI – formerly the Institute of Gas Technology) provides a one-step solution for remediating dredged sediments contaminated with both organic and inorganic materials. In the Cement-Lock Technology, all organic contaminants present in the dredged sediments are completely destroyed, non-volatile inorganic contaminants are immobilized, and the solid product is put to a beneficial use as construction-grade cement.

The Cement-Lock Technology has the flexibility to accommodate the complex and varying nature and levels of contaminants and their widespread spatial distribution within the estuarine environment. Cement-Lock simultaneously immobilizes non-volatile heavy metals and destroys polycyclic aromatic hydrocarbons (PAHs) and organochlorines such as dioxins, furans, polychlorinated biphenyls (PCBs), chlorinated pesticides and herbicides. Through application of the Cement-Lock Technology, contaminated sediments are remediated and converted to a beneficial use and accumulated persistent pernicious pollutants are eliminated from the environment.

The project is a public-private partnership. It is sponsored, in part, by Brookhaven National Laboratory (BNL) under an interagency grant from the U.S. Environmental Protection Agency Region 2 and the U.S. Army Corps of Engineers (New York District). Significant funding is also being provided by the New Jersey Office of Maritime Resources (under the New Jersey Department of Transportation – NJ-DOT). Significant funding has been provided by the Gas Research Institute and other private investors.

The initial demonstration of the Cement-Lock Technology will be conducted on a 2-acre site at the International Matex Tank Terminal (IMTT) site in Bayonne, New Jersey. The overall demonstration will be conducted in two phases: Phase I is a pilot-scale test. Phase II is a larger-scale demonstration. The two phases are discussed below. However, only the estimated environmental impacts of the pilot-scale test are presented in this report.

During Phase I, about 350 cubic yards (cy) of estuarine sediment dredged from the Status Petroleum Site will be processed through the Cement-Lock demonstration plant under a 90-day R&D permit to be issued by the New Jersey Department of Environmental Protection (NJ-DEP). The 350 cy of sediment is currently stored in twenty 20-cubic yard capacity roll-offs at another location. Each roll-off has a plastic liner and a tarp cover to prevent rain intrusion. The roll-offs will be brought to the site prior to the demonstration. The sediment will be offloaded into a live-bottom hopper via a backhoe or similar type of excavator.

During the demonstration, the 350 cy of sediment will be converted into about 175 tons of Ecomelt®. The Ecomelt will be loaded into trucks and hauled to a cement manufacturer for grinding and conversion to construction-grade cement.

Also during the initial Phase I operation of the plant, environmental sampling will be conducted. Samples to be collected include raw sediment and modifiers, Ecomelt, Cement-Lock construction-grade cement, and air emissions from stationary point sources at the plant. The data and information gained from the environmental sampling as well as the initial operations of the plant will be used in preparing a permit application for the longer-duration Phase II demonstration.

As Phase I represents the initial start-up and operation of the Cement-Lock plant, it will be operated at a nominal sediment processing rate of about 10,000 cy/year (or about 1.2 cy/hour).

During Phase II of the demonstration, the Cement-Lock plant will process from 30,000 to 50,000 cy of dredged sediment. The actual quantity of sediment that will be processed during this project phase will depend upon the number of sediment decontamination technology vendors that participate in the large-scale demonstration program. The source of sediment for the demonstration-scale phase of the project has not yet been finalized.

During Phase II, the Cement-Lock plant will be operated in three separate stages, during which time the sediment feed rate will be increased incrementally from 10,000 to 30,000 cy/yr as operating experience with the equipment is gained. The type of oxidant employed for the combustion of natural gas in the system will also be an important operating parameter during the large-scale demonstration phase. Oxidant concentration will be increased from 21 mole percent (mol %) during the initial stage, to 30 mol % during the second stage, and to 40 mol % during the third stage of the demonstration program.

This report describes the estimated environmental impacts from the operation of the Cement-Lock demonstration-scale plant during the Phase I pilot-scale effort. The estimate of air emissions from the Cement-Lock demonstration plant are based on the scaling up data collected during the pilot-scale sediment decontamination campaign conducted at Hazen Research Inc. (Golden, Colorado).

# 1. CEMENT-LOCK PLANT® DESCRIPTION

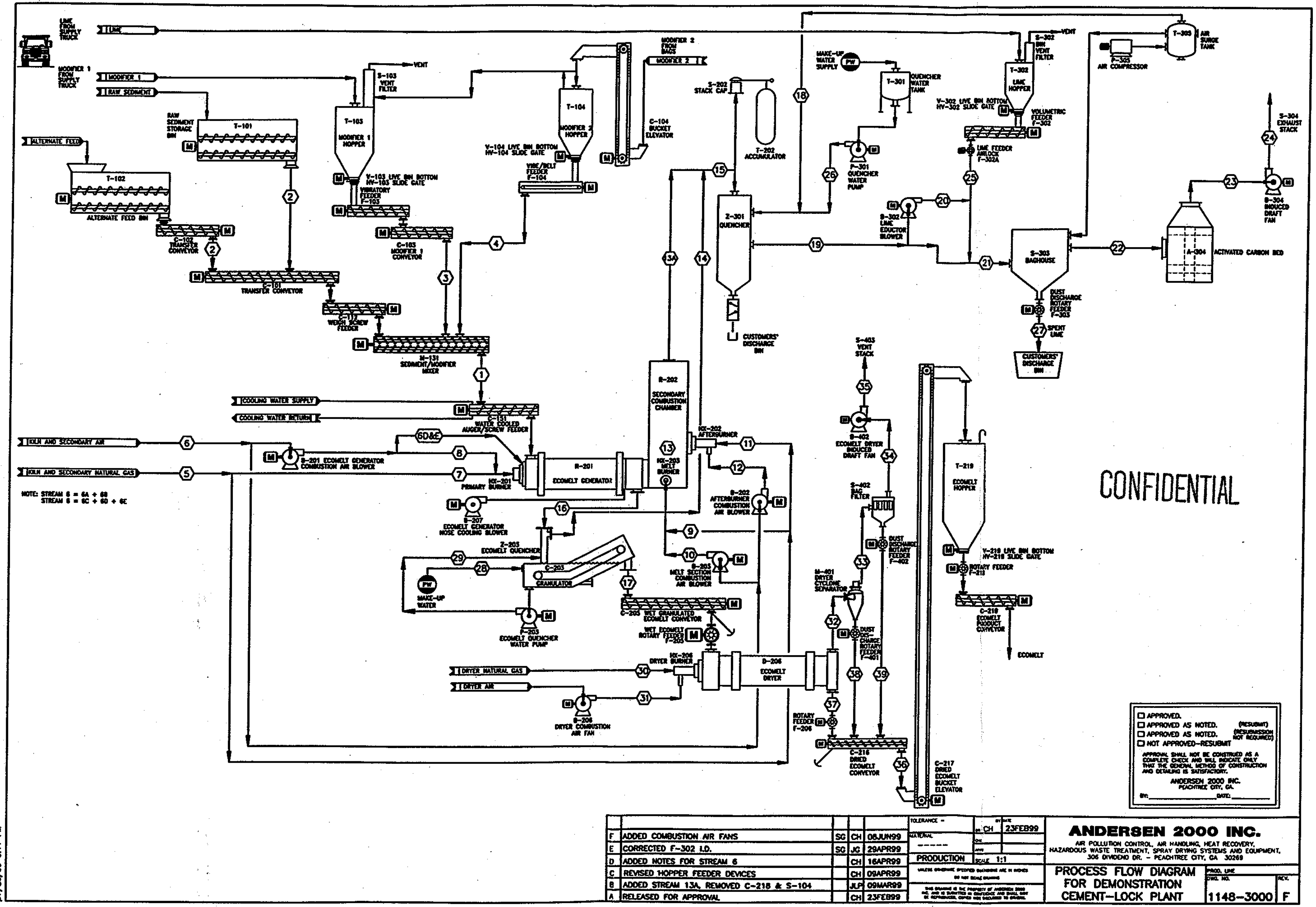
The Cement-Lock® demonstration plant facility is divided into three processing sections:

| | |
|---|---|
| Section 100 | Feed System |
| Section 200 | Ecomelt® Generation |
| Section 300 | Gas Clean-Up |

A fourth processing section (Construction-Grade Cement-Production) will be located at an off-site facility.

| | |
|---|---|
| Section 400 | Construction-Grade Cement Production |

The major equipment and process streams are shown in the process flow diagram in Figure 1-1. Brief descriptions of all four Cement-Lock plant facility and off-site processing sections are given below.

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## 1.1. Section 100: Feed System

Dredged sediment slated for processing during Phase I was dredged by the State of New Jersey from the Stratus Petroleum site in Newark. The sediment will be brought to the plant site in twenty 20-cy capacity, lined and tarped roll-offs. Prior to being stored in the roll-offs, the material had been screened to remove oversized debris (greater than about 1 inch) and dewatered to remove from water by others. The oversized material was disposed of in an ordinary landfill. The screened sediment will be transported by clamshell excavator or other means and stored in the Sediment Storage Bin (T-101). The Sediment Storage Bin is enclosed with a roof structure in order to protect the sediment from the environment.

The screened sediment is fed to the Sediment/Modifier Mixer (M-131) by transfer and weigh screw conveyors. Sediment and Modifier 1 and Modifier 2 solids are blended together in the Sediment/Modifier Mixer. The modifier solids are received from supply trucks, pneumatically conveyed and stored in Modifier 1 and Modifier 2 Hoppers (T-103 and T-104, respectively), and fed to the Sediment/Modifier Mixer through Modifier 1 Conveyor (C-103) and Vibe/Belt Feeder (F-104). The blended sediment-modifiers mixture is then fed to the Ecomelt Generator (R-201).

## 1.2. Section 200: Ecomelt® Generation

The Ecomelt® Generator (R-201) is a direct-fired rotary kiln where the sediment and modifier solids are melted at temperatures in the range of 2400° to 2600°F in the presence of oxygen. The rotary kiln melter for the demonstration project is about 10 feet in diameter and about 30 feet long. The required energy for heating and melting the solids feed is provided by the combustion of natural gas with oxidant. The organic contaminants contained in the sediment are destroyed and converted to water ($H_2O$) vapor and carbon dioxide ($CO_2$). The chlorine component of organo-chlorine compounds present in the dredged sediment is converted into hydrogen chloride (HCl). The gaseous contaminants leaving the Ecomelt Generator are further combusted and destroyed in a Secondary Combustion Chamber (SCC, R-202). The SCC provides an additional 2 seconds of residence time at temperature for the hot flue gases. Non-volatile heavy metals present in the sediment are completely dissolved and immobilized in the resulting melt.

The molten slag discharged from the Ecomelt Generator is rapidly quenched with water and shattered into small Ecomelt granules in the Ecomelt Granulator (C-203). The granulator is a water-filled tank equipped with an inclined dewatering conveyor. Dewatered Ecomelt granules are then transferred to the Ecomelt Dryer (D-206) via the Wet Granulated Ecomelt Conveyor (C-205) and a Rotary Feeder (F-205). The heat for the dryer is provided by the combustion of natural gas with air. The dried Ecomelt is collected and stored in Ecomelt Hopper (T-219). This Ecomelt can be further utilized for the production of construction-grade cement.

Any entrained particulates are removed from the Ecomelt Dryer effluent gas in the Cyclone Separator (M-401) and the Bin Vent Filter (S-402). The cleaned effluent gas is then vented to the atmosphere through the stack (S-402) via an Induced Draft Fan (B-402).

## 1.3. Section 300: Gas Clean-Up

The hot off-gas leaving the SCC (R-202) is cooled evaporatively to 350°F by direct contact with water in a Quencher (Z-301). Pulverized lime absorbent from a Lime Hopper (T-302) is injected into the quenched off-gas to adsorb the acid gas species. The spent absorbent is removed from the gas stream in a Baghouse (S-303) and collected for subsequent disposal.

The off-gas leaving the Baghouse is then passed through an Activated Carbon Bed (A-304) adsorber packed with activated carbon pellets where volatile heavy metals (such as mercury species) are adsorbed. The cleaned effluent gas is then vented (S-304) to the atmosphere through an Induced Draft Fan (B-304).

## 1.4. Section 400: Construction-Grade Cement Production

The Ecomelt generated in Section 200 is stored onsite in the Ecomelt Hopper (T-219). The Ecomelt will be conveyed from the Ecomelt Hopper into trucks for transport to off-site grinding and conversion to construction-grade cement for ultimate use. During the grinding operations, the Ecomelt will be reduced in size to less than about 40 micrometers (an alternate particle size designation would be about 4000 to 4500 Blaine). The finely ground Ecomelt will be intimately blended with the final additive to yield construction-grade cement. The construction-grade cement will be stored and/or packaged for sale.

In an alternate scenario, the Ecomelt will be interground with cement clinker from an ongoing cement manufacturing operation. The construction-grade cement product will be stored and/or packaged for use.

During Phase I, the construction-grade cement will be used in local construction projects. The NJ-DOT has indicated that they will help locate appropriate projects for utilizing the construction-grade cement.

## 2. PLANT OPERATION

During the Phase I pilot-scale campaign, a total of about 320 tons (350 cubic yards) of raw sediment will be processed by the Cement-Lock demonstration plant. At a nominal processing rate of about 1 ton per hour, this quantity of dredged sediment will require the plant to be operated for a total of about 320 hours or a little over 13 days. However, due to the typical pace of plant startup activities, we anticipate that the actual operating time will span 45 to 60 days. A simplified process flow diagram and overall material balance for the pilot-scale operation four operating periods are shown in Figure 2-1 and Table 2-1.

During Period 1, the Ecomelt Generator will be fired with ambient air containing 21 mol % oxygen. A total of 2,470 cubic yards of raw sediment will be processed at a nominal sediment feed rate of 10,000 cubic yards per year or 2,373 lb/h for three months.

During Period 2, the Ecomelt Generator will be fired with oxygen-enriched air containing 30 mol % oxygen. A total of 4,930 cubic yards of raw sediment will be processed at a nominal sediment feed rate of 20,000 cubic yards per year or 4,746 lb/h for three months.

During Period 3, the Ecomelt Generator will be fired with oxygen-enriched air containing 40 mole percent oxygen. A total of 22,600 cubic yards of raw sediment will be processed at a nominal sediment feed rate of 30,000 cubic yards per year or 7,252 lb/h for nine months.

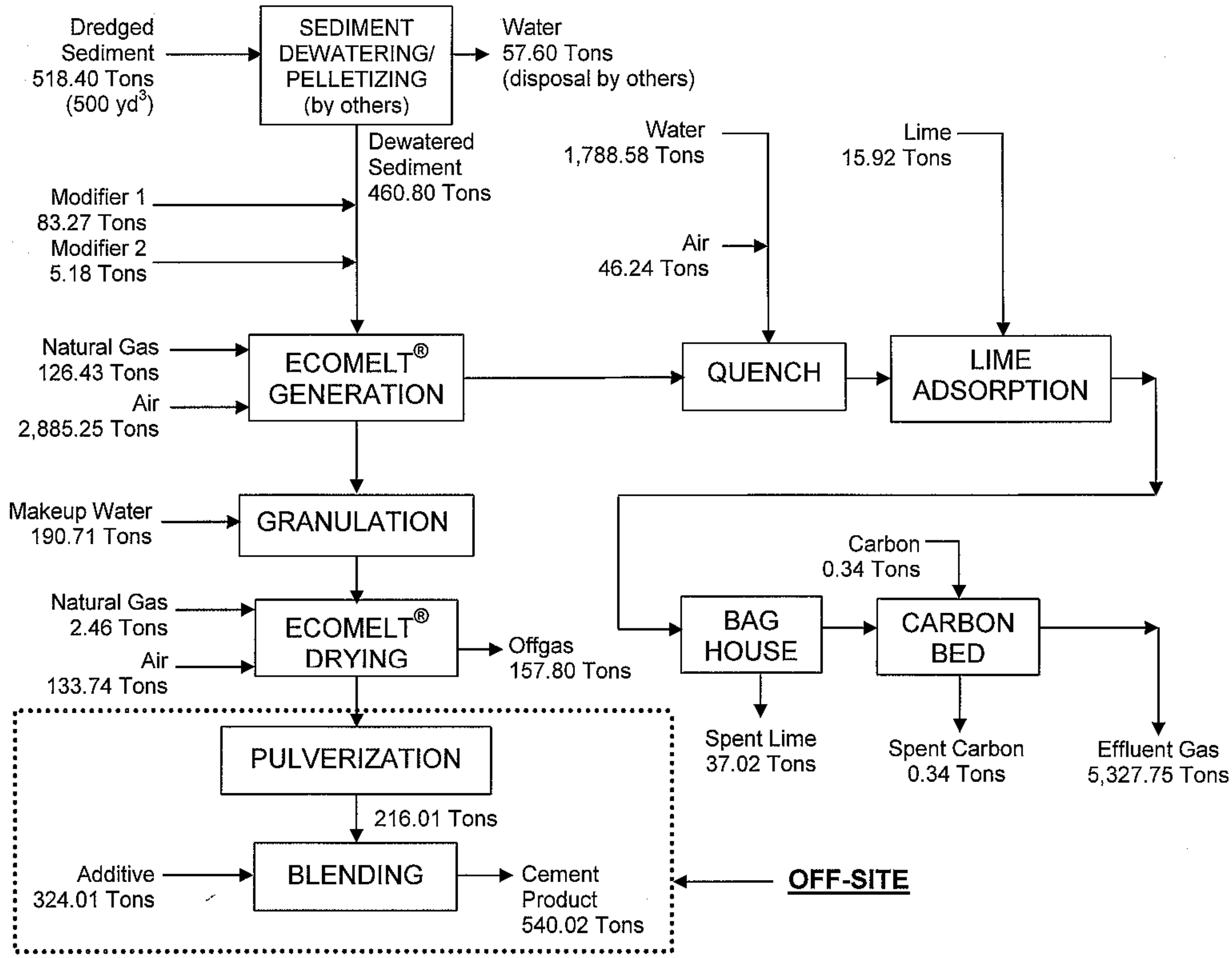



**Figure 2-1. BLOCK FLOW DIAGRAM FOR THE CEMENT-LOCK® TEST FACILITY**

**Table 2-1. Overall Material Balances for the Cement-Lock Demonstration Plant Operations**

| Operating Period | PP | 1 | 2 | 3 |
|---|---|---|---|---|
| Duration, months | 18days (90-days) | 3 | 3 | 9 |
| Raw Sediment Processed, $yd^3$ | 500 | 2,470 | 4,930 | 22,600 |
| Oxygen Content in Oxidant, mol % | 21 | 21 | 30 | 40 |
| Nominal Sediment Feed Rate, $yd^3/yr$ | 10,000 | 10,000 | 20,000 | 30,000 |
| | | | | |
| **Input Streams** | ------------ Pounds per hour ------------ | | | |
| Raw Sediment | 2,373 | 2,373 | 4,746 | 7,252 |
| Modifier 1 (Limestone) | 381 | 381 | 762 | 1,166 |
| Modifier 2 (Alumina) | 24 | 24 | 48 | 73 |
| Lime | 40 | 40 | 80 | 122 |
| Natural Gas to Ecomelt Generator | 885 | 885 | 840 | 965 |
| Natural Gas to Ecomelt Dryer | 9 | 9 | 18 | 28 |
| Water to Quencher | 12,710 | 12,710 | 11,221 | 12,422 |
| Water to Granulator | 111 | 111 | 222 | 339 |
| Oxidant to Ecomelt Generator | 18,239 | 18,239 | 12,264 | 10,706 |
| Air to Ecomelt Dryer | 447 | 447 | 894 | 1,366 |
| Air to Quench Column | 914 | 914 | 914 | 914 |
| **Total In** | **36,133** | **36,133** | **32,009** | **35,353** |
| **Output Streams** | | | | |
| Dry Ecomelt | 997 | 997 | 1,994 | 3,047 |
| Spent Lime | 55 | 55 | 110 | 168 |
| Carbon Adsorber Exhaust Gas | 34,514 | 34,514 | 28,771 | 30,045 |
| Ecomelt Dryer Exhaust Gas | 567 | 567 | 1,134 | 1,733 |
| **Total Out** | **36,133** | **36,133** | **32,009** | **35,353** |

Note: Raw sediment containing 60 wt % water with a heating value of 700 Btu/lb is fed to the Ecomelt Generator operated with 20% excess oxidant for natural gas, a heat loss of 1,000,000 Btu/h, and a 100% on-stream factor.

# 3. CHARACTERISTICS OF EFFLUENT STREAMS

The characteristics of the effluent streams generated by the proposed Cement-Lock demonstration plant are discussed in this section. The emission rates and concentrations of pollutants in the exhaust gas from the Activated Carbon Bed adsorber (A-304) of the proposed demonstration plant have been estimated from the experimental data generated in the Cement-Lock pilot plant tests conducted at Hazen Research, Inc., Golden, Colorado.

## 3.1. Pilot Plant Test and Data

Brief descriptions of the pilot plant facilities, the operating conditions, and the pertinent test data are given in this section.

The raw sediment containing about 60 weight percent water and mixed with modifier solids was fed directly to a 2-foot inside diameter by 6.5-foot long rotary kiln melter operated at about 2450°F. Exhaust gas from the rotary kiln was ducted into a 21-inch diameter by 24-foot long secondary combustion chamber (SCC). Hot off-gas from the SCC was quenched with lime slurry in a 21-inch diameter by 7.5-foot high quench column where acid gases were removed. The cooled gas – at about 350°F – was filtered in a baghouse with a cloth area of 184 $ft^2$. The baghouse off-gas was ducted to a fixed-bed adsorption column packed with pelletized activated carbon and granular Sorbalit™ adsorbent, where mercury and other pollutants were removed. The clean gas was vented to the atmosphere with an induced-draft fan.

Process gases generated during pilot plant test program were sampled at the SCC outlet duct and analyzed continuously for $O_2$, CO, $CO_2$, $SO_2$, $NO_2$, and THC (total hydrocarbons). The gas sample was filtered and cooled to remove entrained particulate matter and water vapor before the gas entered the continuous analyzer. The THC analyzer received a filtered hot sample. Stack gas sampling were also performed at the SCC outlet and at the adsorption column outlet for particulates, metals, dioxins, furans, semivolatile organic compounds (SVOC's), HCl, $O_2$, $CO_2$, $SO_2$, and $NO_2$. Key operating data of the pilot plant are shown in Table 3-1. The emission rates and concentrations of pollutants in the effluent gas stream are summarized in Table 3-2.

**Table 3-1. Average Operating Conditions of the Cement-Lock® Pilot Plant Test Campaign**

| **Kiln Parameters** | | --- lb/h --- |
|---|---|---|
| Sediment Feed Rate | | 100 |
| Modifier Feed Rate | | 28 |
| Ecomelt Product | | 28.6 |
| | | |
| **Temperatures** | | -- °F -- |
| Kiln Bed | | 2420 |
| Kiln Outlet | | 2390 |
| SCC Outlet | | 2005 |
| Baghouse Outlet | | 355 |
| Adsorption Column | | 310 |
| | | |
| **Gas Flow Rates** | | - SCFM - |
| Air to Kiln | | 163 |
| Air to SCC | | 51 |
| Natural Gas to Kiln | | 16.5 |
| Natural Gas to SCC | | 6.2 |
| | | |
| **SCC Exhaust Gas Composition** | Corrected to 7% $O_2$ | |
| $O_2$, mol % | -- | 2.5 |
| $CO_2$, mol % | 8.8 | 11.6 |
| CO, ppm | 24 | 32 |
| NOx, ppm | 71 | 94 |
| THC, ppm | 10.6 | 14 |

**Table 3.2. Emission Rates and Concentrations of Pollutants in the Adsorber Exhaust Gas of the Cement-Lock Pilot Plant (sampling and analysis by AirNova, Pennsauken, NJ)**

| | Emission Rate, lb/h | Concentration, ppmv (dry basis) |
|---|---|---|
| Particulate Matter | $< 2.0 \times 10^{-4}$[a] | $< 4.9 \times 10^{-5}$ g/DSCF[b] |
| Hydrogen Chloride (HCl) | 0.04 | 17.9 (14.2)[c] |
| Sulfur Dioxide ($SO_2$) | 0.2 | 54 (44.1)[c] |
| Nitrogen Oxides (as $NO_2$) | 0.2 | 75 |
| | | |
| Mercury | | |
| Gas Phase | $9.8 \times 10^{-6}$ | 7.12[d] |
| Particulate Phase | $< 2.2 \times 10^{-7}$ | <0.16[d] |
| | | |
| 2,3,7,8-CDD (Total) | | |
| Gas Phase (TEF) | $< 4.0 \times 10^{-12}$[e] | |
| Particulate Phase (TEF) | $< 8.0 \times 10^{-12}$[e] | |
| 2,3,7,8-CDF(Total) | | |
| Gas Phase (TEF) | $< 8.1 \times 10^{-12}$[e] | |
| Particulate Phase (TEF) | $< 7.3 \times 10^{-13}$[e] | |

a. Less than the detection limit of the analytical procedure employed.
b. Grains per dry standard cubic foot.
c. Corrected to 7 mol % oxygen.
d. Micrograms (µm) per dry standard cubic meter.
e. Toxicity Equivalency Factor.

## 3.2. Gas Effluents

### 3.2.1. Exhaust Gas From the Activated Carbon Bed

The composition of major components of the exhaust gases from the Activated Carbon Bed (A-304) of the proposed demonstration plant are shown in Table 3-3.

**Table 3-3. Compositions of Major Components in Activated Carbon Bed Exhaust Gas of the Cement-Lock Demonstration Plant**

| **Operating Period** | **PP** | **1** | **2** | **3** |
|---|---|---|---|---|
| Major Components, mol % | | | | |
| $O_2$ | 1.97 | 1.97 | 2.20 | 2.25 |
| $CO_2$ | 4.03 | 4.03 | 4.91 | 5.52 |
| $H_2O$ | 59.21 | 59.21 | 68.25 | 74.93 |
| $N_2$ | 34.79 | 34.79 | 24.64 | 17.30 |
| Total | 100.00 | 100.00 | 100.00 | 100.00 |
| Flow Rate, mol/h | 1,522 | 1,522 | 1,315 | 1,426 |
| lb/h | 34,693 | 34,693 | 28,950 | 30,584 |
| Temperature, °F | 300 | 300 | 300 | 300 |

The emission rates of HCl, mercury species, dioxins, and furans at the adsorber outlet of the proposed demonstration plant were determined based on pilot plant data as shown in Table 3-2 and then normalized by the feed rates of raw sediment to the demonstration plant during each operating period.

The concentration of CO at the adsorber outlet of the Cement-Lock pilot plant was not analyzed. Therefore, the emission rates of CO at the adsorber outlet of the demonstration plant have been estimated based on the CO concentration measured at the pilot plant SCC outlet and then normalized by the feed rates of raw sediment to the demonstration plant during each operating period. It is assumed that no CO will be removed in the gas clean-up section.

The concentration of THCs at the adsorber outlet of the Cement-Lock pilot plant was not analyzed. Therefore, the emission rates of THC at the adsorber outlet of the demonstration plant have been estimated based on THC concentration measured at the pilot plant SCC outlet. It has been assumed that 80 percent of the THCs is removed in the activated carbon adsorption column. The emission rates are then normalized by the feed rates of raw sediment to the demonstration plant during each operating period.

The analytical data of $SO_2$ taken at the pilot plant adsorber outlet appear to be inaccurate. Therefore, the emission rates of $SO_2$ at the adsorber outlet of the demonstration plant have been estimated based on the $SO_2$ emission rate measured at the pilot plant SCC outlet. It has been assumed that 85 percent of the $SO_2$ is removed in the lime adsorption system (which was quoted by a vendor). The emission rates are then normalized by the feed rates of raw sediment to the demonstration plant during each operating period.

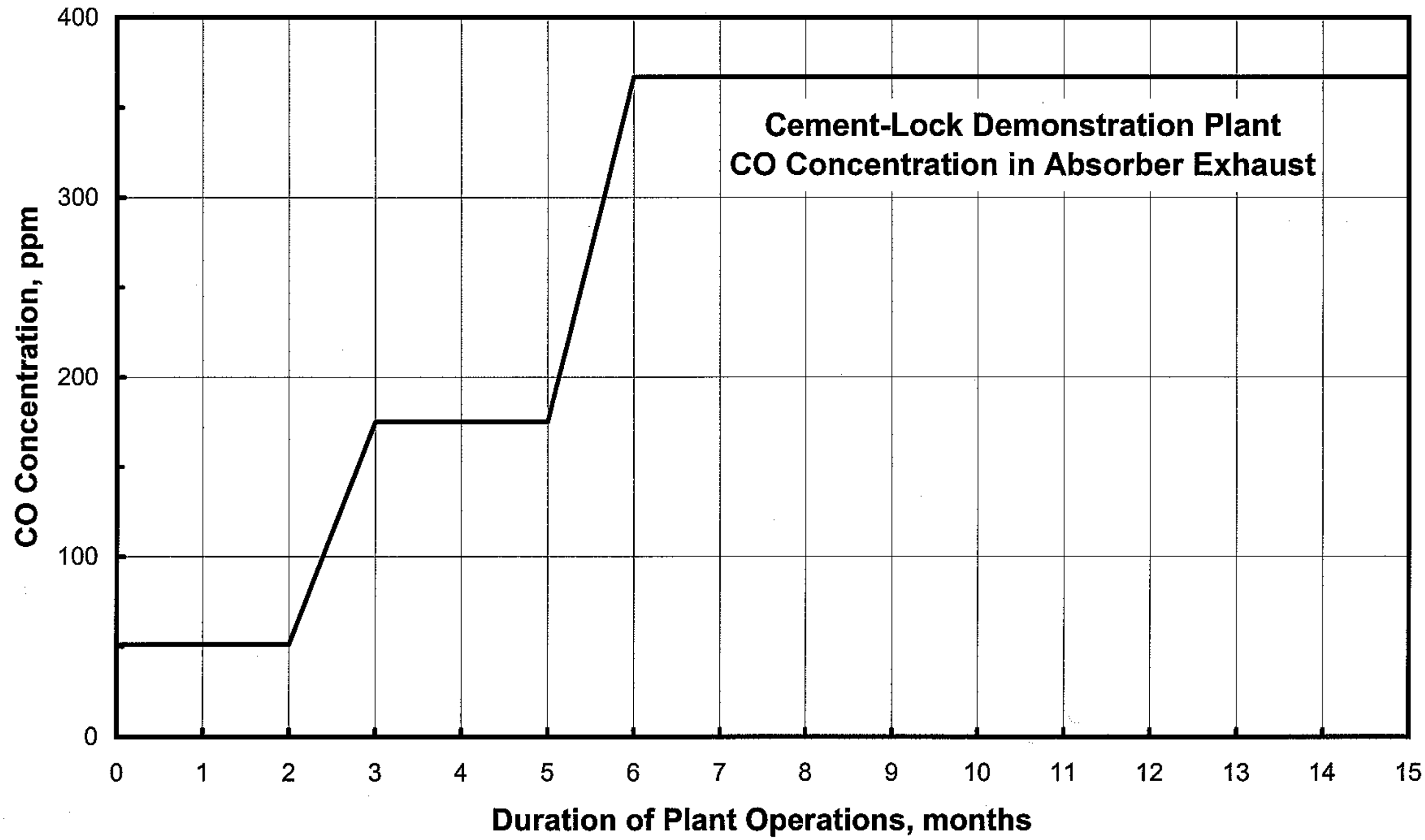
The emission rates of $NO_2$ at the adsorber outlet of the demonstration plant were estimated based on the pilot plant data as shown in Table 3-2 and then normalized by the nitrogen content in the stoichiometric amount of oxidant used for the combustion of natural gas in the Ecomelt Generator.

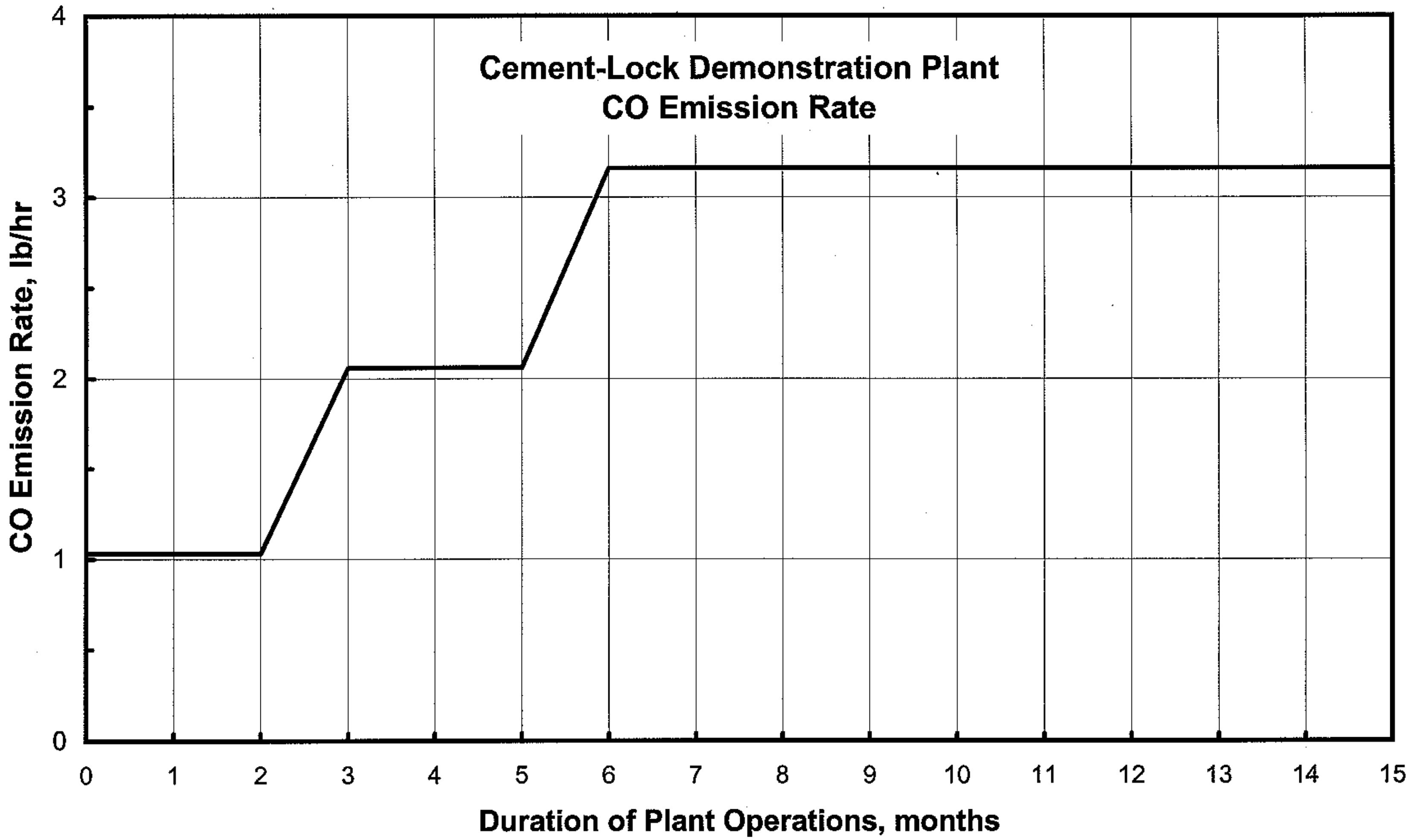
The emission rates of particulate matter at the adsorber outlet of the demonstration plant were estimated based on the pilot plant data as shown in Table 3-2 and then normalized by the flow rates of adsorber exhaust gases during each operating period.

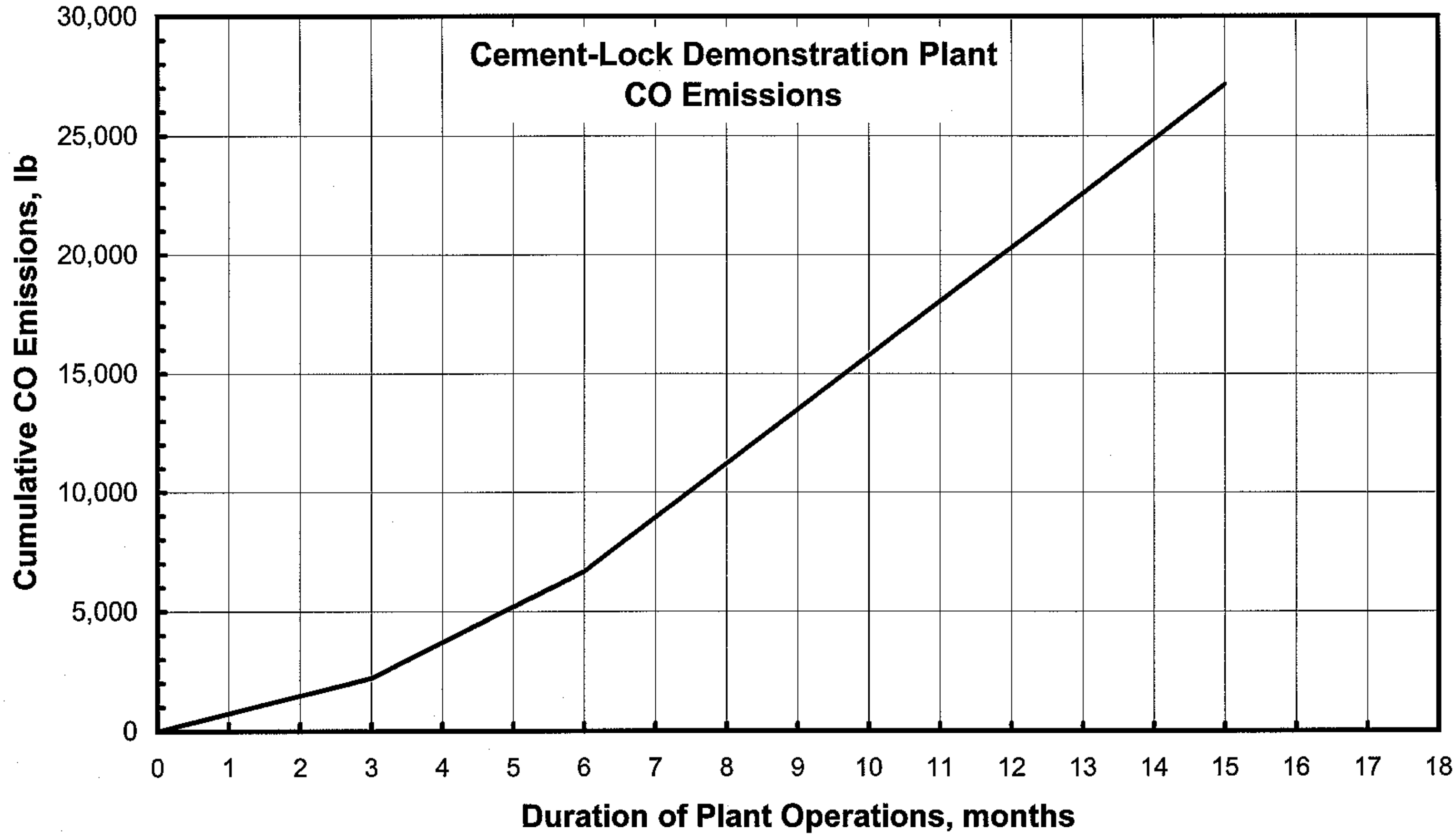
The concentrations of these pollutants were calculated from the emission rates and the flow rates of the activated carbon bed adsorber exhaust gases. The emission rates and concentrations of pollutants for operating Periods 1, 2, and 3 are given in Tables 3-4 through 3-6. The graphic presentation of concentrations, emission rates, and cumulative emissions at the activated carbon bed adsorber outlet of the demonstration plant are shown in the following figures (in the following order).

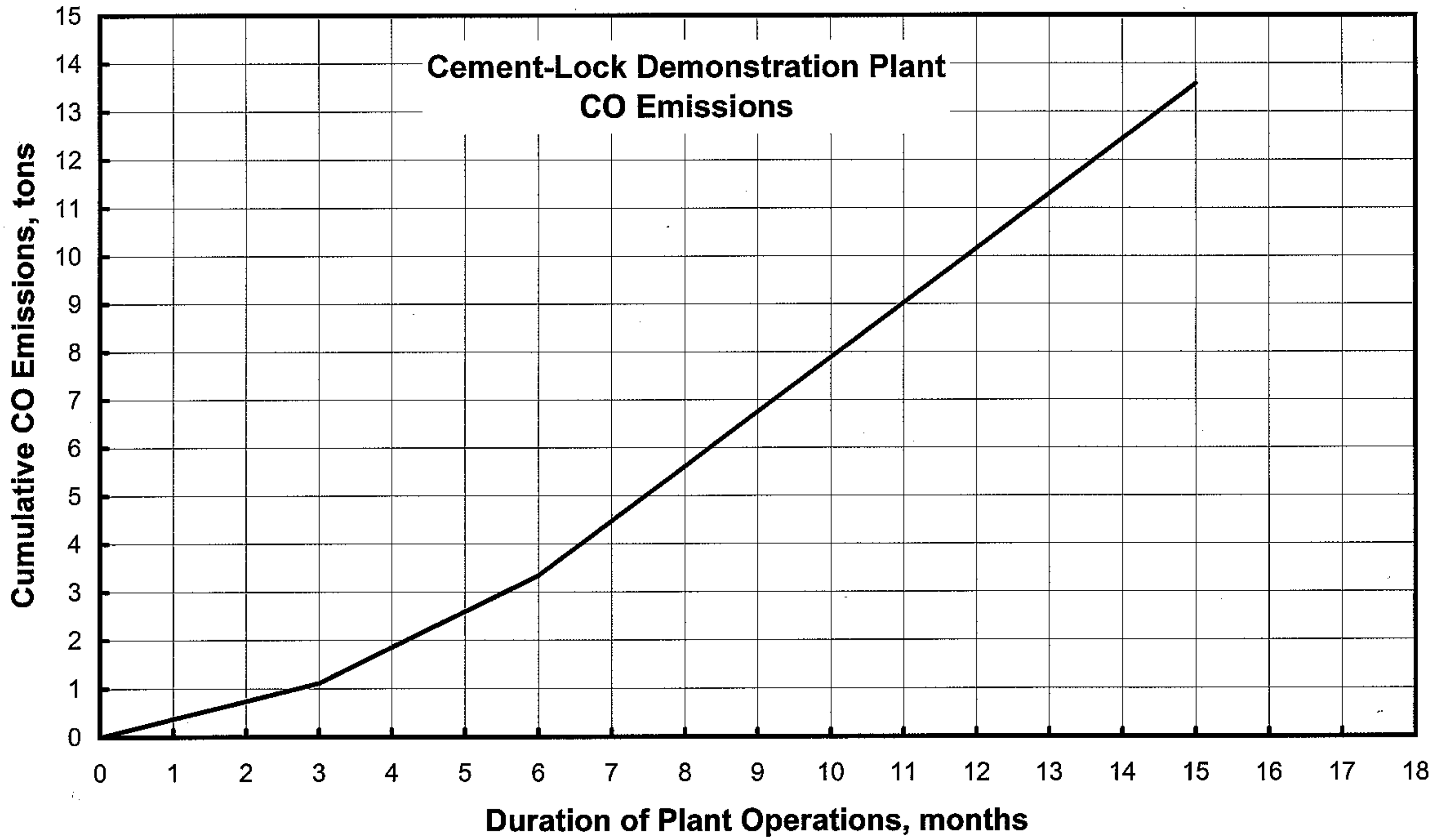
1. CO
2. $CO_2$
3. $SO_2$
4. $NO_2$
5. HCl
6. THC
7. Hg
8. PCDD
9. PCDF
10. Particulates

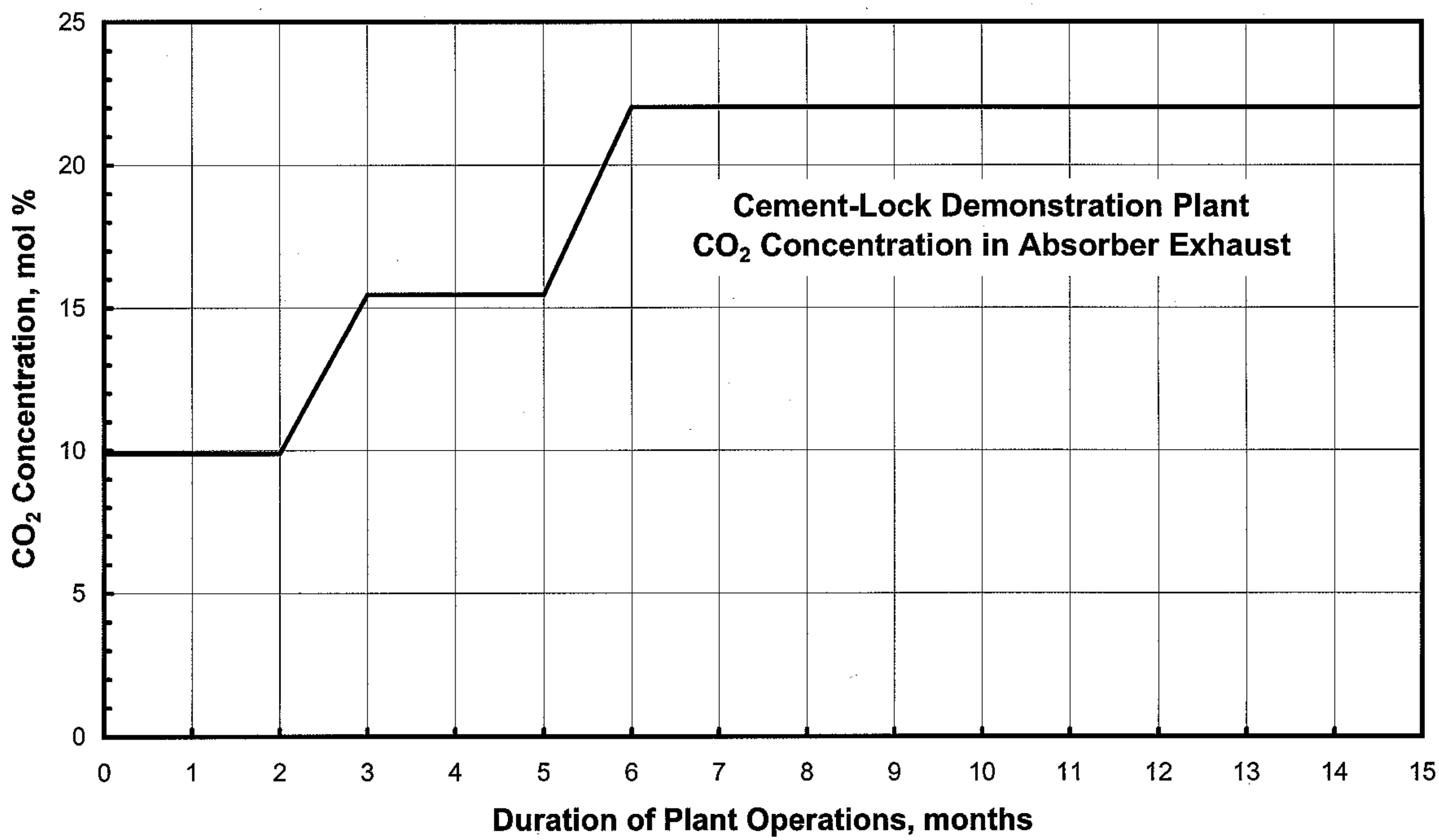
Note that the environmental impacts of Period PP are not specifically indicated on the figures; they can be estimated from those of Period 1.

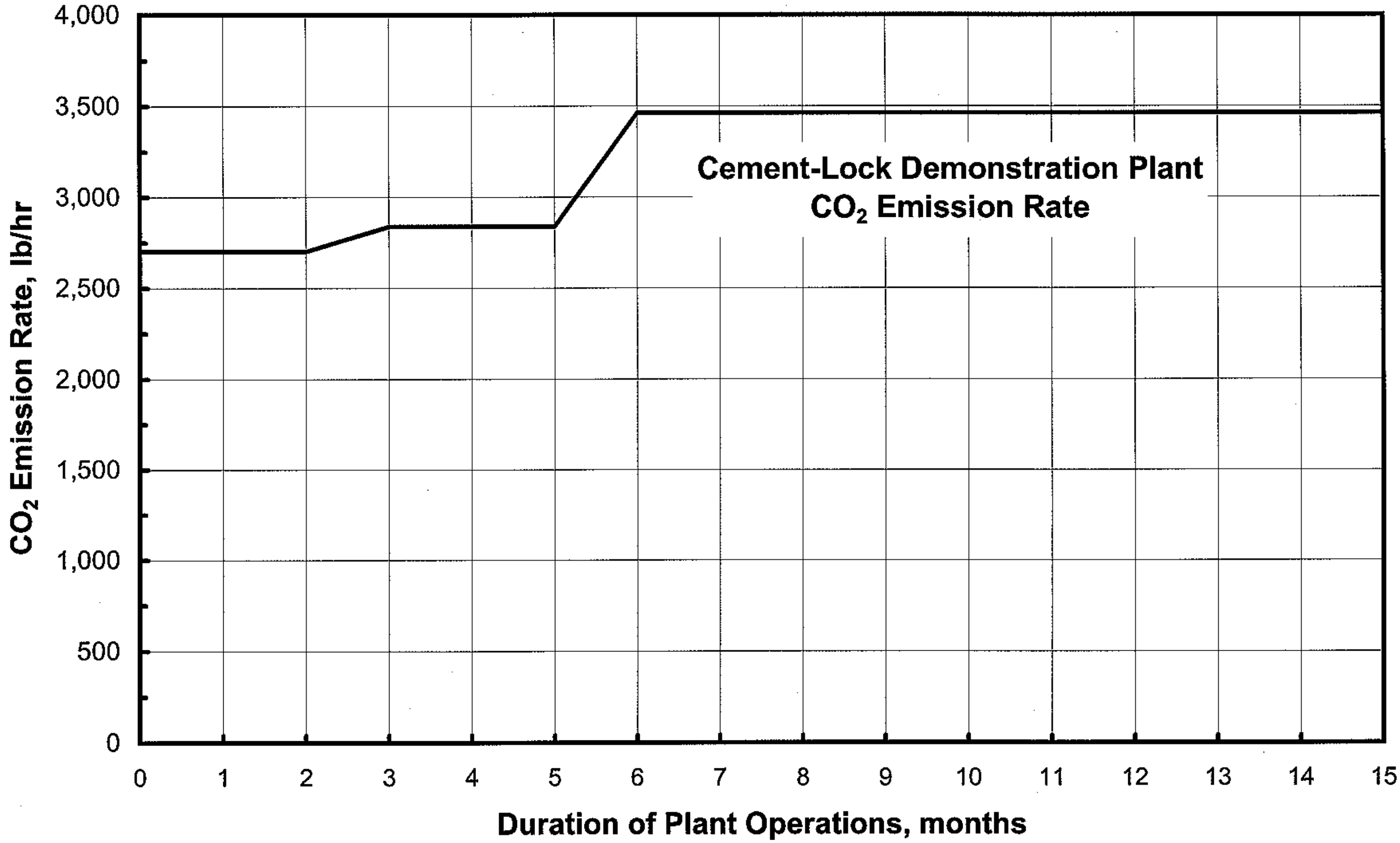

Cement-Lock Demonstration Plant
CO Concentration in Absorber Exhaust
CO Concentration, ppm
400
300
200
100
0
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Duration of Plant Operations, months

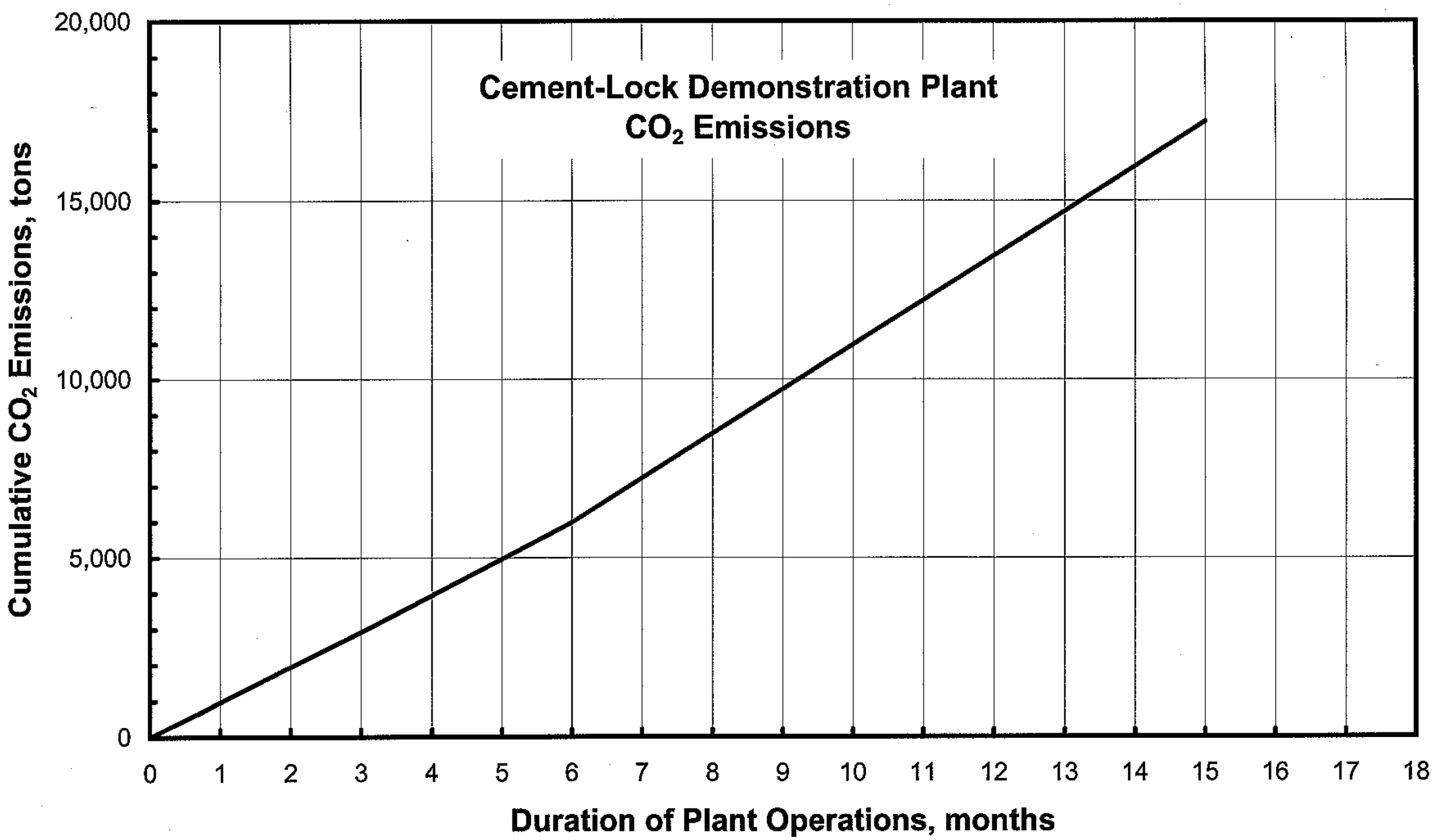

Cement-Lock Demonstration Plant
CO Emission Rate
CO Emission Rate, lb/hr
0
1
2
3
4
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Duration of Plant Operations, months

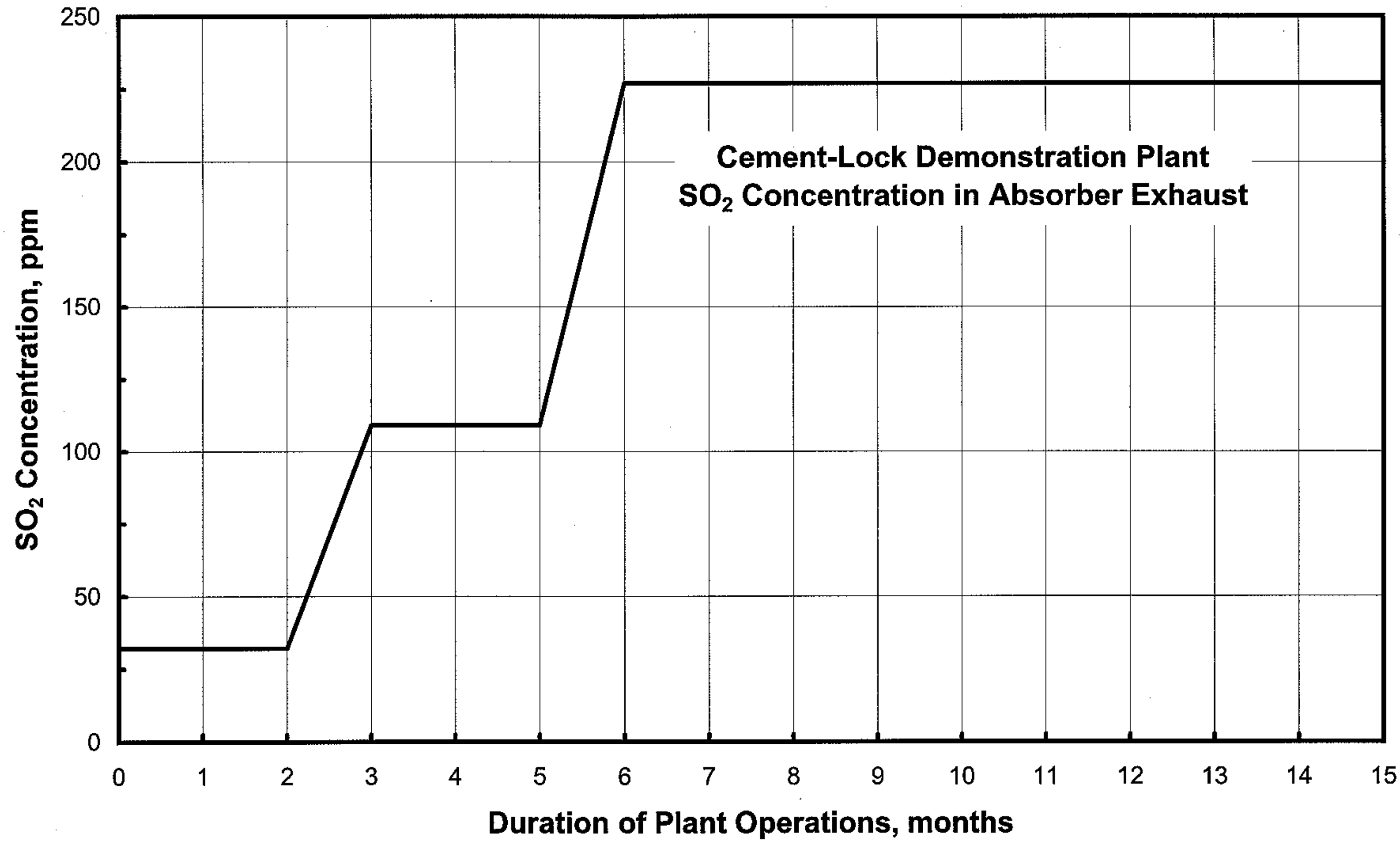

Cement-Lock Demonstration Plant
CO Emissions
Cumulative CO Emissions, lb
30,000
25,000
20,000
15,000
10,000
5,000
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Duration of Plant Operations, months


Cement-Lock Demonstration Plant
CO Emissions
Cumulative CO Emissions, tons
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Duration of Plant Operations, months
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18

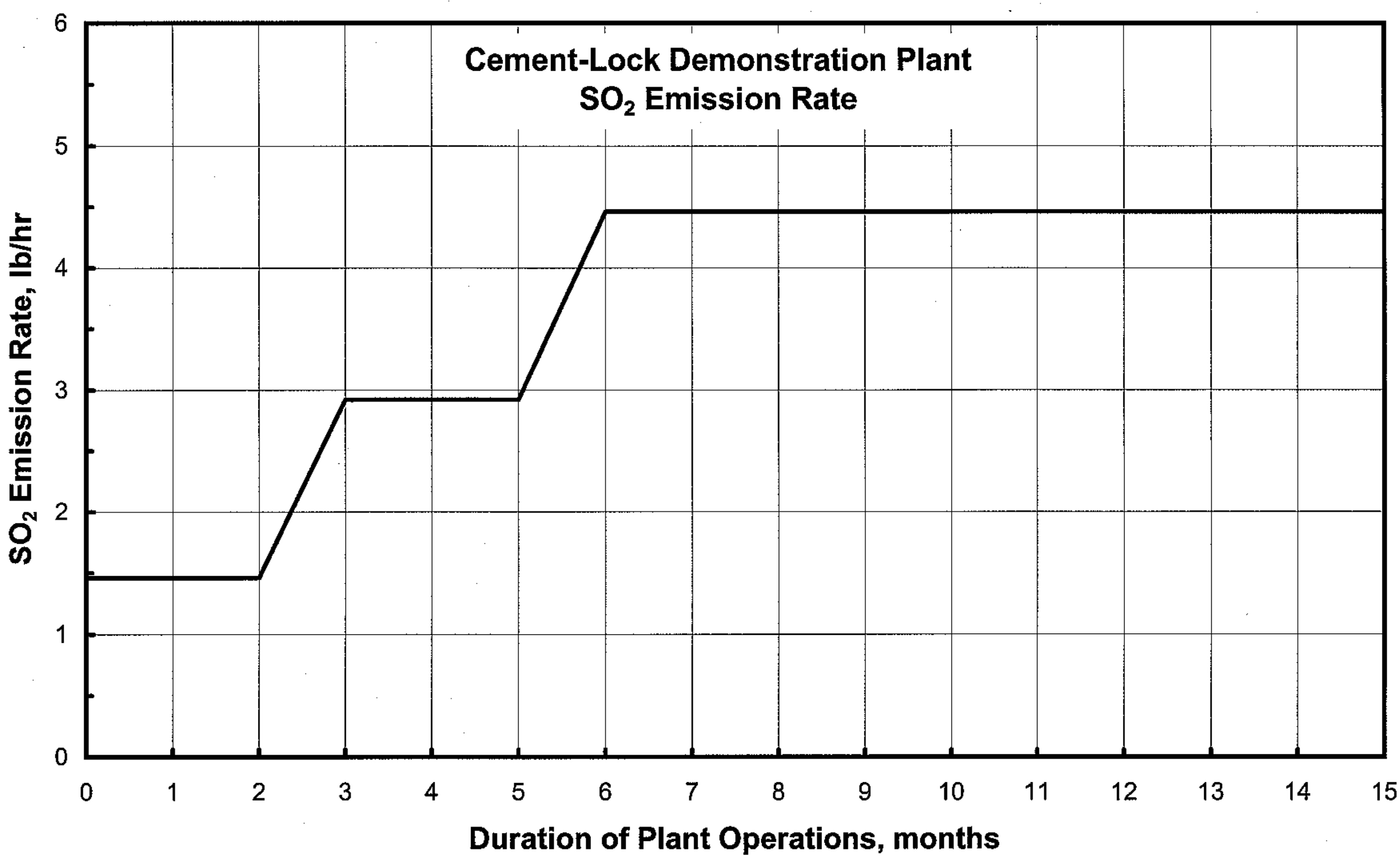

Cement-Lock Demonstration Plant
CO2 Concentration in Absorber Exhaust
CO2 Concentration, mol %
Duration of Plant Operations, months
0
5
10
15
20
25
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15


Cement-Lock Demonstration Plant
CO2 Emission Rate
CO2 Emission Rate, lb/hr
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Duration of Plant Operations, months

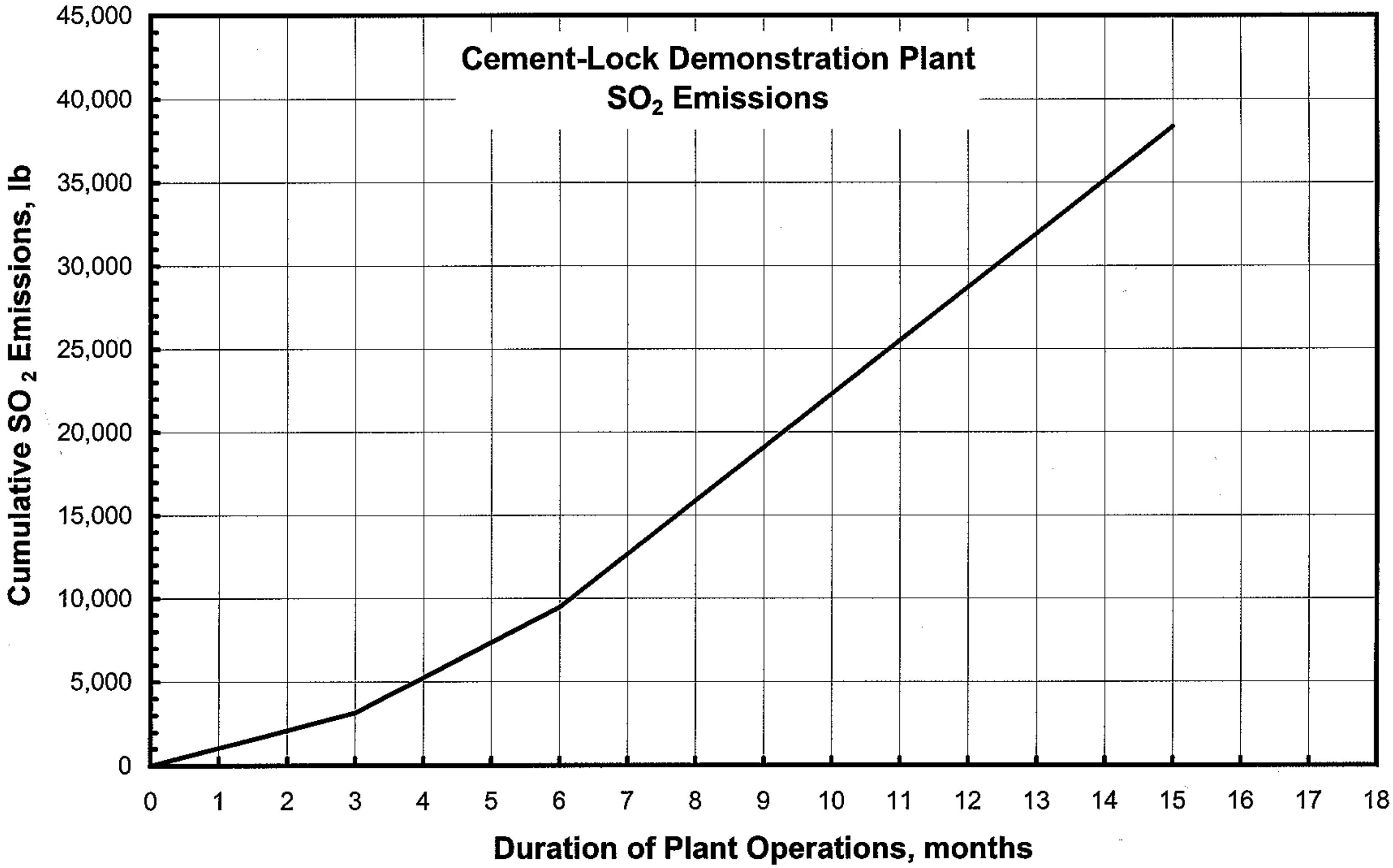

Cement-Lock Demonstration Plant
CO2 Emissions
Cumulative CO2 Emissions, tons
20,000
15,000
10,000
5,000
0
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
Duration of Plant Operations, months

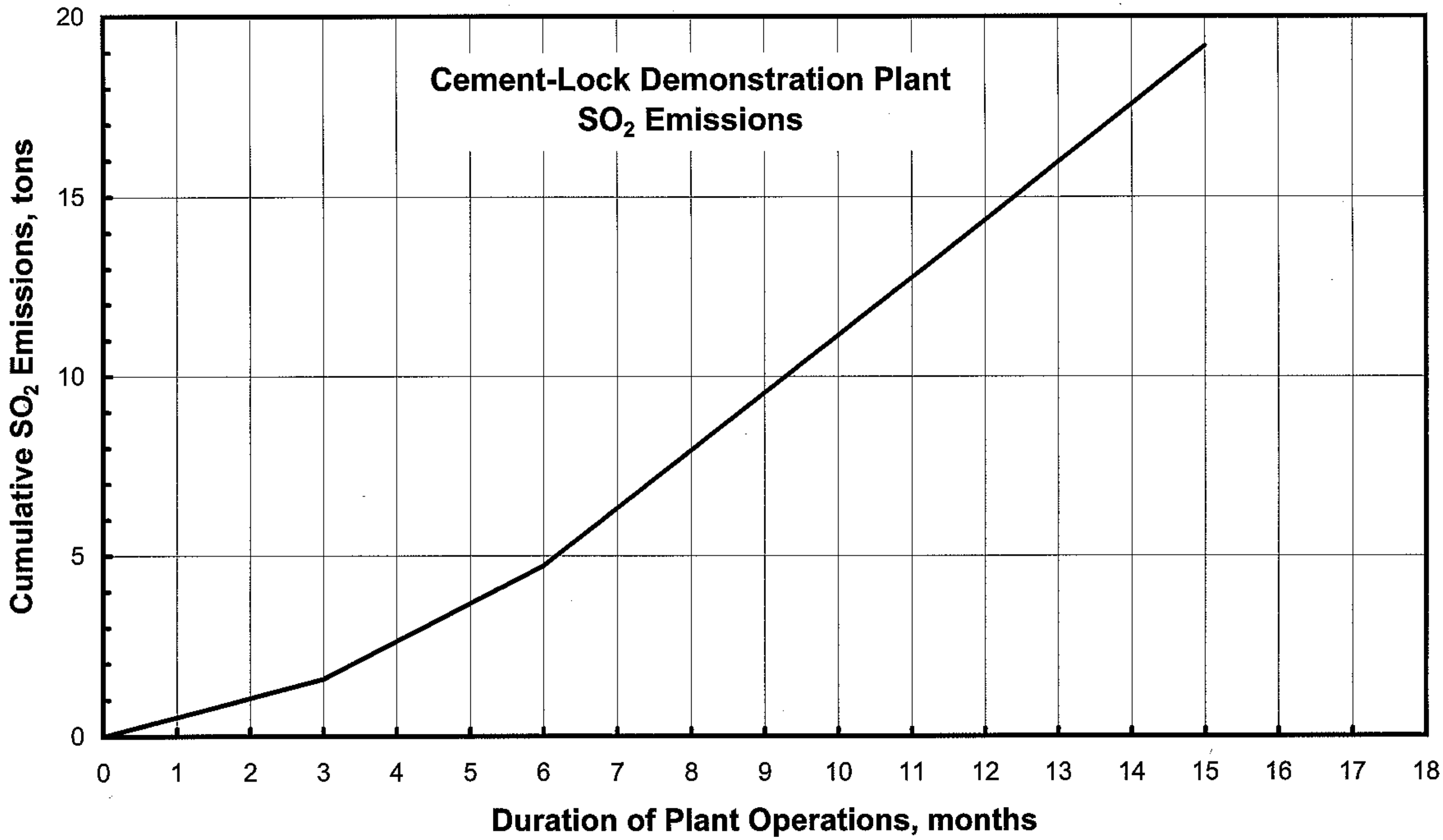


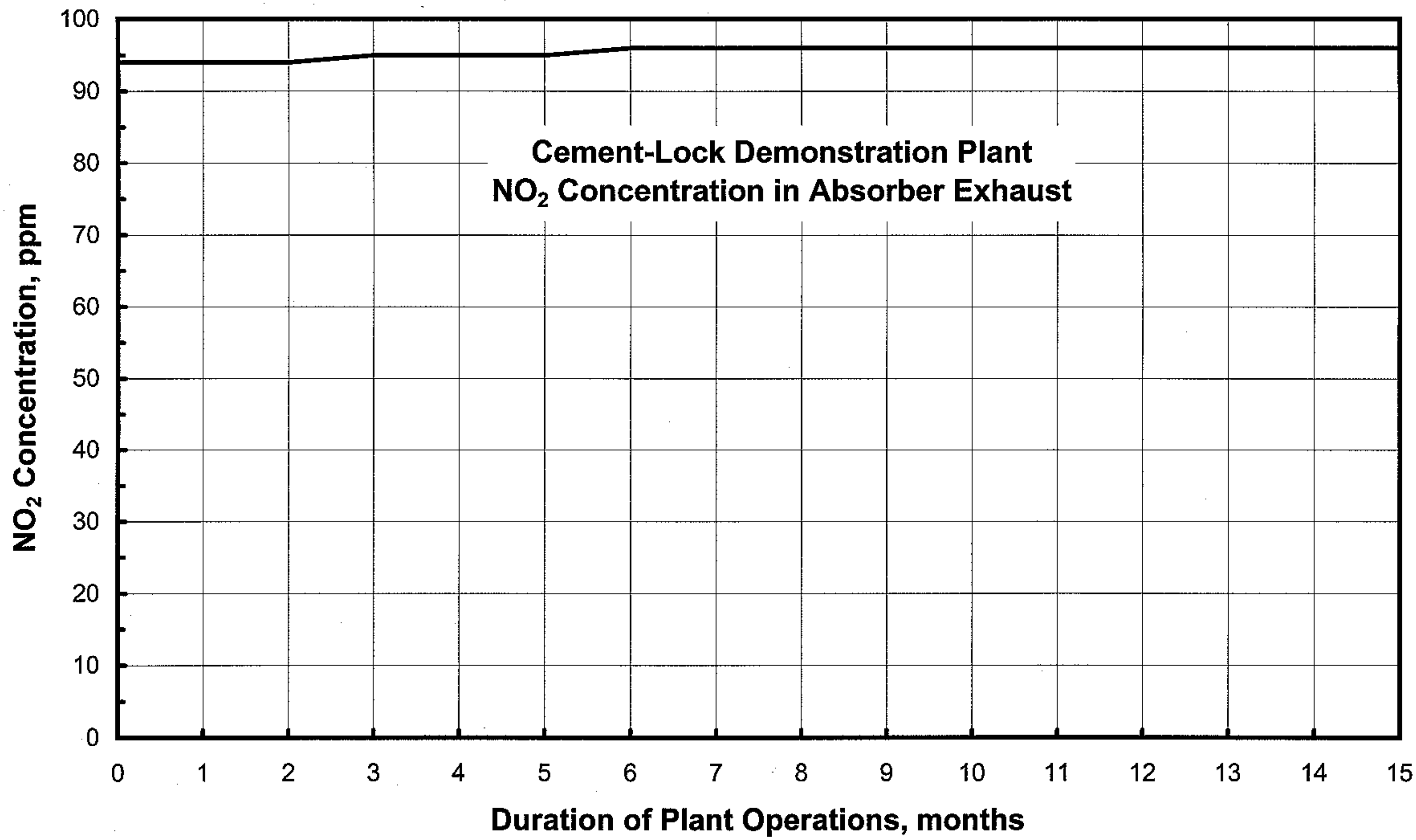
Cement-Lock Demonstration Plant
$SO_2$ Concentration in Absorber Exhaust
$SO_2$ Concentration, ppm
250
200
150
100
50
0
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Duration of Plant Operations, months

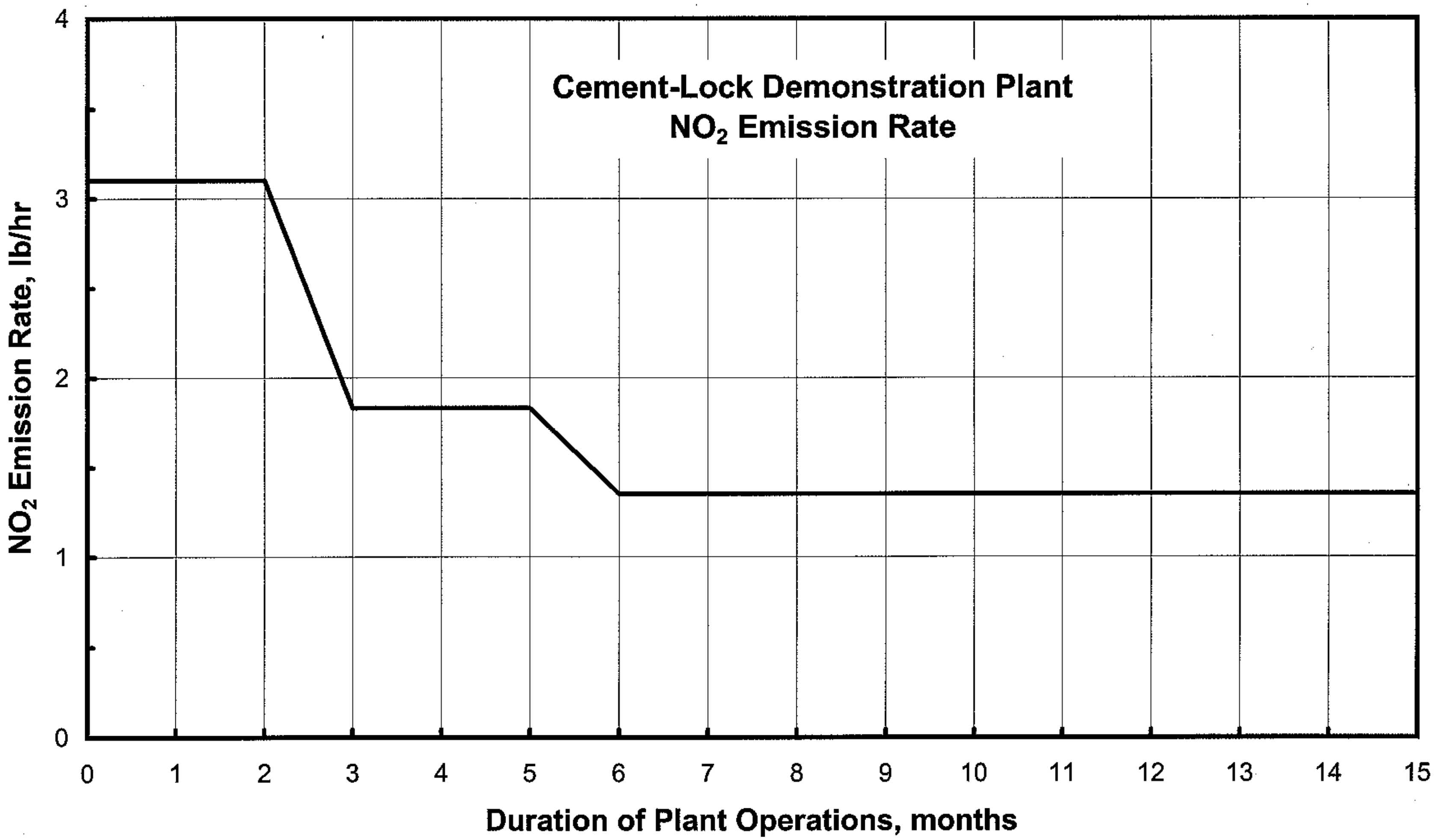


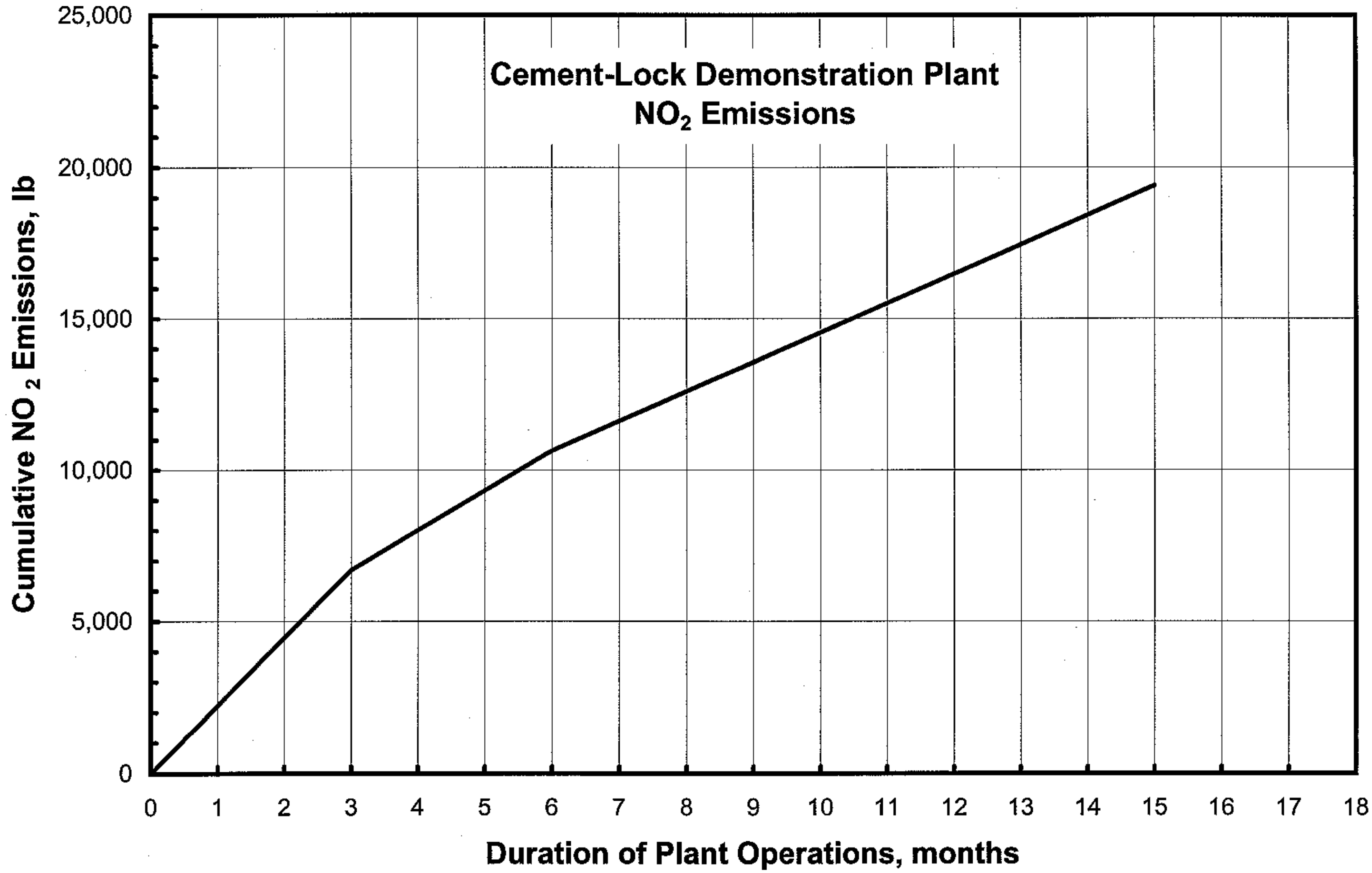
Cement-Lock Demonstration Plant
SO2 Emission Rate
SO2 Emission Rate, lb/hr
0
1
2
3
4
5
6
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Duration of Plant Operations, months

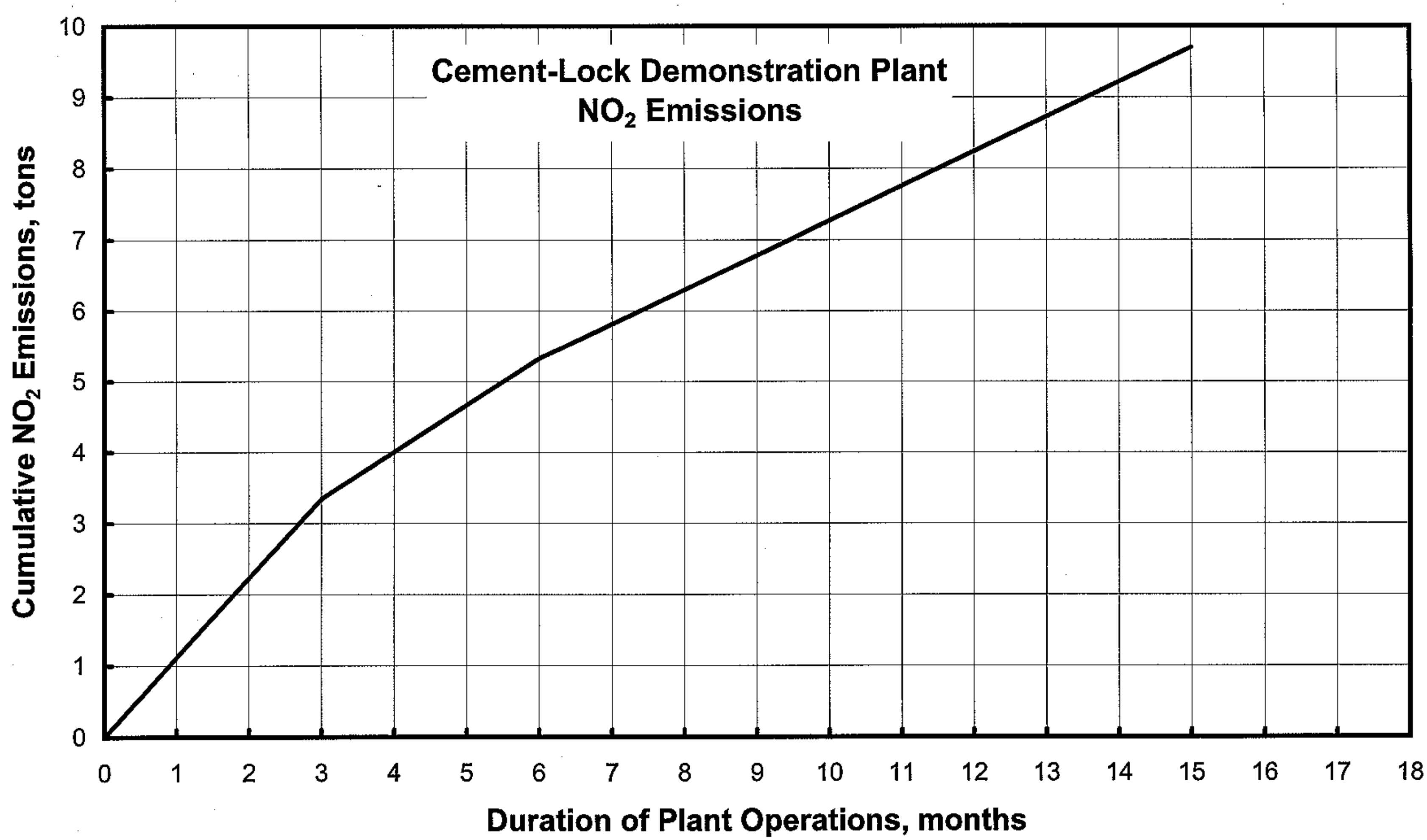

Cement-Lock Demonstration Plant
$SO_2$ Emissions
Cumulative $SO_2$ Emissions, lb
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Duration of Plant Operations, months

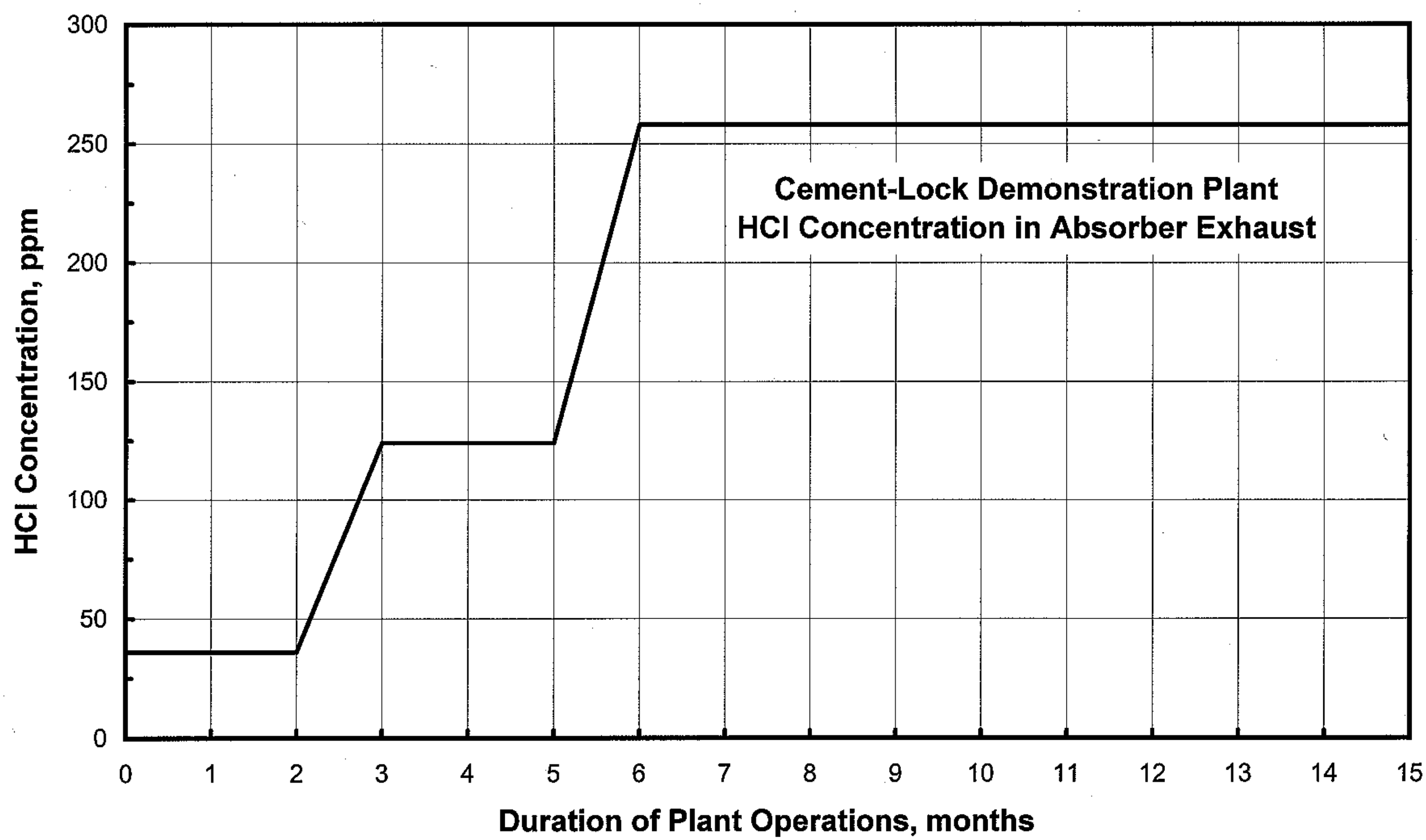

Cement-Lock Demonstration Plant
$SO_2$ Emissions
Cumulative $SO_2$ Emissions, tons
0
5
10
15
20
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
Duration of Plant Operations, months

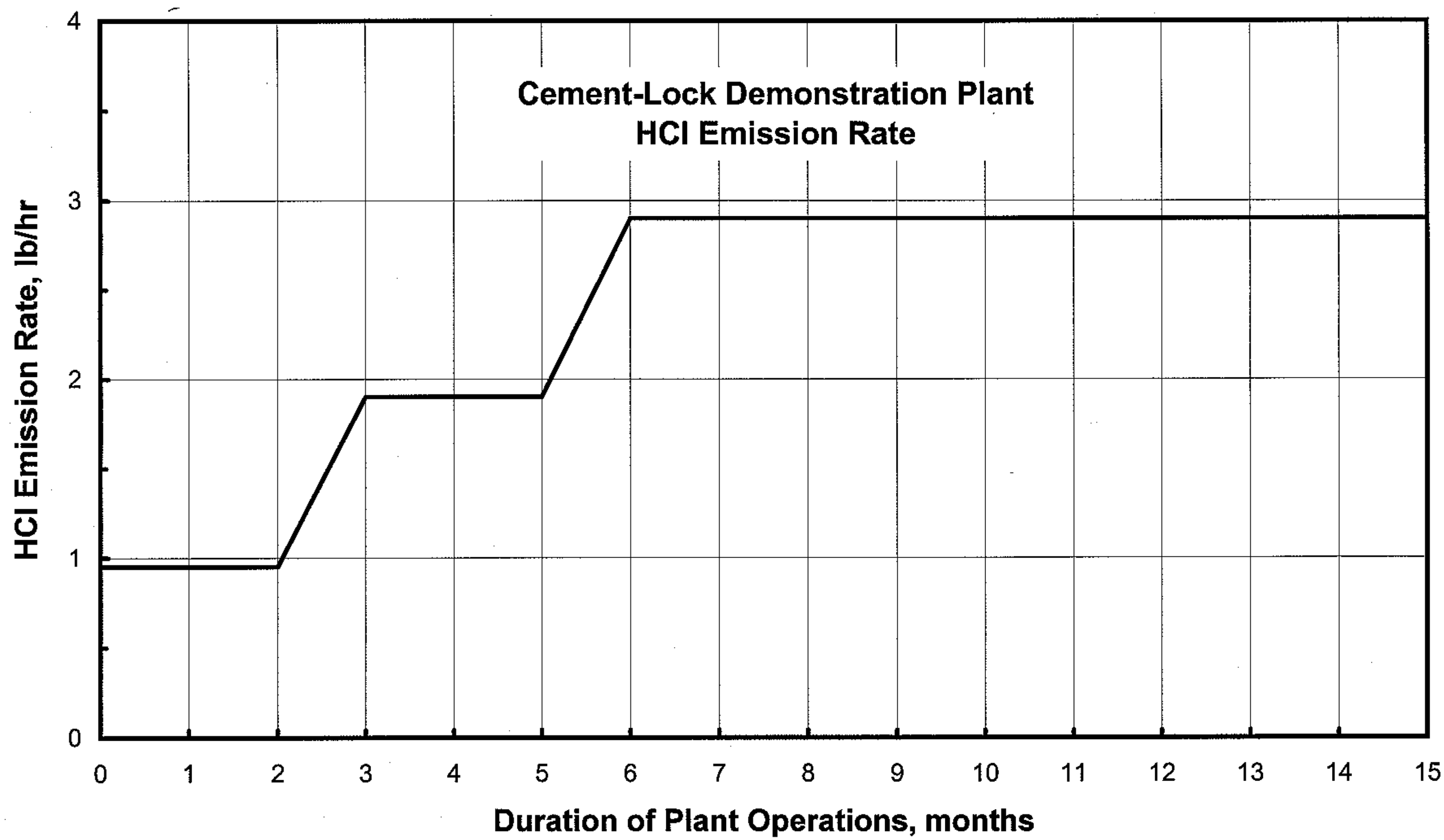

Cement-Lock Demonstration Plant
NO2 Concentration in Absorber Exhaust
NO2 Concentration, ppm
100
90
80
70
60
50
40
30
20
10
0
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Duration of Plant Operations, months


Cement-Lock Demonstration Plant
NO2 Emission Rate
NO2 Emission Rate, lb/hr
Duration of Plant Operations, months
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

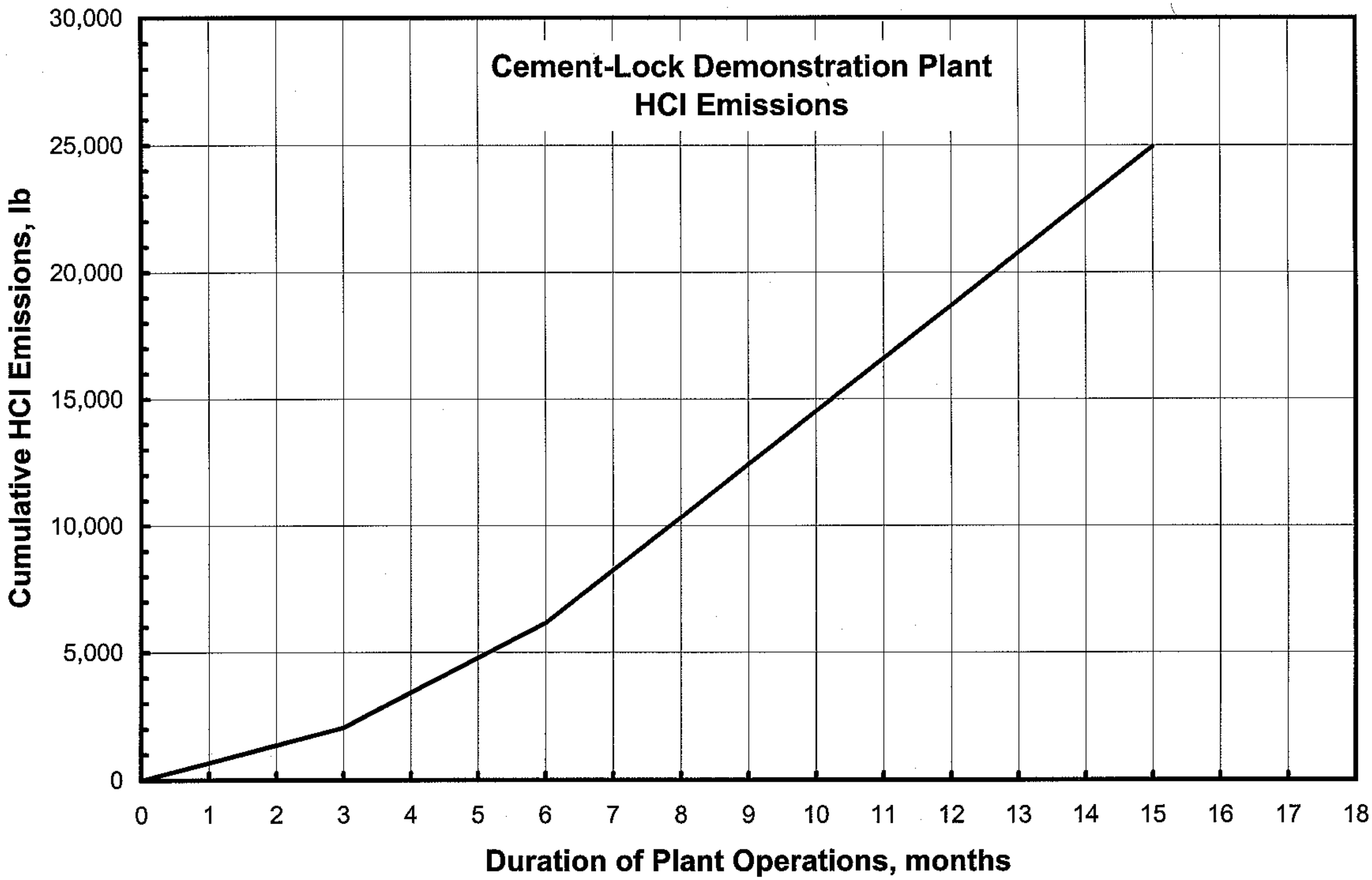

Cement-Lock Demonstration Plant
NO2 Emissions
Cumulative NO 2 Emissions, lb
25,000
20,000
15,000
10,000
5,000
0
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
Duration of Plant Operations, months

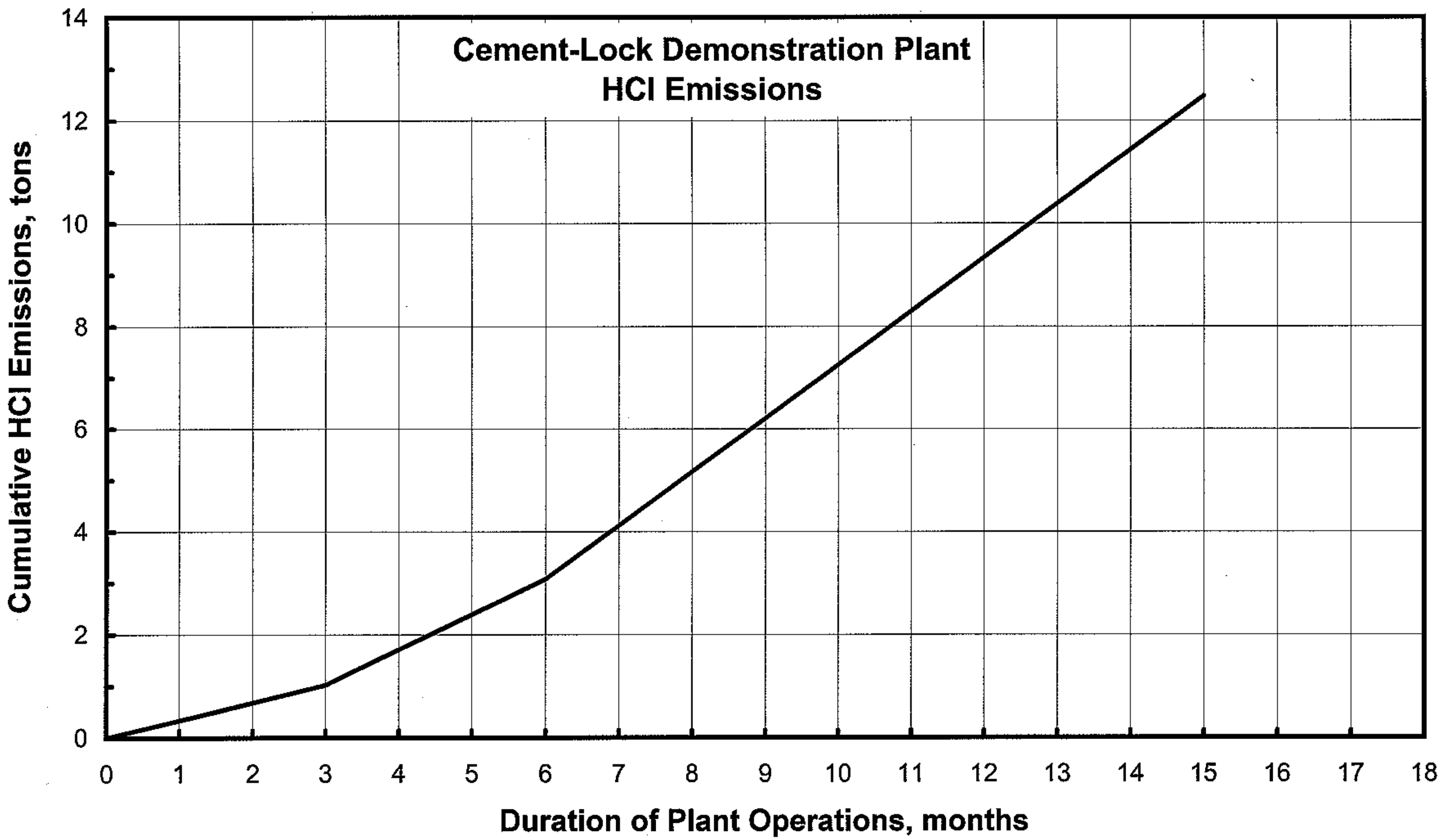

Cement-Lock Demonstration Plant
NO2 Emissions
Cumulative NO2 Emissions, tons
0
1
2
3
4
5
6
7
8
9
10
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Duration of Plant Operations, months

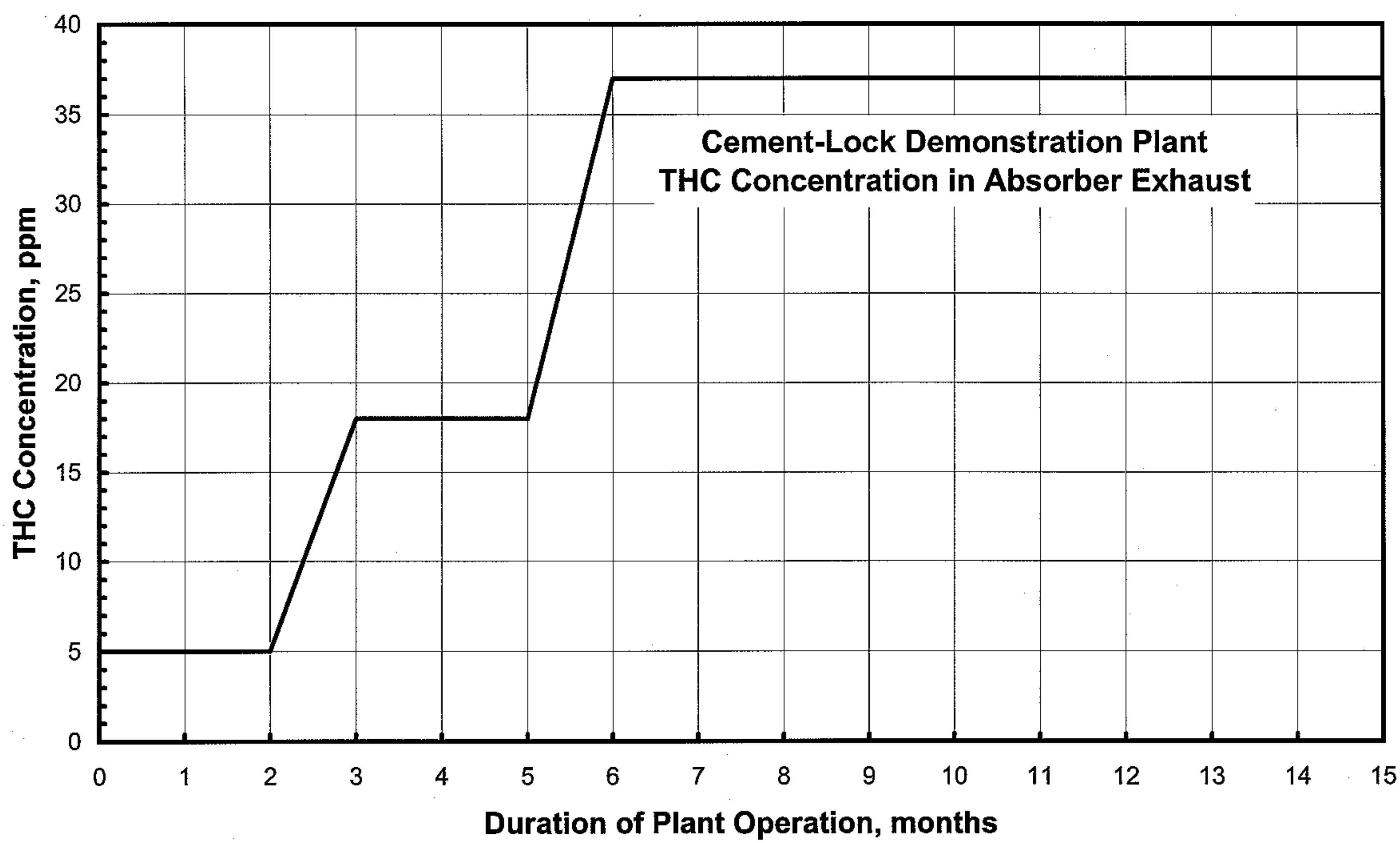

Cement-Lock Demonstration Plant
HCl Concentration in Absorber Exhaust
HCl Concentration, ppm
300
250
200
150
100
50
0
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Duration of Plant Operations, months

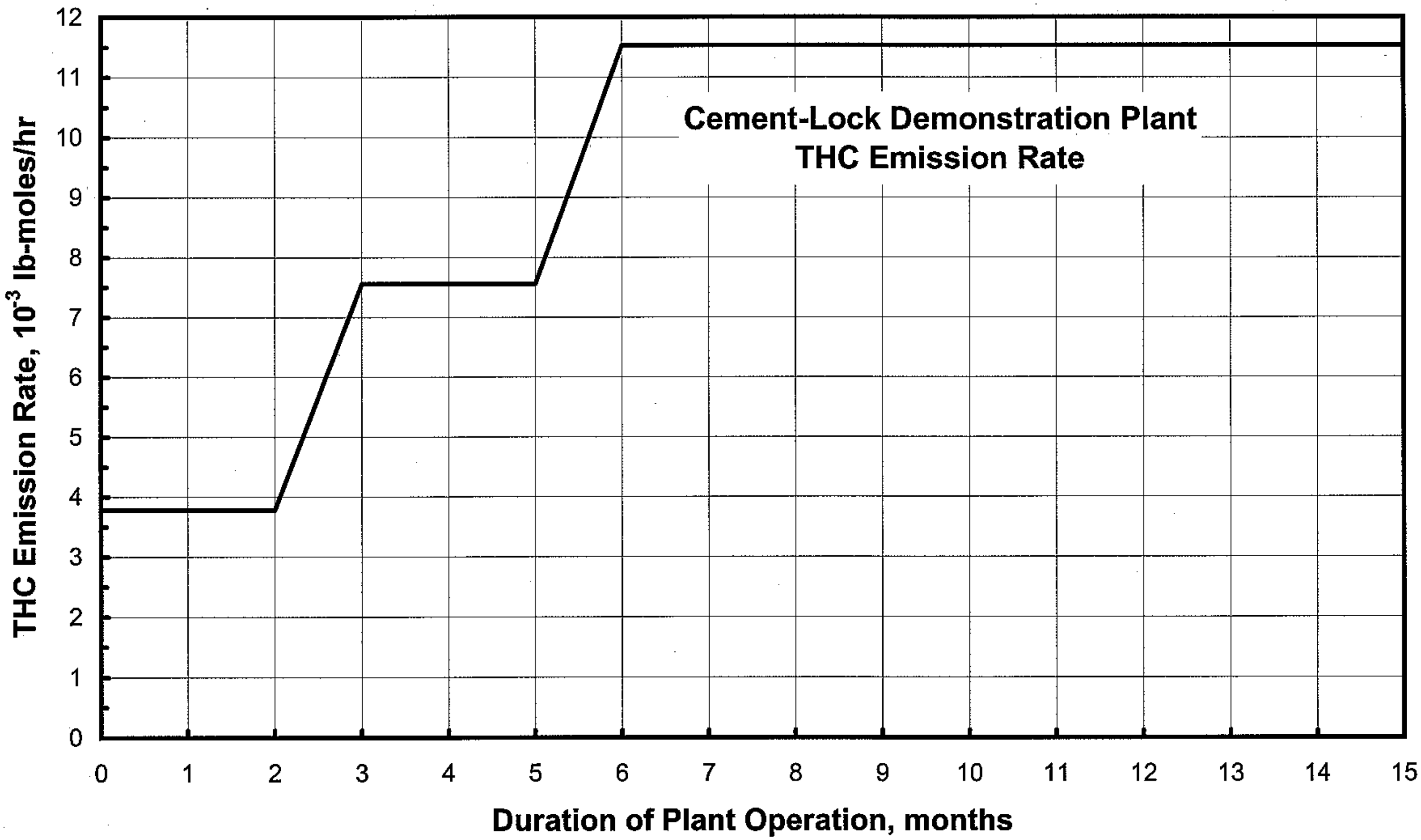


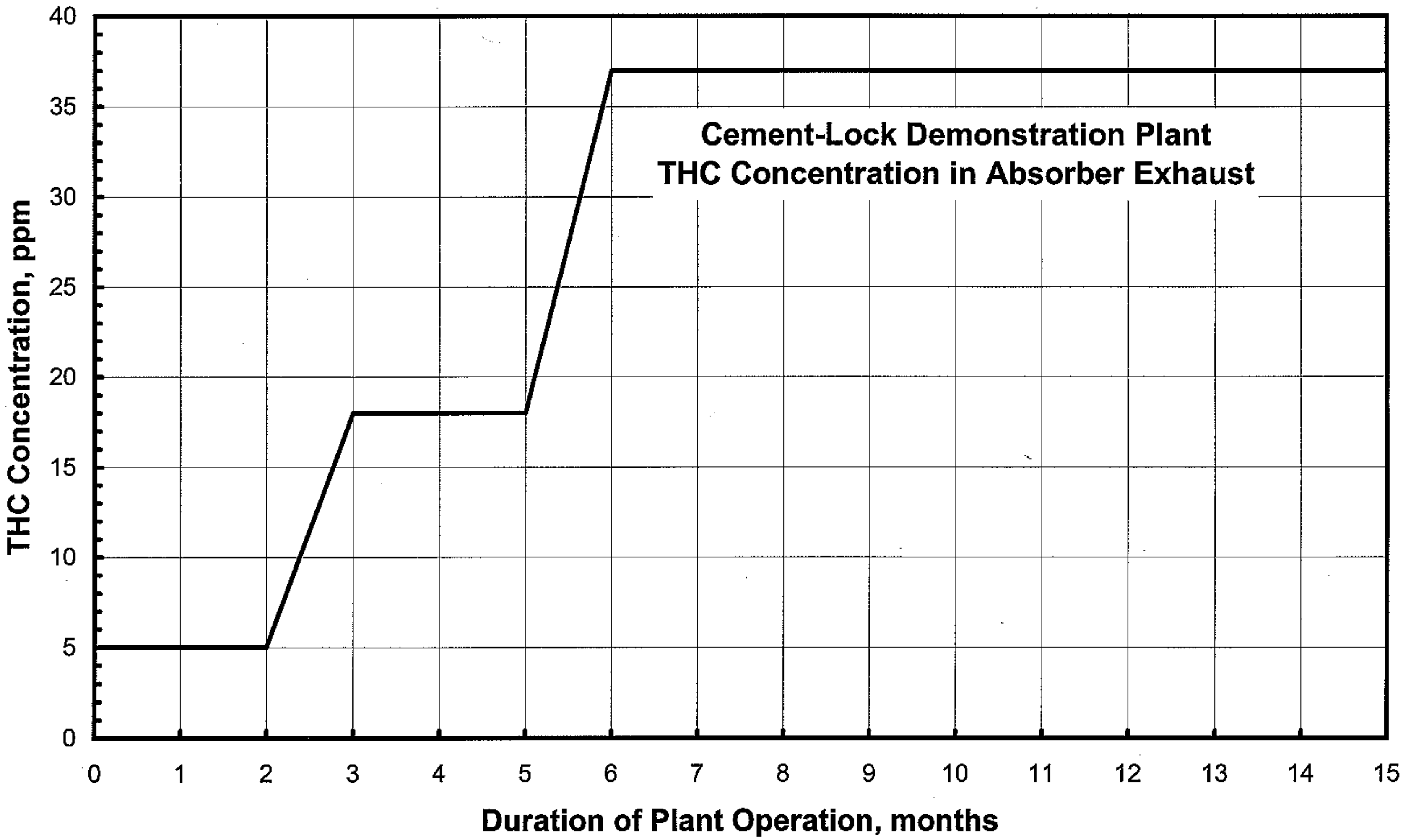
Cement-Lock Demonstration Plant
HCl Emission Rate
HCl Emission Rate, lb/hr
0
1
2
3
4
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Duration of Plant Operations, months

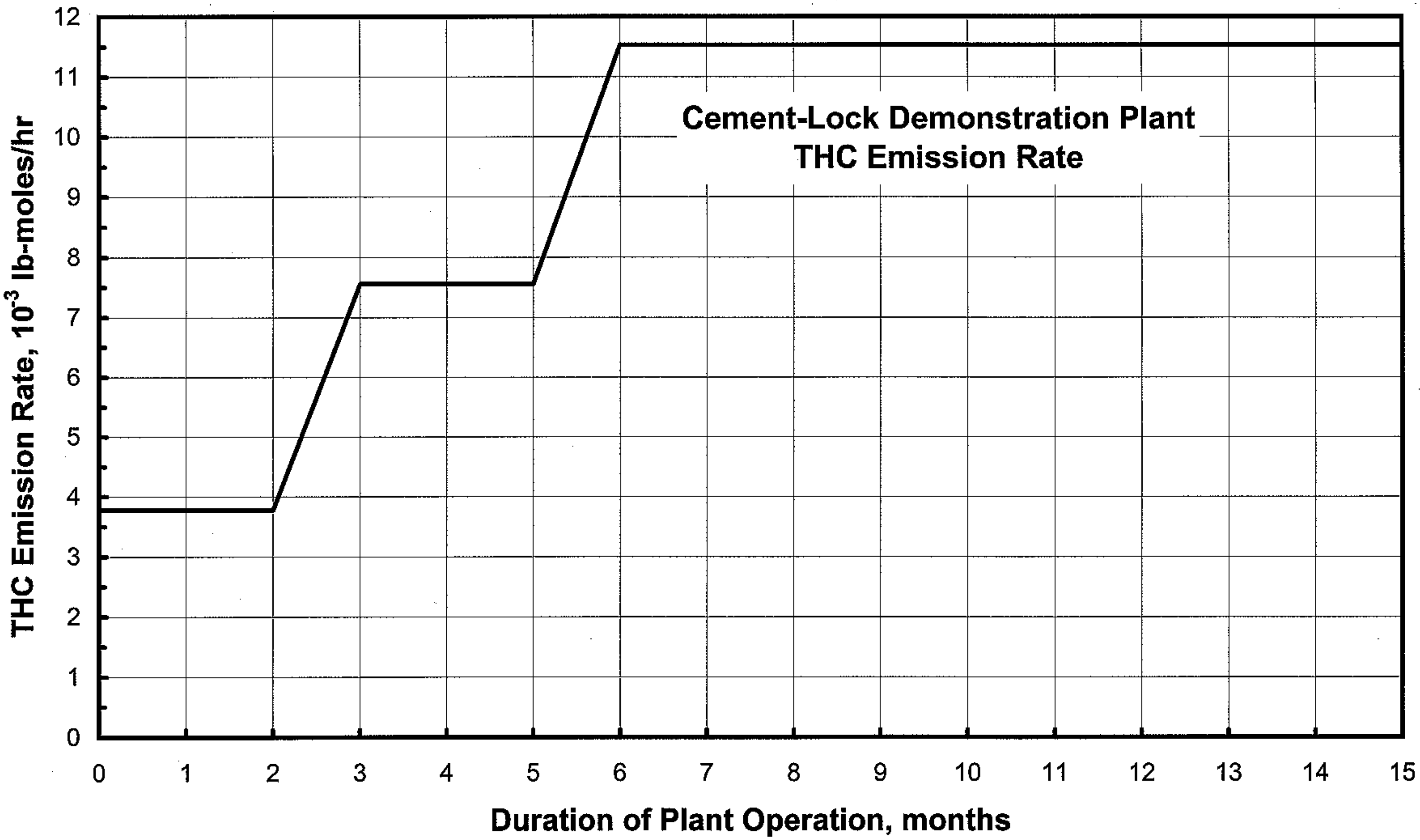

Cement-Lock Demonstration Plant
HCl Emissions
Cumulative HCl Emissions, lb
30,000
25,000
20,000
15,000
10,000
5,000
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Duration of Plant Operations, months

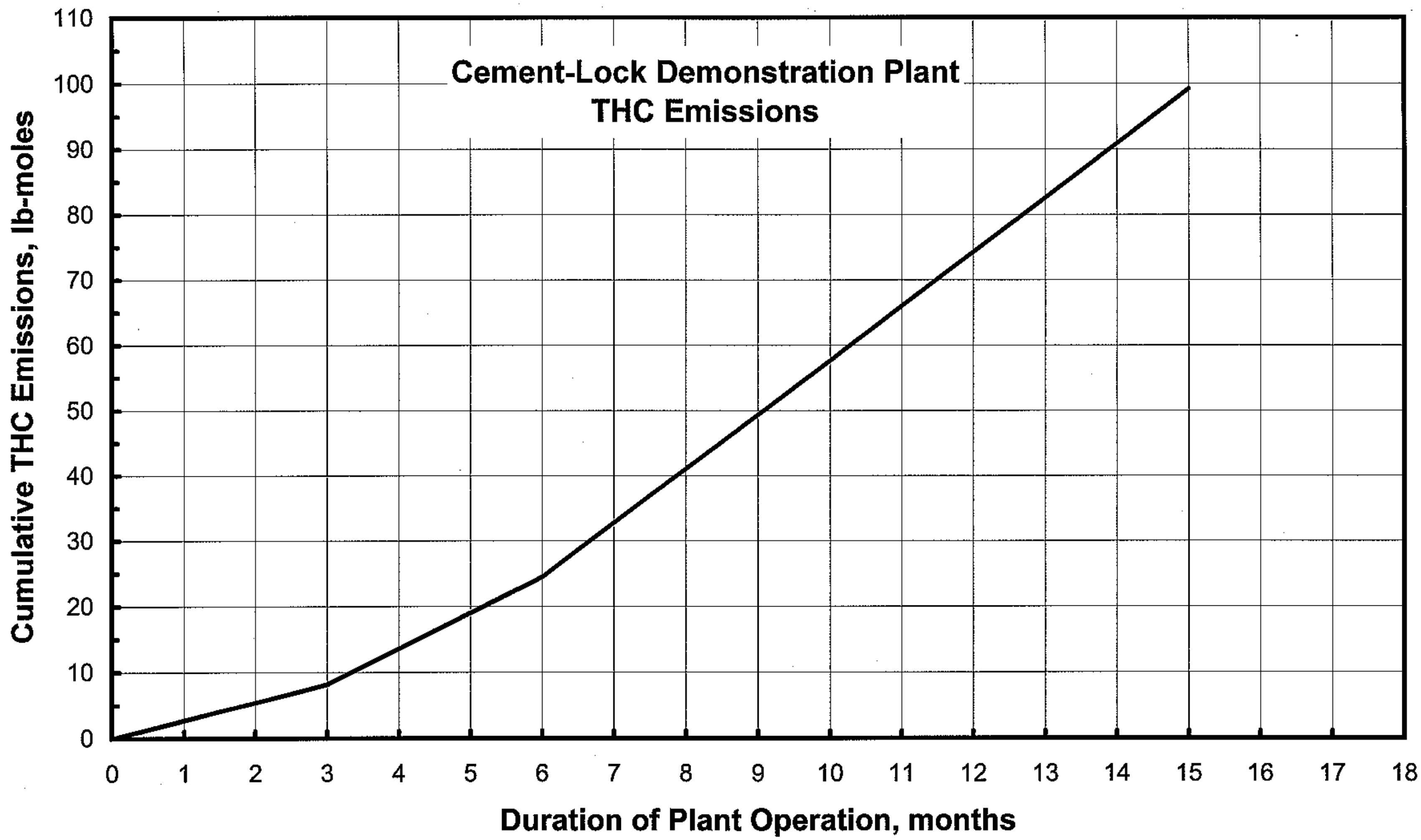

Cement-Lock Demonstration Plant
HCl Emissions
Cumulative HCl Emissions, tons
0
2
4
6
8
10
12
14
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
Duration of Plant Operations, months


Cement-Lock Demonstration Plant
THC Concentration in Absorber Exhaust
THC Concentration, ppm
40
35
30
25
20
15
10
5
0
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Duration of Plant Operation, months

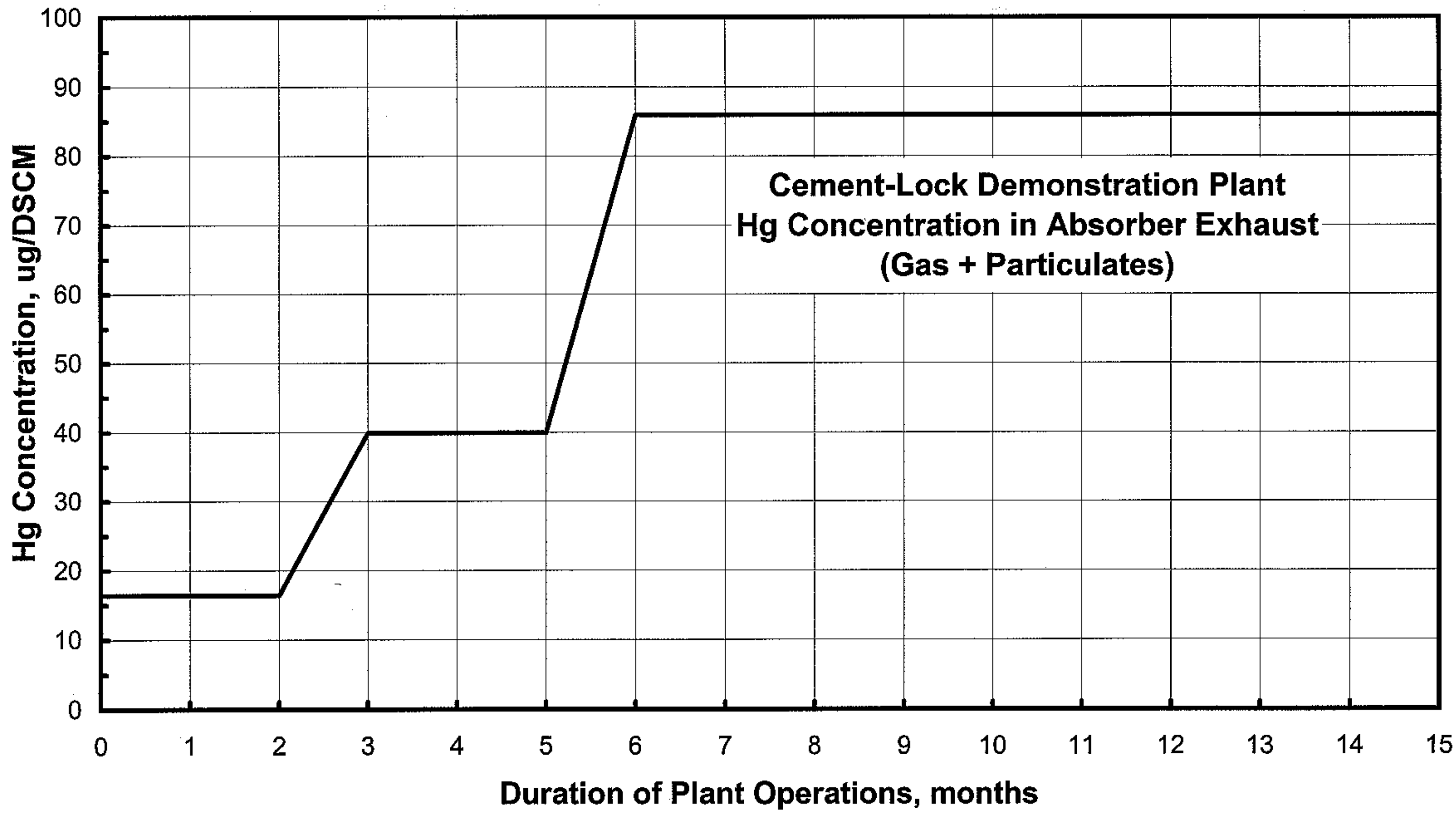

Cement-Lock Demonstration Plant
THC Emission Rate
THC Emission Rate, 10-3 lb-moles/hr
0
1
2
3
4
5
6
7
8
9
10
11
12
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Duration of Plant Operation, months

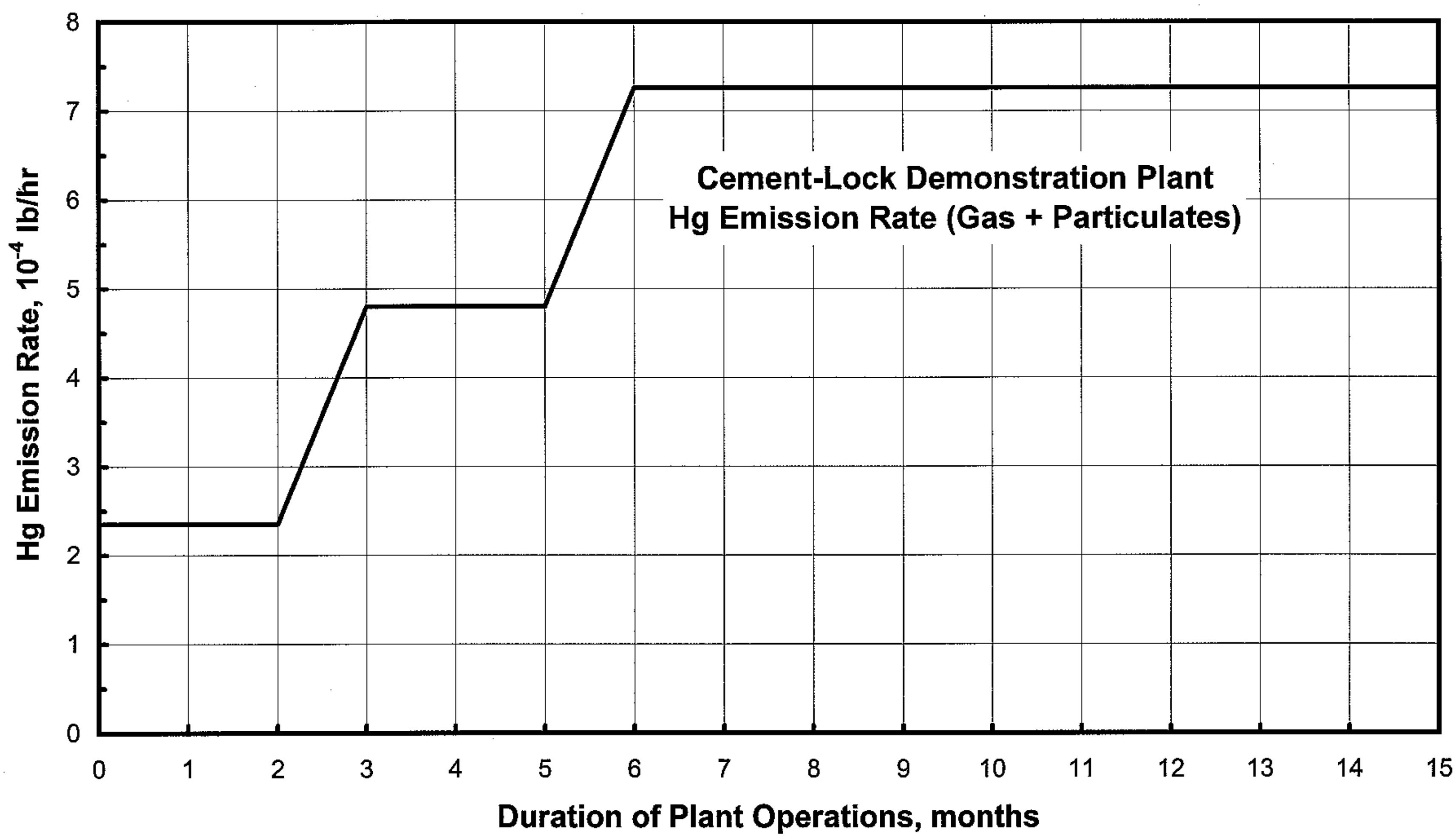

Cement-Lock Demonstration Plant
THC Concentration in Absorber Exhaust
THC Concentration, ppm
0
5
10
15
20
25
30
35
40
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Duration of Plant Operation, months

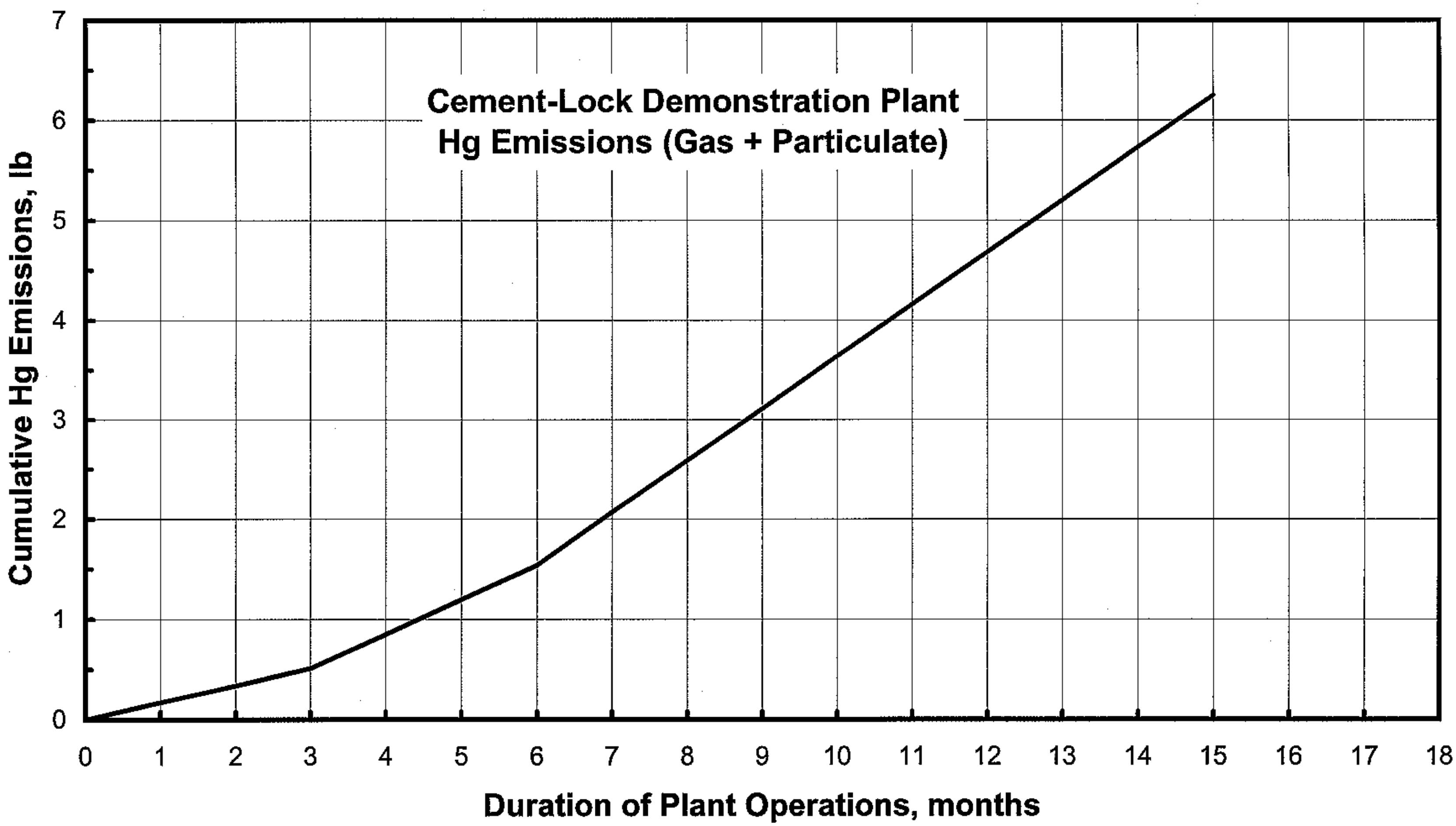

Cement-Lock Demonstration Plant
THC Emission Rate
THC Emission Rate, 10-3 lb-moles/hr
12
11
10
9
8
7
6
5
4
3
2
1
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Duration of Plant Operation, months



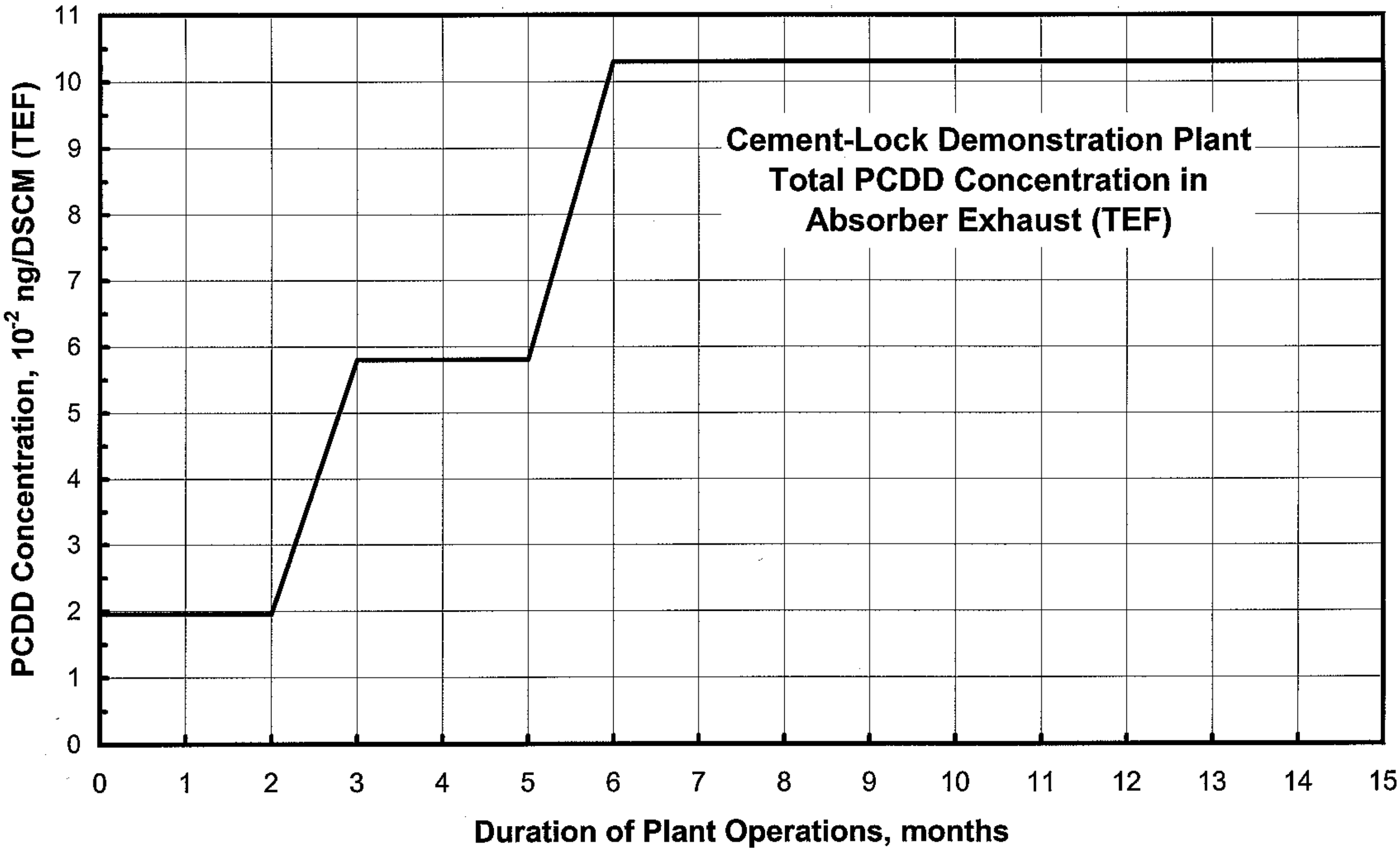
Cement-Lock Demonstration Plant
THC Emissions
Cumulative THC Emissions, lb-moles
110
100
90
80
70
60
50
40
30
20
10
0
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
Duration of Plant Operation, months

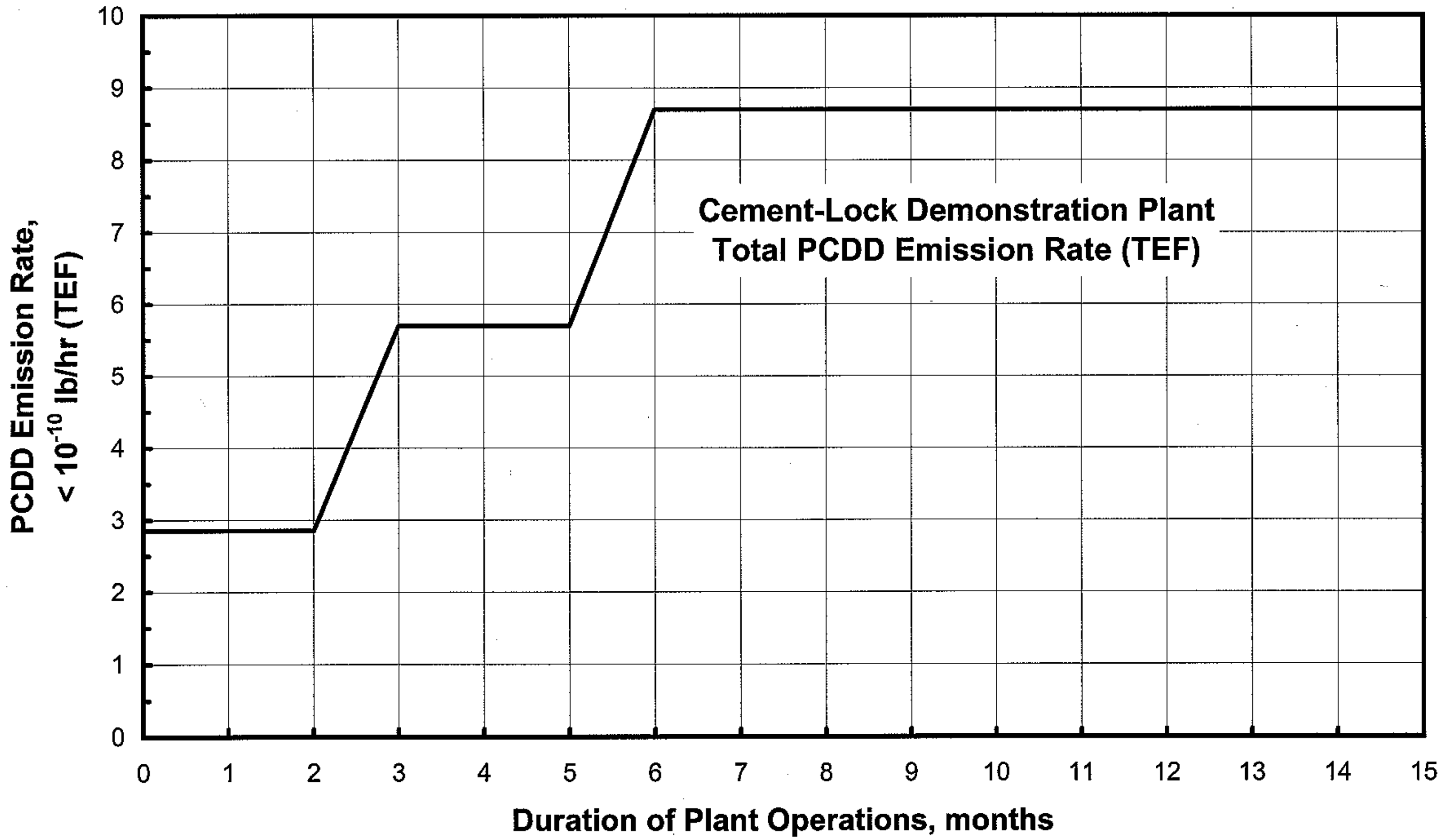

Cement-Lock Demonstration Plant
Hg Concentration in Absorber Exhaust
(Gas + Particulates)
Hg Concentration, ug/DSCM
Duration of Plant Operations, months
0
10
20
30
40
50
60
70
80
90
100
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

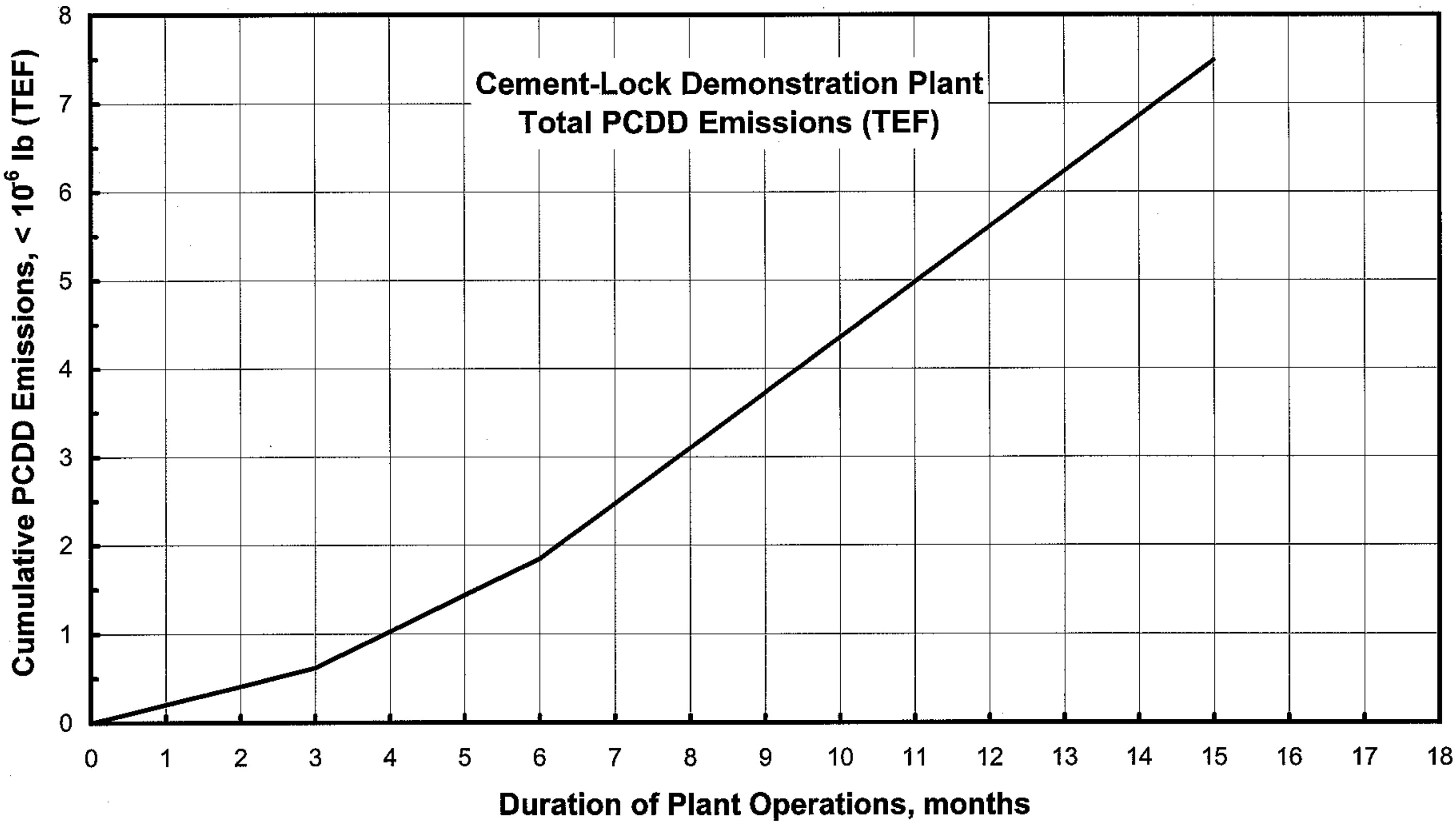

Cement-Lock Demonstration Plant
Hg Emission Rate (Gas + Particulates)
Hg Emission Rate, 10-4 lb/hr
Duration of Plant Operations, months
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

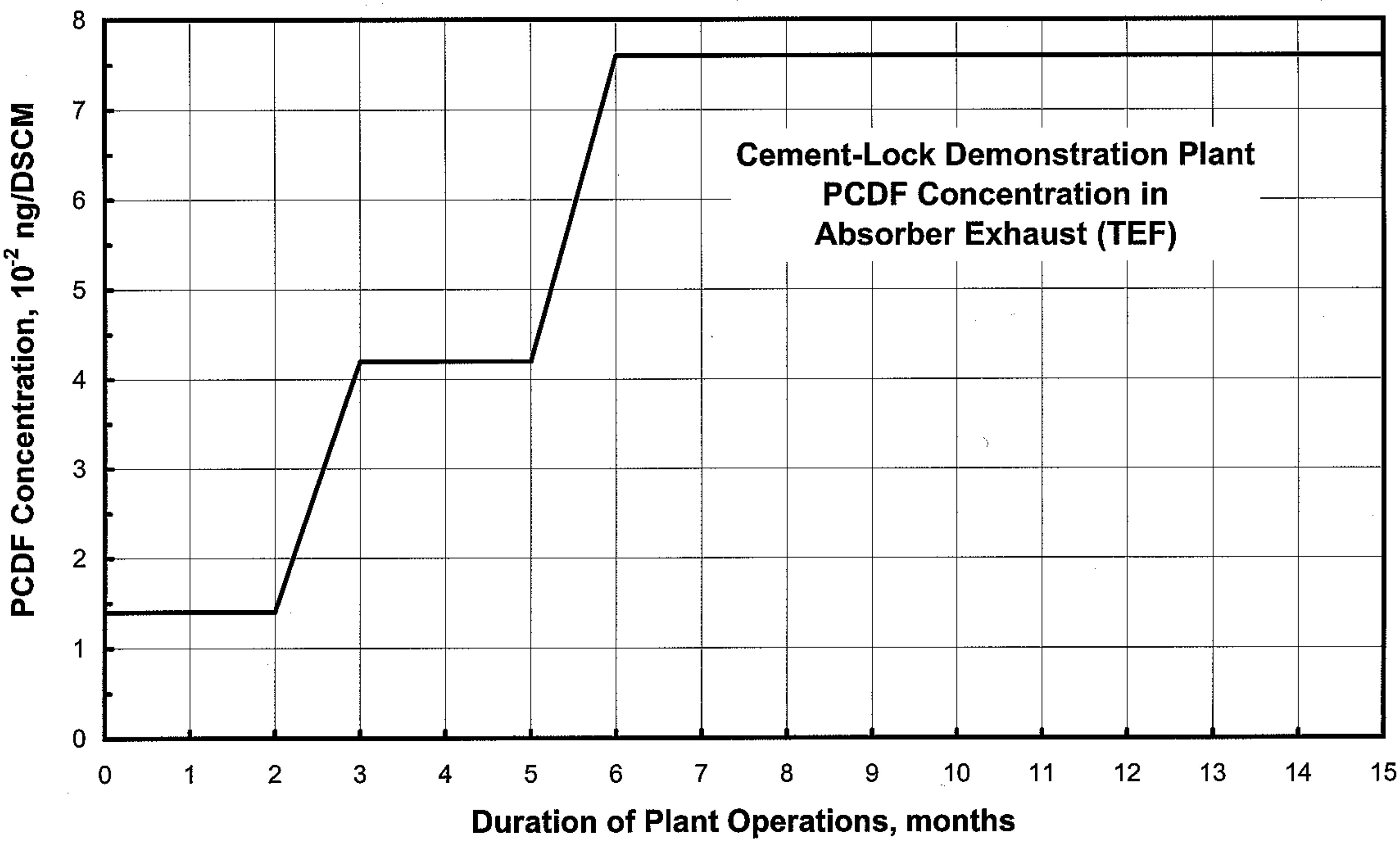


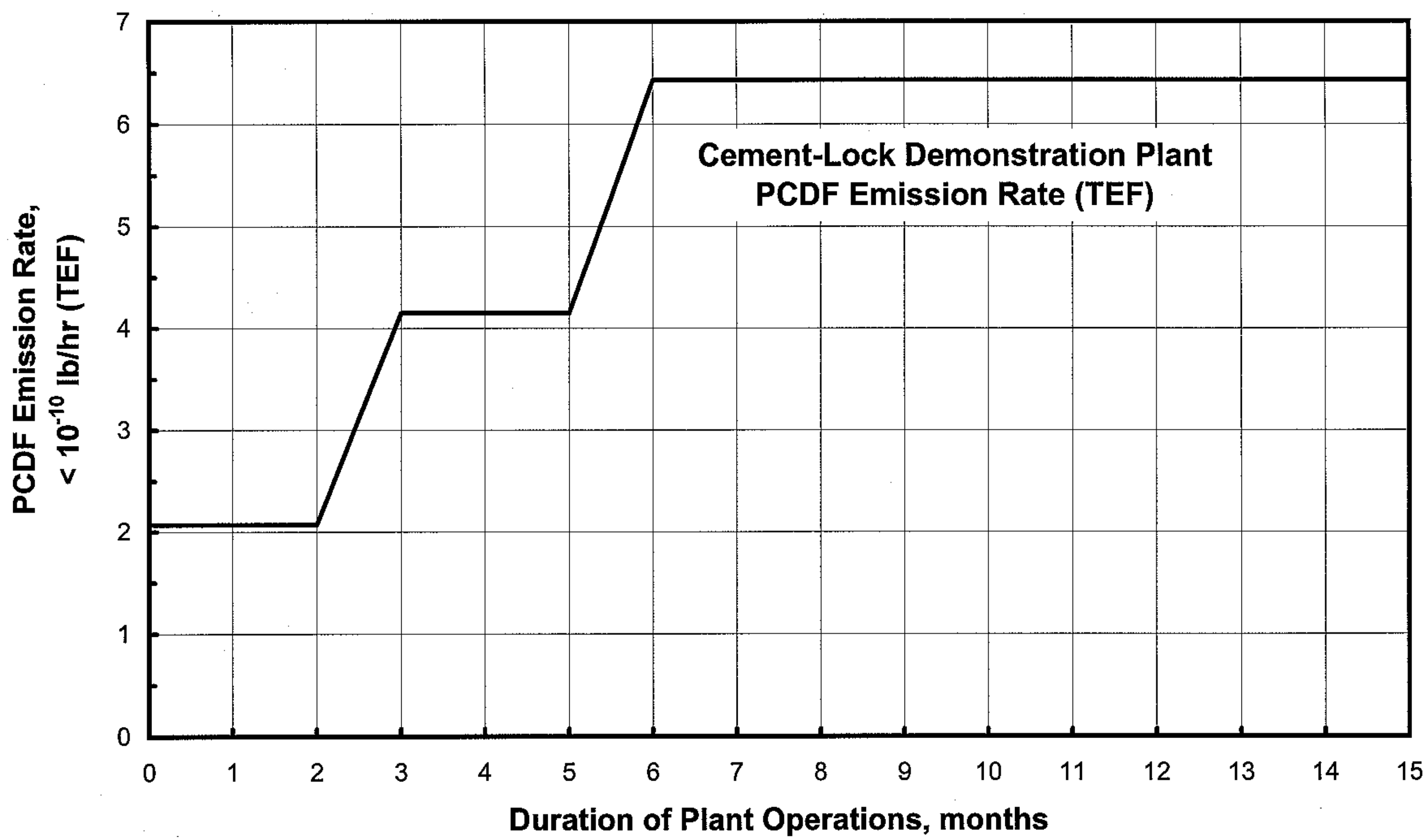
Cement-Lock Demonstration Plant
Hg Emissions (Gas + Particulate)
Cumulative Hg Emissions, lb
0
1
2
3
4
5
6
7
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
Duration of Plant Operations, months


Cement-Lock Demonstration Plant
Total PCDD Concentration in
Absorber Exhaust (TEF)
PCDD Concentration, 10-2 ng/DSCM (TEF)
0
1
2
3
4
5
6
7
8
9
10
11
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Duration of Plant Operations, months

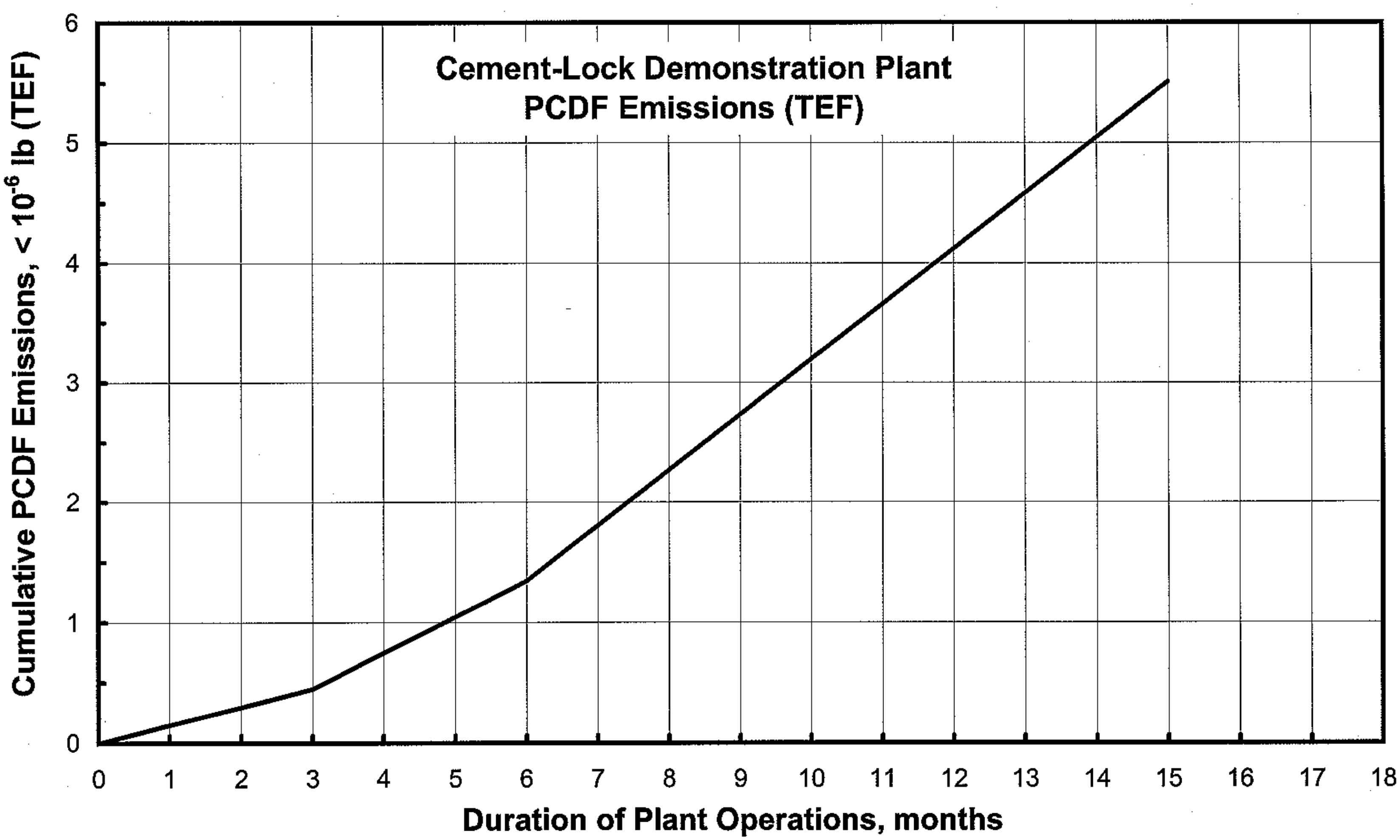

Cement-Lock Demonstration Plant
Total PCDD Emission Rate (TEF)
PCDD Emission Rate,
< $10^{-10}$ lb/hr (TEF)
Duration of Plant Operations, months
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

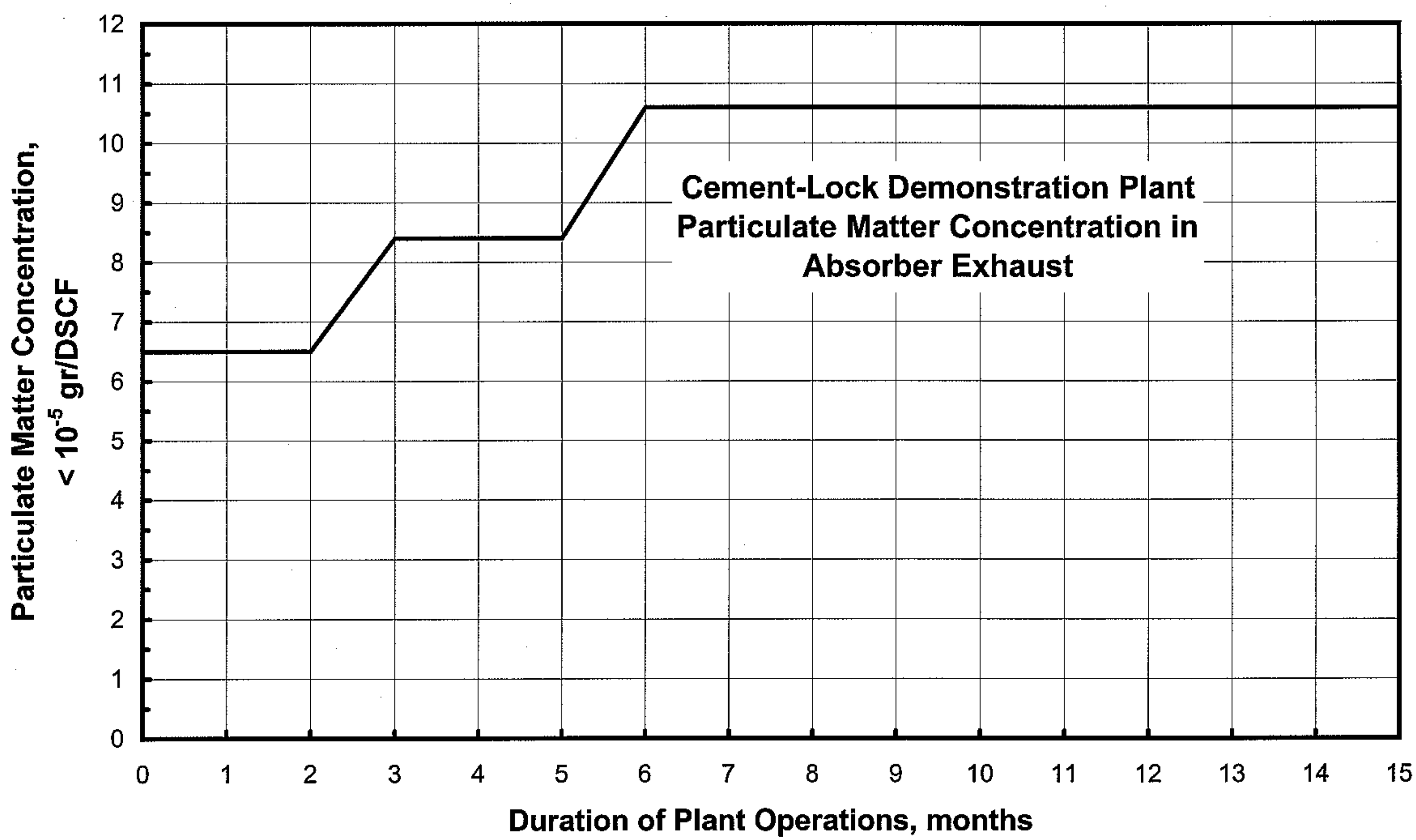

Cement-Lock Demonstration Plant
Total PCDD Emissions (TEF)
Cumulative PCDD Emissions, < 10^6 lb (TEF)
0
1
2
3
4
5
6
7
8
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Duration of Plant Operations, months

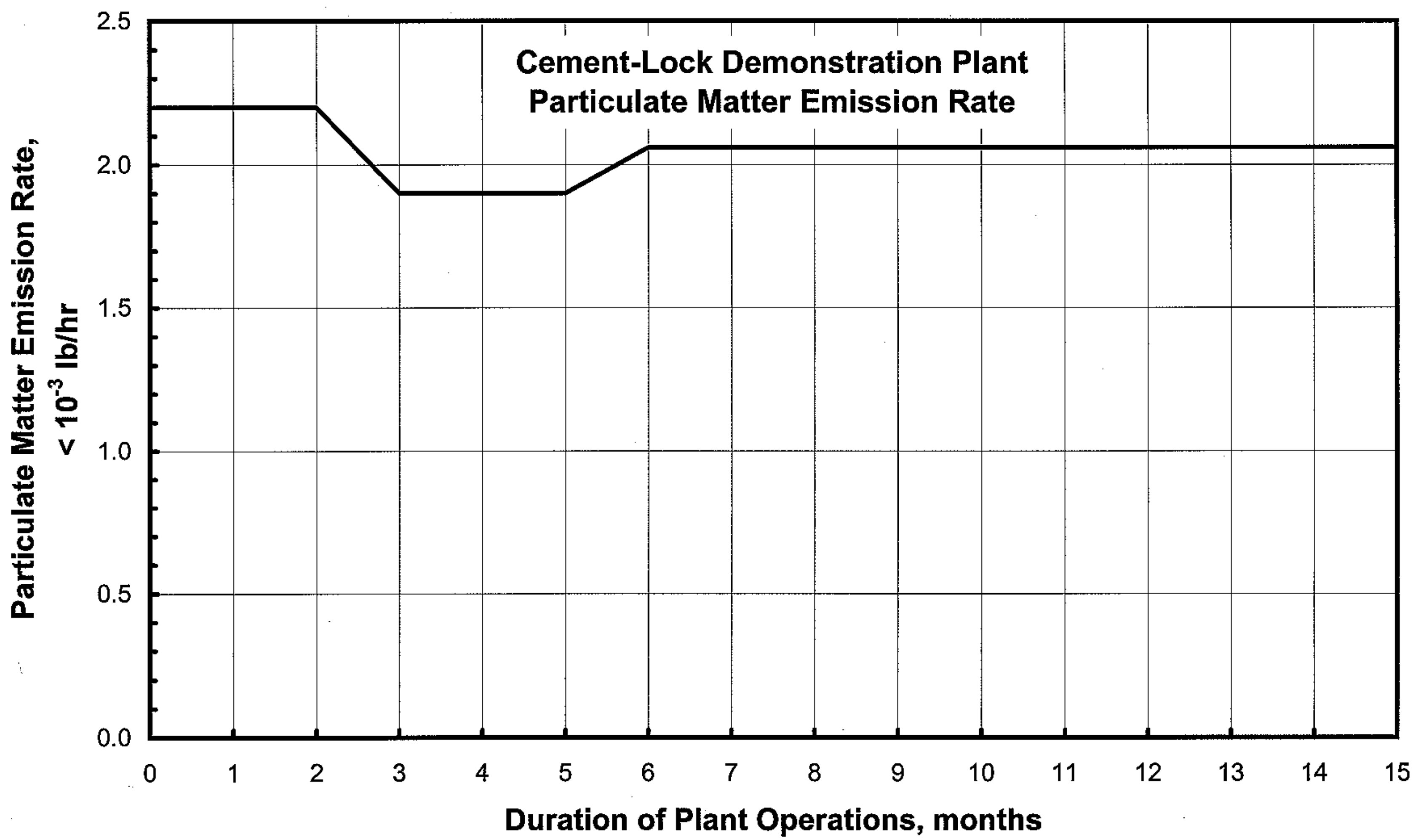

Cement-Lock Demonstration Plant
PCDF Concentration in
Absorber Exhaust (TEF)
PCDF Concentration, 10-2 ng/DSCM
0
1
2
3
4
5
6
7
8
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Duration of Plant Operations, months



Cement-Lock Demonstration Plant
PCDF Emission Rate (TEF)
PCDF Emission Rate,
< 10^-10 lb/hr (TEF)
0
1
2
3
4
5
6
7
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Duration of Plant Operations, months


Cement-Lock Demonstration Plant
PCDF Emissions (TEF)
Cumulative PCDF Emissions, < 10-6 lb (TEF)
0
1
2
3
4
5
6
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Duration of Plant Operations, months


Cement-Lock Demonstration Plant
Particulate Matter Concentration in
Absorber Exhaust
Particulate Matter Concentration,
< 10^-5 gr/DSCF
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Duration of Plant Operations, months


Cement-Lock Demonstration Plant
Particulate Matter Emission Rate
Particulate Matter Emission Rate,
< 10^-3 lb/hr
2.5
2.0
1.5
1.0
0.5
0.0
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Duration of Plant Operations, months

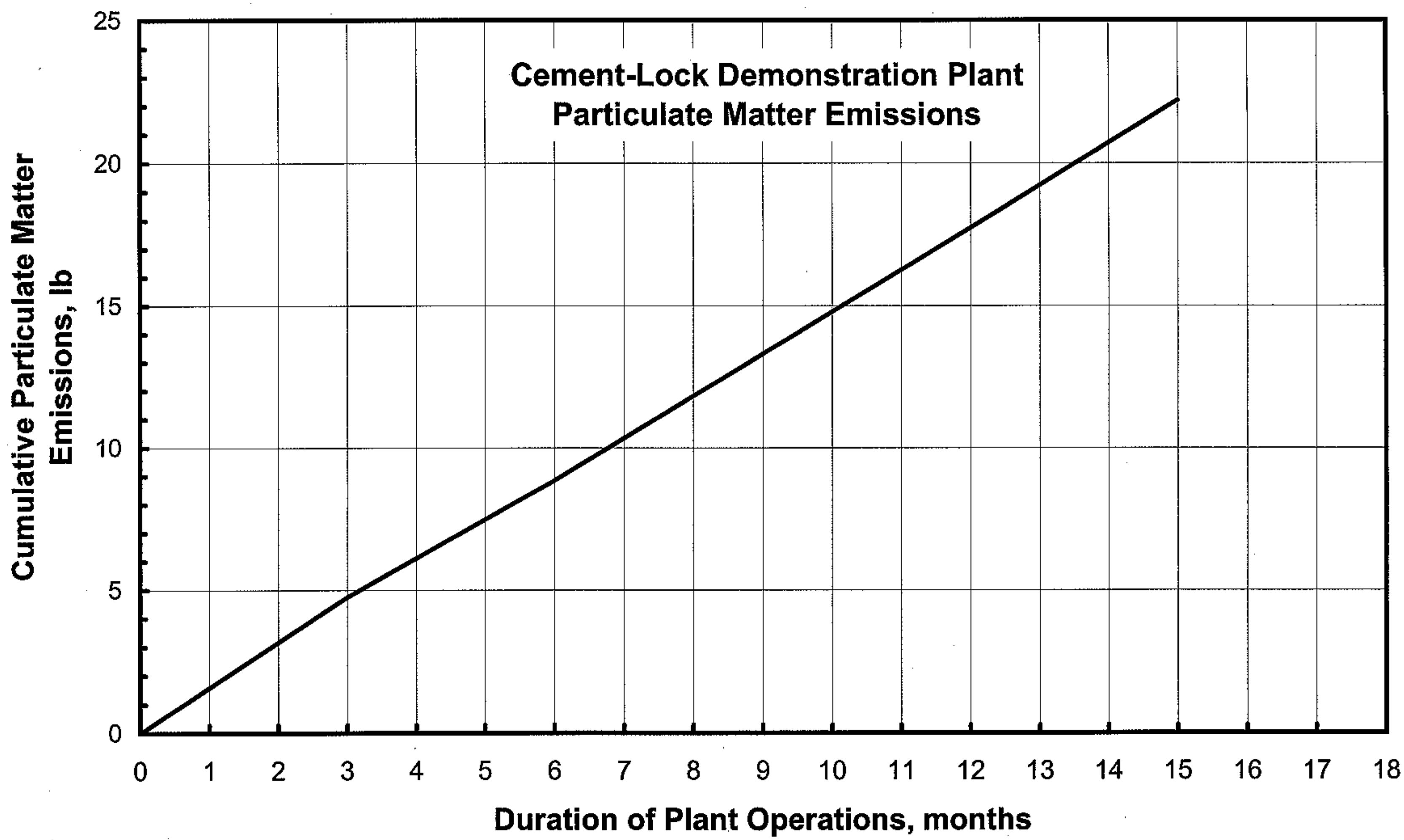

Cement-Lock Demonstration Plant
Particulate Matter Emissions
Cumulative Particulate Matter Emissions, lb
0
5
10
15
20
25
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
Duration of Plant Operations, months

**Table 3-4. Emission Rates and Concentrations of Pollutants in Activated Carbon Bed Exhaust Gas of Cement-Lock Demonstration Plant for Operating Periods PP and 1**

| | CO | $CO_2$ | $SO_2$ | $NO_2$ | HCl | THC | Hg | CDD[f] | CDF[f] | PM[g] |
|---|---|---|---|---|---|---|---|---|---|---|
| Emission Rate | Pounds per hour | | | | | | | | | |
| Gas Phase | 1.03 | 2,702 | 1.46 | 3.1 | 0.95 | 3.8E-3[b] | 2.3E-4 | 9.5E-11 | 1.9E-10 | 2.2E-3 |
| Particulate Phase | | | | | 9.5E-4 | | < 5.2E-6 | 1.9E-10 | 1.7E-11 | |
| Concentration[a] | Parts per million | | | | | | | | | |
| Gas Phase | 51 | 9.88[e] | 32 | 94 | 36 | 5 | 16[c] | 6.5E-3[h] | 1.3E-2[h] | 6.5E-5[d] |
| Particulate Phase | | | | | 0.04 | | < 0.4[c] | 1.3E-2[h] | 1.2E-3[h] | |

a. Adjusted to 7 mol % oxygen, dry volume basis.
b. Moles per hour.
c. Micrograms (µg) per dry standard cubic meter.
d. Grains per dry standard cubic foot.
e. Mole percent, dry basis.
f. Toxicity Equivalency Factor.
g. Particulate matter.
h. Nanogram (ng) per dry standard cubic meter.

**Table 3-5. Emission Rates and Concentrations of Pollutants in Adsorber Exhaust Gas of Cement-Lock Demonstration Plant for Operating Period 2**

| | CO | $CO_2$ | $SO_2$ | $NO_2$ | HCl | THC | Hg | CDD[f] | CDF[f] | PM[g] |
|---|---|---|---|---|---|---|---|---|---|---|
| Emission Rate | Pounds per hour | | | | | | | | | |
| Gas Phase | 2.06 | 2,838 | 2.92 | 1.83 | 1.9 | 7.6E-3[b] | 4.7E-4 | 1.9E-10 | 3.8E-10 | 1.9E-3 |
| Particulate Phase | | | | | 1.9E-3 | | < 1E-5 | 3.8E-10 | 3.5E-11 | |
| Concentration[a] | Parts per million | | | | | | | | | |
| Gas Phase | 175 | 15.46[e] | 109 | 95 | 124 | 18 | 39[c] | 1.9E-2[h] | 3.9E-2[h] | 8.4E-5[d] |
| Particulate Phase | | | | | 0.1 | | < 0.9[c] | 3.9E-2[h] | 3.6E-3[h] | |

a. Adjusted to 7 mol % oxygen, dry volume basis.
b. Moles per hour.
c. Micrograms (μg) per dry standard cubic meter.
d. Grains per dry standard cubic foot.
e. Mole percent, dry basis.
f. Toxicity Equivalency Factor.
g. Particulate matter.
h. Nanograms (ng) per dry standard cubic meter.

**Table 3-6. Emission Rates and Concentrations of Pollutants in Adsorber Exhaust Gas of Cement-Lock Demonstration Plant for Operating Period 3**

| | CO | $CO_2$ | $SO_2$ | $NO_2$ | HCl | THC | Hg | CDD[f] | CDF[f] | PM[g] |
|---|---|---|---|---|---|---|---|---|---|---|
| Emission Rate | Pounds per hour | | | | | | | | | |
| Gas Phase | 3.16 | 3,463 | 4.46 | 1.35 | 2.9 | 1.2E-2[b] | 7.1E-4 | 2.9E-10 | 5.9E-10 | 2.1E-3 |
| Particulate Phase | | | | | 2.9E-3 | | < 1.6E-5 | 5.8E-10 | 5.3E-11 | |
| Concentration[a] | Parts per million | | | | | | | | | |
| Gas Phase | 367 | 22.02[e] | 227 | 96 | 258 | 37 | 84[c] | 3.4E-2[h] | 7.0E-2[h] | 10.6E-5[d] |
| Particulate Phase | | | | | 0.3 | | < 1.9[c] | 6.9E-2[h] | 6.3E-3[h] | |

a. Adjusted to 7 mol % oxygen, dry volume basis.
b. Moles per hour.
c. Microgram (μg) per dry standard cubic meter.
d. Grains per dry standard cubic foot.
e. Mole percent, dry basis.
f. Toxicity Equivalency Factor.
g. Particulate matter.
h. Nanograms (ng) per dry standard cubic meter.

### 3.2.2. Exhaust Gas From Ecomelt Dryer

Wet Ecomelt leaving the Ecomelt Granulator (C-203) is dried in a direct gas-fired Ecomelt Dryer (D-206). Any entrained particulates are removed from the Ecomelt Dryer exhaust gas in the Cyclone Separator (M-401) and Bag Filter (S-402). The particulates are collected and combined with dry Ecomelt and then conveyed to the Ecomelt Hopper (T-219). The cleaned dryer exhaust gas is discharged to the atmosphere through the Ecomelt Dryer Induced Draft Fan (B-402). The major components of the exhaust gases from the Ecomelt Dryer are shown in Table 3-7.

**Table 3-7. Compositions of Major Components in Ecomelt Dryer Exhaust Gas of Cement-Lock Demonstration Plant**

| **Operating Period** | **PP** | **1** | **2** | **3** |
|---|---|---|---|---|
| Major Components, mol % | | | | |
| $O_2$ | 9.58 | 9.58 | 9.58 | 9.58 |
| $CO_2$ | 2.53 | 2.53 | 2.53 | 2.53 |
| $H_2O$ | 32.81 | 32.81 | 32.81 | 32.81 |
| $N_2$ | 55.08 | 55.08 | 55.08 | 55.08 |
| Total | 100.00 | 100.00 | 100.00 | 100.00 |
| Flow Rate, mol/h | 22 | 22 | 44 | 67 |
| lb/h | 567 | 567 | 1,134 | 1,733 |
| Temperature, °F | 230 | 230 | 230 | 230 |

### 3.2.3 Vent Gases From Pneumatic Conveying Systems

Crushed limestone, alumina, and lime are pneumatically conveyed from supply trucks to the Modifier 1 Hopper (T-103), Modifier 2 Hopper (T-104), and Lime Hopper (T-302), respectively. The filling operation of each hopper is intermittent. Any entrained particulates are removed from the conveying air streams by the Bin Vent Filters (S-103 and S-302). The cleaned air streams are then discharged to the atmosphere. The flow rate of each conveying air stream is about 300 standard cubic feet per minute (SCFM). The content of particulate matter in each vent gas stream is less than 0.01 gr/DSCF and the particle size is 100 percent less than 1.5 microns (μm).

## 3.3. Solid Effluents

### 3.3.1. Cement-Lock Cement

A total of 13,320 tons of dry Ecomelt will be produced during the proposed Cement-Lock sediment decontamination demonstration project. The Ecomelt product will be further processed by others in an off-site facility and used for producing construction-grade cement. The construction-grade cement will be subsequently used in construction projects to make concrete.

### 3.3.2. Spent Lime

Spent lime from the flue gas scrubber system will be analyzed and then disposed of as appropriate for the demonstration project.

### 3.3.3 Spent Carbon

Spent carbon from the activated carbon adsorption bed will be analyzed and then disposed of as appropriate for the demonstration project.

### 3.3.4 Oversized Materials From Raw Sediment

The oversized materials collected from the barge and the sediment screening system constitute about 1 percent of the raw sediment or a total of about 317 tons from the treatment of about 30,500 cubic yards of sediment. The oversized materials are comprised primarily of wood, bark, and metal pieces and will be disposed of in a landfill.

## 3.4. Liquid Effluents

Raw sediment is stored in the storage bin covered with a roof and then transferred to the processing area using a clamshell excavator. All other process equipment of the proposed plant is totally enclosed. This prevents raw sediment and process streams from being exposed to incident rain water. Any surface water runoff from the sediment storage and processing areas can be readily discharged to the environment.

All liquids contained in raw sediment are processed along with the solids in the Ecomelt Generator and secondary combustion chamber (SCC). There is no liquid effluent stream generated by the process.

# 4. PLANT EMISSION DURING EMERGENCY CONDITIONS

The potential emissions from the proposed demonstration plant during emergency conditions such as loss of feed materials, loss of natural gas, loss of electric power, and loss of water are discussed in this section.

## 4.1. Loss of Feed Materials

When the flow of raw sediment or modifier solids to the Ecomelt Generator is interrupted, this will activate the emergency interlocks of the feed system to automatically shut down all other feed materials to the Ecomelt Generator. The Ecomelt Generator will continue to operate at high temperature for about one hour while all holdup materials are completely discharged. The emission rates and concentrations of any flue gas constituents at the activated carbon bed outlet will decrease from normal levels to about zero in one hour.

## 4.2. Loss of Natural Gas Supply

When the natural gas supply to the Ecomelt Generator and secondary combustion chamber (SCC) is interrupted, the backup propane gas is introduced automatically and all other feed materials are stopped. The holdup materials in the Ecomelt Generator will be completely discharged within one hour, and the emission rates and concentrations of any flue gas constituents at the adsorber outlet will decrease from normal levels to about zero in one hour.

## 4.3. Loss of Water Supply

When the water supply to the plant is interrupted, the backup water to the quench column and Ecomelt Granulator will be automatically activated to continue the cooling of SCC exhaust gas and the molten slag discharged from the Ecomelt Generator. All other feed materials to the Ecomelt Generator are also stopped automatically and the holdup materials in the Ecomelt Generator will be completely discharged within one hour. The emission rates and concentrations of flue gas constituents at the adsorber outlet will decrease from normal levels to about zero in one hour.

## 4.4. Loss of Electrical Power

The loss of electric power will immediately trigger the shutdown of all feed materials to the Ecomelt Generator. The natural gas flow will be maintained to keep the Ecomelt Generator and SCC hot. A backup generator will provide sufficient power to maintain operations for about one hour until the accumulated holdup material in the Ecomelt Generator can be completely discharged. The emission rates and concentrations of flue gas constituents at the activated carbon bed outlet will decrease from normal levels to about zero in one hour.