EPA-450/3-78-046
August 1977

FABRIC FILTER COSTS FOR LARGE COAL-FIRED STEAM GENERATORS

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Waste Management
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

FABRIC FILTER COSTS

FOR LARGE COAL-FIRED STEAM GENERATORS

Prepared By

Industrial Gas Cleaning Institute
Stamford, Connecticut 06904

Contract No. 68-02-2532
Task No. 5

Prepared For

U.S. Environmental Protection Agency
Strategies and Air Standards Division
Economic Analysis Branch
Research Triangle Park
North Carolina 27711

August 1977

CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 INTRODUCTION

The purpose of this task is to determine the costs of fabric filters to control particulate emissions from large coal-fired steam generators. These costs are to be a function of boiler size only. The emission limit (0.01 gr/acf) and coal specification are assumed to be identical for each application. The scope of this report is limited to the development of capital and annualized costs of fabric filters on boilers firing pulverized coal. Investment costs cover the fabric filters, inlet and outlet duct transitions, foundations and support steel, equipment erection, painting, and electrical work. A turnkey cost will be determined by adding these direct costs to the indirect installation costs, which include engineering, construction, field expenses and fees, startup, and contingencies.

The above costs include the piping and valve components of a fly ash collection and handling system from the fabric filter hoppers to a common collection point.

Annualized costs are defined as the direct costs of fabric filter operation plus fixed costs for overhead and

capitalization. The cost of fly ash disposal is excluded, because some utilities have adequate space for on-site disposal.

The specifications (see Appendix) cover fabric filters that treat flue gas under conditions involving the following combination of variables.

Boiler size, MW	Emission regulation,	
	gr/acf	lb/10^6 Btu
200	0.01	0.033
500	0.01	0.033
700	0.01	0.033

The specifications were sent to three IGCI members recommended by the Engineering Standards Committee as experts in this field of application.

The quotations received were tabulated and averaged. Estimated installed costs of valving and piping for an ash handling system were added to this average figure.

The efficiency data provided in this study represents the maximum performance that can be guaranteed by the equipment suppliers. These values will be obtained when the collection equipment is in good condition and operating within design flow specifications. This does not mean that these efficiencies will be achieved all of the time. Unforeseen upsets in process gas flows or conditions such as a change in process chemistry or an excessive dust loading will

affect performance. Good maintenance procedures are necessary to maintain high-level efficiency.

2.0 PROCESS DESCRIPTION

Figure 2-1 depicts a coal-fired utility boiler equipped with a fabric filter for particulate emission control. Air is blown into the boiler by forced-draft fans, and induced draft fans are used to pull the cleaned flue gas through the fabric filter to make up for pressure drop through the filter and to operate the boiler in a balanced-draft condition. As an economy measure, air passes through a heat exchanger designed to recover heat from the hot exhaust gases. In the boiler, pulverized coal burned with the preheated air generates steam from boiler feed water.

Coal combustion produces ash (a noncombustible coal residue) and hot gases. Although a small amount of the ash falls to the bottom of the combustion chamber and is subsequently removed as bottom ash, 70 to 95 percent of it is entrained (as fly ash) in the hot gas stream. Because this material is of such fine particle size, it is difficult to separate from the combustion gas stream. A fabric filter may be used to remove this fly ash from the boiler exhaust gases.

Fabric filters are selected for particular boiler installations on an economic basis, which depends on the

type of fabric used, method of cleaning, and the air-to-cloth ratio. The chemical composition of the fly ash affects filter performance somewhat, mostly through corrosive problems. Acid condensation can cause corrosion within the filter; however, this occurs only when the gas stream is lowered below 300°F.

As boiler exhaust gases pass through the fabric filter, fly ash particules contained in the gas are collected primarily by direct interception and inertial impaction. Periodic cleaning of the fabric (by mechanical shake and/or reverse air) causes the accumulated particles to fall into collecting hoppers beneath the filter compartments. The cleaned exhaust gases are sent through an induced-draft fan to a stack and are ultimately discharged to the atmosphere.

When the fly ash collected in the hoppers reaches a specified level, valves discharge it to a pneumatic conveying system for transport to a disposal area. Sometimes the hopper disposal process is timer-actuated rather than controlled by a level indicator.

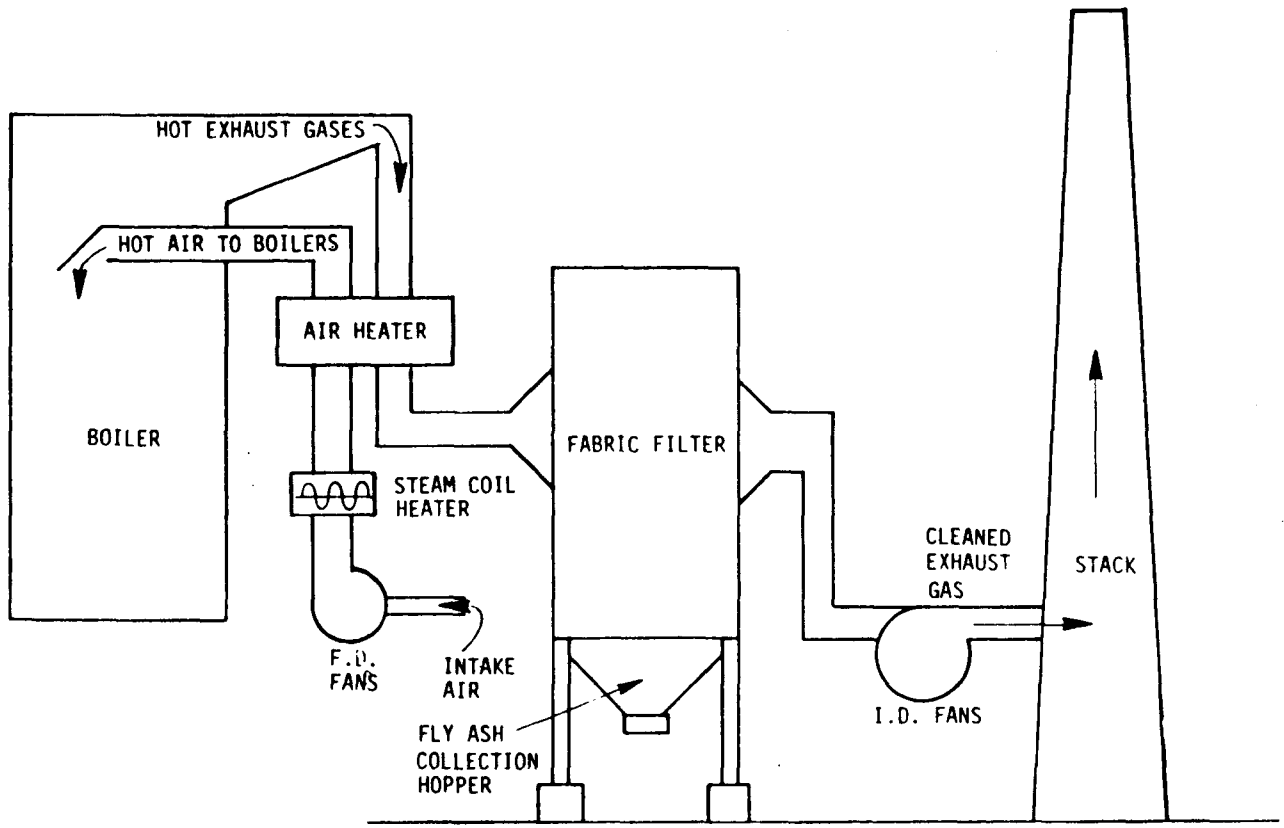

Figure 2-1. Typical fabric filter arrangement.

3.0 PARTICULATE EMISSION CONTROL BY FABRIC FILTER

3.1 DESIGN SPECIFICATION

The design specifications for fabric filter operation on three boiler sizes are presented in the Appendix. The fabric filter efficiency and residual particulate emission values shown are directly correlated with the emission control level considered-0.01 gr/acf, or 0.033 lb/MM Btu.

3.2 CAPITAL INVESTMENT COSTS

Table 3-1 presents the capital investment required for fabric filters to achieve the particulate emission control level when operating under design conditions.

The various cost items shown represent the sum of the fabric filter costs and installed costs of piping and valves for a fly ash handling system. Fabric filter auxiliary equipment typically includes access and supports. Ash handling auxiliary components (storage silos, unloaders, controls, etc.) are not included.

Duct and stack costs are not included in the direct costs of installation because only flange-to-flange costs of the fabric filters are considered.

3.3 ANNUALIZED OPERATING COSTS

Table 3-2 shows the estimated total costs of operating

CAPITAL COST DATA
FABRIC FILTER
FOR LARGE SIZED BOILERS

Data Sheet No. 1 of 2
Project No. 68-02-2532
Task No. 5

BOILER SIZE Megajoules/sec or MW	200	500	700
Inlet & outlet gas flow			
ACFM	798,000	1,993,000	2,790,000
°F	350	350	350
SCFM	520,000	1,305,000	1,826,000
Moisture, Vol. %	10	10	10
Contaminant loading			
Inlet, gr/ACF	1.46	1.46	1.46
Inlet, lb/hr	9,970	24,930	34,900
Outlet, gr/ACF	0.01	0.01	0.01
Outlet, lb/hr	70	175	245
Cleaning efficiency	99.3	99.3	99.3
Gas cleaning equipment cost	1,884,800	4,077,000	5,605,100
Cost of auxiliaries			
Installed ash handling equipment	376,000	1,038,000	1,267,000
Total equipment cost	2,260,800	5,115,000	6,872,100
Installation costs, direct*	732,200	1,309,500	1,838,100
Foundation and supports	99,700	221,200	292,900
Duct work	By Others		
Stack	By Others		
Piping	17,400	41,800	58,100
Insulation	528,000	1,196,000	1,630,000
Painting	41,000	91,100	121,200
Electrical	159,800	378,000	628,700
Total direct costs	1,578,100	3,237,600	4,569,000
Installation costs, indirect	459,700	914,900	1,269,200
Engineering	180,600	303,900	382,700
Constr. and field expense	396,300	788,900	1,099,200
Construction fees	265,900	592,700	817,000
Start-up	17,800	32,700	41,000
Performance test	12,300	15,800	17,200
Contingencies	70,900	157,300	212,100
Total Indirect costs	1,403,500	2,806,200	3,838,400
Turnkey cost	5,242,000	11,158,800	15,279,500

* Where specified

Table 3-1. CAPITAL COST DATA FOR FABRIC FILTERS USED ON LARGE-SIZED BOILERS

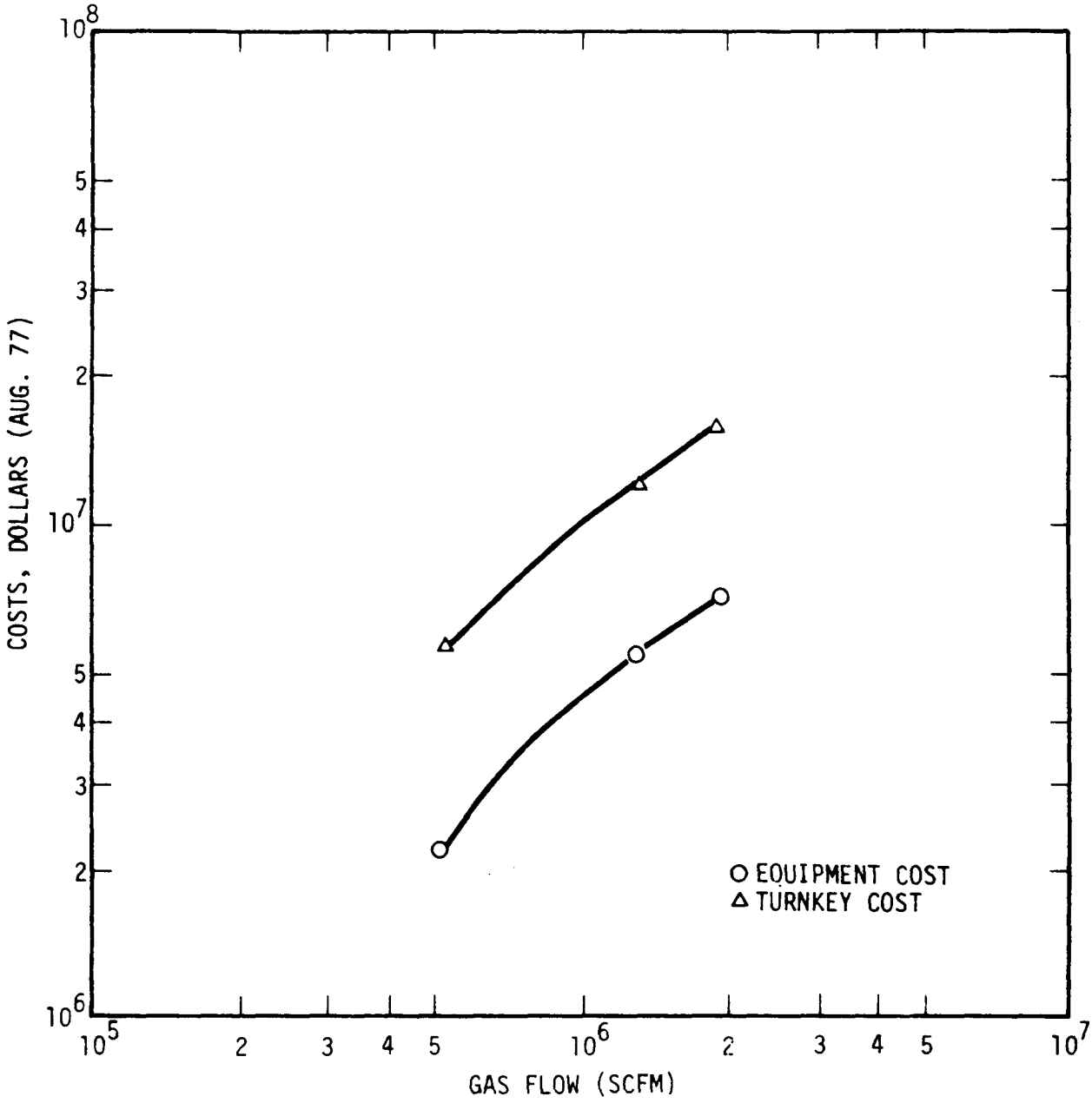

Figure 3-1. Capital cost of fabric filters used on large-sized boilers.

ANNUAL OPERATING COST DATA
FABRIC FILTERS

Data Sheet No. 2 of 2

Project No. 68-02-2532

Task No. 5

BOILER SIZE Megajoules/sec. or MW		200	500	700
Inlet & outlet gas flow				
ACFM		798,000	1,993,000	2,790,000
°F		350	350	350
SCFM		522,000	1,305,000	1,824,000
Moisture, Vol. %		10	10	10
Contaminant loading				
Inlet, gr/ACF		1.46	1.46	1.46
Inlet, lb/hr		9,970	24,930	34,900
Outlet, gr/ACf		0.01	0.01	0.01
Outlet, lb/hr		70.0	175.0	245.0
Cleaning efficiency		99.3	99.3	99.3
Operating cost item	Unit cost			
Direct costs:				
Operating labor				
Operator	$10/manhour	20,900	23,200	25,900
Supervisor	$12/manhour	6,000	6,400	7,000
Total		26,900	29,600	32,900
Maintenance				
Labor	$10/manhour	14,500	27,900	37,100
Materials		1,900	3,500	4,200
Total		16,400	31,400	41,300
Replacement parts		57,200	119,500	160,800
Utilities				
Electricity	$0.03/kWh	243,000	571,900	786,000
Pressure drop across collector Flange to flange ΔP, maximum , minimum		6-8, "W.G. 5-5 1/2	6-8 5-5 1/2	6-8 5-5 1/2
Total				
Total direct costs		343,500	752,400	1,021,000
Capital charges		891,100	1,897,000	2,597,500
Total annual cost		1,234,600	2,649,400	3,618,500

Operating costs to be based on annual operation of 8760 hours per year @ 65% capacity factor.

Table 3-2. ANNUAL OPERATING COST DATA FOR FABRIC FILTERS USED ON LARGE-SIZED BOILERS

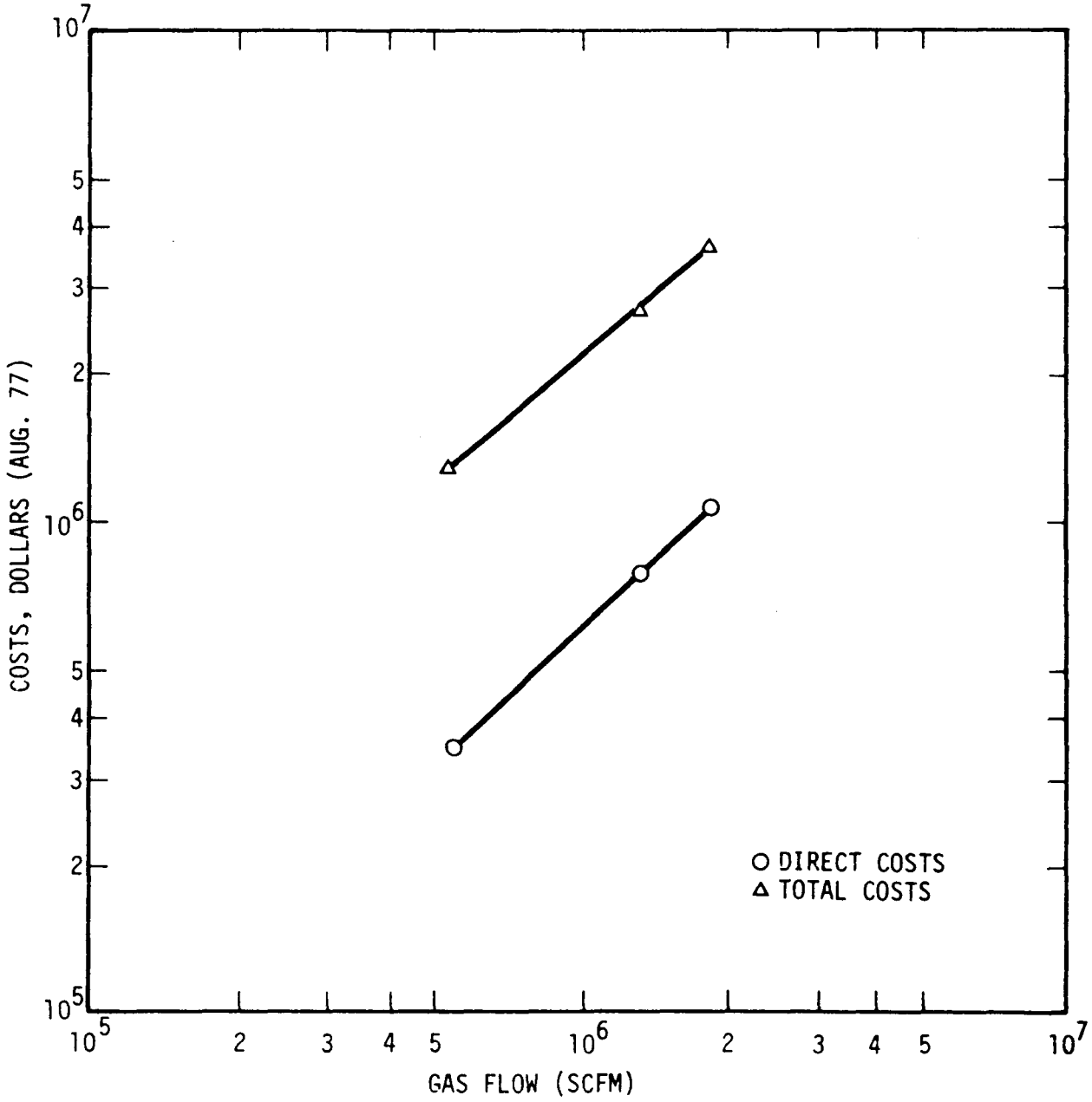

Figure 3-2. Annualized costs of fabric filters used on large-sized boilers.

a fabric filter under the specified conditions on 200-, 500- and 700-MW units, respectively. These costs are predicated upon operation of the fabric filters at 65 percent capacity (load) factor.

The total costs represent the average of the direct operating costs submitted by the three IGCI members and the computed overhead and capitalization charges. Fan operation (both induced-draft and reverse-air) for air movement is included. Utility costs of ash conveying are not included.

APPENDIX

FABRIC FILTER SPECIFICATIONS

APPENDIX A

1.0 FABRIC FILTER SPECIFICATIONS

A fabric filter is to remove solid particulate matter from the exhaust flue gas of a large pulverized coal-fired boiler. The system shall be quoted complete, including the following:

1. Fabric filter
2. Structural steel for installation of the fabric filter with at least 5 feet clearance under ash discharge
3. Insulation, 2" thick
4. Reverse air cleaning, including reverse air fan
5. Slide gates
6. Dust collection hoppers
7. Other necessary auxiliary equipment including cleaning cycle sequence timers.

Ash handling equipment and controls are not included in these specifications.

Details:

1. The fabric filter shall be of compartmental construction to allow isolation of a single compartment for cleaning and maintenance.
2. Pneumatic or electric remote control gate valves shall be provided to isolate modules, and ductwork shall be provided to allow for a single inlet and a single outlet connection to and from the fabric filter.

3. Construction shall allow for suction operation of the fabric filters; the induced draft fan will be attached to the fabric filter outlet. The connecting ductwork will be supplied by others.

4. Housings, valves and ductwork shall be of carbon steel construction. Fabric shall be fiberglass.

System Requirements

1. The attached data sheets outline the system variations on which quotations will be received, and provides inlet and outlet flow rates and particulate loadings. The gas cleaning device is to reduce the solids content of the gas to the levels specified.

2. The coal being fired in the boilers has the following analysis:

° Sulfur	0.5%	
° Ash	5.9%	
° Moisture	28.1%	
° Heat value	19.36 8,322	Joules/nanogram (Btu/lb)

3. Size distribution of particles in the inlet gas is as follows:

Particle size	Percent by weight*
Above 100 microns	10
40 to 100 microns	15
20 to 40 microns	15
10 to 20 microns	20
Below 10 microns	40

* From Fine Particulate Emission Inventory and Control Survey, by the Midwest Research Institute, January 1974.

CAPITAL COST DATA
FABRIC FILTER
FOR LARGE
SIZED BOILERS

Data Sheet No. _____
Project No. 68-02-2532
Task No. 5

BOILER SIZE Megajoules/sec. or MW	200	500	700
Inlet and outlet gas flow			
ACFM	798,000	1,993,000	2,790,000
°F	350	350	350
SCFM	520,000	1,305,000	1,826,000
Moisture, Vol. %	10	10	10
Contaminant loading			
Inlet, gr/ACF	1.46	1.46	1.46
Inlet, lb/hr	9,970	24,930	34,900
Outlet, gr/ACF	0.01	0.01	0.01
Outlet, lb/hr	70	175	245
Cleaning efficiency	99.3	99.3	99.3
Gas cleaning equipment cost			
Cost of auxiliaries			
Total equipment cost			
Installation costs, direct*			
Foundation and supports			
Duct work			
Stack			
Piping			
Insulation			
Painting			
Electrical			
Total direct costs			
Installation costs, indirect			
Engineering			
Constr. and field expense			
Construction fees			
Start-up			
Performance test			
Contingencies			
Total Indirect costs			
Turnkey cost			

* Where specified

ANNUAL OPERATING COST DATA
FABRIC FILTERS

Data Sheet No. _____
Project No. 68-02-2532
Task No. 5

BOILER SIZE Megajoules/sec. or MW		200	500	700
Inlet & outlet gas flow				
ACFM		798,000	1,993,000	2,790,000
°F		350	350	350
SCFM		522,000	1,305,000	1,824,000
Moisture, Vol. %		10	10	10
Contaminant loading				
Inlet, gr/ACF		1.46	1.46	1.46
Inlet, lb/hr		9,970	24,930	34,900
Outlet, gr/ACF		0.01	0.01	0.01
Outlet, lb/hr		70.0	175.0	245.0
Cleaning efficiency		99.3	99.3	99.3
Operating cost item	Unit cost			
Direct costs:				
Operating labor				
Operator	$10/manhour			
Supervisor	$12/manhour			
Total				
Maintenance				
Labor	$10/manhour			
Materials				
Total				
Replacement parts				
Utilities				
Electricity	$0.03/kWh			
Pressure drop across collector Flange to flange ΔP, maximum , mimimum				
Total				
Total direct costs				
Capital charges				
Total annual cost				

Operating costs to be based on annual operation of 8760 hours per year @ 65% capacity factor.

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO.
EPA-450/3-78-046		

4. TITLE AND SUBTITLE	5. REPORT DATE
Fabric Filter Costs for Large Coal-Fired Steam Generators	August 1977
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S)	8. PERFORMING ORGANIZATION REPORT NO.
John Bruck, N.D. Noe	
9. PERFORMING ORGANIZATION NAME AND ADDRESS	10. PROGRAM ELEMENT NO.
Industrial Gas Cleaning Institute 700 N. Fairfax Street, Suite 304 Alexandria, Virginia 22314	11. CONTRACT/GRANT NO. 68-02-2532, Task 5
12. SPONSORING AGENCY NAME AND ADDRESS	13. TYPE OF REPORT AND PERIOD COVERED
U.S. Environmental Protection Agency Office of Air Quality Planning and Standards Research Triangle Park, North Carolina 27711	Final 14. SPONSORING AGENCY CODE
15. SUPPLEMENTARY NOTES	

16. ABSTRACT

Capital and annualized costs are provided by vendors for fabric filters used for particulate emission control of large coal-fired steam generators. Generator sizes of 200, 500, and 700 megawatts are considered at an emission level of 14.3 nanograms per joule (0.033 lbs/million Btu) both equipment and turnkey costs are provided.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Air Pollution Cost Estimates Dust Control	Air Pollution Control Stationary Sources Coal-Fired Boilers Fabric Filters Emission Standards	13B

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS *(This Report)*	21. NO. OF PAGES
Unlimited	Unclassified	21
	20. SECURITY CLASS *(This page)*	22. PRICE
	Unclassified	

EPA Form 2220-1 (9-73)