CHAPTER V: COSTS OF COMPLIANCE

INTRODUCTION

This chapter assesses the costs to establishments in all affected industry sectors of reducing worker exposures to silica to an eight-hour time-weighted average (TWA) permissible exposure limit (PEL) of 50 μg/m^3 and of complying with the proposed standard's ancillary requirements. This preliminary cost assessment is based on OSHA's technological feasibility analysis presented in Chapter IV of this PEA; analyses of the costs of the proposed standard conducted by OSHA's contractor, Eastern Research Group (ERG, 2007a, 2007b, and 2011); and the comments submitted to the docket as part of the SBREFA panel process.

OSHA estimates that the proposed standard will cost $657.9 million per year in 2009 dollars. Of that total, $146.7 million will be borne by the general industry and maritime sectors, and $511.2 million will be borne by the construction sector. Costs originally estimated for earlier years were adjusted to 2009 dollars using the appropriate price indices. All costs were annualized using a discount rate of 7 percent, which—along with 3 percent—is one of the discount rates recommended by OMB; annualization periods for expenditures on equipment based on equipment life,[1] and a 10-year annualization period for one-time costs. Note that the benefits of the proposed standard, discussed in Chapter VII of this PEA, were annualized over a 60-year period to reflect the time needed for benefits to reach steady-state values. Therefore, the time horizon of OSHA's analysis for this proposed rule is 60 years. Note that, over this time horizon, employment and production in affected industries are being held constant for purposes of the analysis. All non-annual costs are estimated to repeat over the 60-year time horizon, including one-time costs that recur because of changes in operations over time or because of new entrants that must comply with the proposed standard.[2] OSHA welcomes comment on the best assumptions for the purpose of this analysis, recognizing the uncertainties of long-term forecasts and the need for long-term forecasts to capture the full effects of the standard on benefits.

Table V-1 shows, by affected industry in general industry and maritime, annualized compliance costs for all establishments, annualized compliance costs for all small entities (as defined by the Small Business Act and the Small Business Administration's (SBA's) implementing regulations; see 15 U.S.C. 632 and 13 CFR 121.201), and annualized compliance costs for all very small entities (those with fewer than 20 employees). Tables V-2 shows, by affected industry in construction, annualized compliance costs for all entities, annualized compliance costs for all small entities, and annualized compliance costs for all very small entities.

OSHA's exposure profile, presented in Chapter III of this PEA, represents the Agency's best estimate of current exposures (i.e., baseline exposures). OSHA did not attempt to determine the

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[1] Appendix V-D of this PEA presents costs by NAICS industry and establishment size categories using, as alternatives, a 3 percent discount rate and a 0 percent discount rate. In the sensitivity analysis presented in Chapter VII of this PEA, OSHA compares the estimated cost of the proposed rule using the 7 percent discount rate to the estimated cost using these alternative discount rates.

[2] To the extent one-time costs do not recur, OSHA's cost estimates, when expressed as annualizations over a 10-year period, will overstate the cost of the proposed standard.

extent to which current exposures in compliance with the current silica PELs are the result of baseline engineering controls or the result of circumstances leading to low exposures. This information is not needed to estimate the costs of (additional) engineering controls needed to comply with the proposed standard.

The estimated costs for the proposed silica rule represent the additional costs necessary for employers to achieve full compliance. They do not include costs associated with current compliance that has already been achieved with regard to the new requirements or costs necessary to achieve compliance with existing silica requirements, to the extent that some employers may currently not be fully complying with applicable regulatory requirements.

Because of the severe health hazards involved, the Agency expects that the estimated 15,446 abrasive blasters in the construction sector and the estimated 4,550 abrasive blasters in the maritime sector are currently wearing respirators as required by OSHA's abrasive blasting provisions (29 CFR 1915.154 (referencing 29 CFR 1910.134)) . Furthermore, for the construction baseline, an estimated 241,269 workers, including abrasive blasters, will need to use respirators to achieve compliance with the proposed rule, and, based on the NIOSH/BLS respirator use survey (NIOSH/BLS, 2003), an estimated 56 percent of construction employees whose exposures are high enough that they would need respirators under the proposed rule currently use such respirators. OSHA estimates that 56 percent of affected construction employers already have respirator programs that meet OSHA's respirator standard. These employers are also assumed to be in compliance with the respiratory protection program requirements. OSHA has not estimated any respirator costs for employers and their workers currently in compliance with the respiratory provisions in the proposed rule.

In addition, under both the general industry and construction baselines, an estimated 50 percent of employers have pre-existing training programs that address silica-related risks (as required under OSHA's hazard communication standard) and partially satisfy the proposed rule's training requirements (for costing purposes, estimated to satisfy 50 percent of the training requirements in the proposed rule). These employers will need fewer resources to achieve full compliance with the proposed rule than those employers without pre-existing training programs that address silica-related risks.

Other than respiratory protection and worker training concerning silica-related risks, OSHA did not assume baseline compliance with any ancillary provisions, even though some employers have reported that they do currently monitor silica exposure and some employers have reported conducting medical surveillance.

The remainder of this chapter is organized as follows. First, unit and total costs by proposed provision are presented for general industry and maritime. Then, unit and total costs by proposed provision are presented for construction. The chapter concludes with a summary of the estimated costs of the proposed rule for all affected industries.

COSTS FOR GENERAL INDUSTRY AND MARITIME

Estimation of the costs of the proposed rule for general industry and maritime is broken out below for three categories of costs: (1) control costs to comply with the proposed PEL of 50 $\mu g/m^3$; (2) respirator costs, in those cases where engineering controls are not sufficient to guarantee compliance with the proposed PEL; and (3) "program" costs to comply with the ancillary provisions of the rule.

Table V-1: Annualized Costs, by Industry, for All General Industry and Maritime Entities Affected by the Proposed Silica Standard

NAICS	Industry	All Establish-ments	Small Firms (SBA-defined)	Very Small Entities (<20 Employees)
324121	Asphalt paving mixture and block manufacturing	$242,070	$140,305	$27,770
324122	Asphalt shingle and roofing materials	$3,157,257	$872,614	$85,253
325510	Paint and coating manufacturing	$144,281	$71,718	$18,910
327111	Vitreous china plumbing fixtures & bathroom accessories manufacturing	$1,659,194	$231,845	$26,606
327112	Vitreous china, fine earthenware, & other pottery product manufacturing	$2,601,471	$1,854,472	$747,902
327113	Porcelain electrical supply mfg	$1,748,297	$1,004,480	$79,824
327121	Brick and structural clay mfg	$7,838,050	$3,062,272	$76,696
327122	Ceramic wall and floor tile mfg	$4,132,107	$2,189,278	$382,871
327123	Other structural clay product mfg	$936,699	$510,811	$67,176
327124	Clay refractory manufacturing	$482,438	$212,965	$29,861
327125	Nonclay refractory manufacturing	$608,017	$211,512	$34,061
327211	Flat glass manufacturing	$275,155	$275,155	$4,450
327212	Other pressed and blown glass and glassware manufacturing	$1,084,706	$243,132	$87,895
327213	Glass container manufacturing	$756,888	$57,797	$4,798
327320	Ready-mixed concrete manufacturing	$16,511,080	$10,490,561	$1,897,131
327331	Concrete block and brick mfg	$4,437,939	$2,862,910	$544,975
327332	Concrete pipe mfg	$2,747,484	$1,441,766	$116,670
327390	Other concrete product mfg	$12,900,251	$8,826,516	$1,885,496
327991	Cut stone and stone product manufacturing	$8,600,298	$8,028,431	$2,753,051
327992	Ground or treated mineral and earth manufacturing	$4,595,006	$2,108,649	$389,745
327993	Mineral wool manufacturing	$1,094,552	$291,145	$48,575
327999	All other misc. nonmetallic mineral product mfg	$1,966,052	$1,130,230	$311,859
331111	Iron and steel mills	$424,557	$424,557	$9,342
331112	Electrometallurgical ferroalloy product manufacturing	$8,577	$4,987	$0
331210	Iron and steel pipe and tube manufacturing from purchased steel	$84,537	$84,537	$1,706
331221	Rolled steel shape manufacturing	$42,672	$42,672	$1,612
331222	Steel wire drawing	$57,557	$57,557	$2,939
331314	Secondary smelting and alloying of aluminum	$28,757	$15,277	$1,254
331423	Secondary smelting, refining, and alloying of copper	$4,940	$4,206	$0

Table V-1: Annualized Costs, by Industry, for All General Industry and Maritime Entities Affected by the Proposed Silica Standard (continued)

NAICS	Industry	All Establish-ments	Small Firms (SBA-defined)	Very Small Entities (<20 Employees)
331492	Secondary smelting, refining, and alloying of nonferrous metal (except cu & al)	$36,946	$18,357	$2,897
331511	Iron foundries	$15,310,815	$5,312,382	$330,543
331512	Steel investment foundries	$4,283,138	$1,705,373	$47,902
331513	Steel foundries (except investment)	$4,596,837	$2,521,998	$162,670
331524	Aluminum foundries (except die-casting)	$6,975,150	$4,316,135	$503,027

Table V-1: Annualized Costs, by Industry, for All General Industry and Maritime Entities Affected by the Proposed Silica Standard (continued)

NAICS	Industry	All Establish-ments	Small Firms (SBA-defined)	Very Small Entities (<20 Employees)
331525	Copper foundries (except die-casting)	$1,636,463	$1,596,288	$370,110
331528	Other nonferrous foundries (except die-casting)	$1,232,708	$620,344	$162,043
332111	Iron and steel forging	$105,955	$47,376	$4,089
332112	Nonferrous forging	$34,982	$13,056	$784
332115	Crown and closure manufacturing	$12,720	$5,080	$992
332116	Metal stamping	$255,832	$212,110	$27,154
332117	Powder metallurgy part manufacturing	$32,828	$17,537	$2,072
332211	Cutlery and flatware (except precious) manufacturing	$22,970	$10,419	$2,217
332212	Hand and edge tool manufacturing	$145,223	$87,599	$19,535
332213	Saw blade and handsaw manufacturing	$28,851	$9,221	$2,296
332214	Kitchen utensil, pot, and pan manufacturing	$15,678	$10,475	$0
332323	Ornamental and architectural metal work	$35,267	$28,608	$9,527
332439	Other metal container manufacturing	$60,330	$43,857	$5,279
332510	Hardware manufacturing	$180,292	$78,538	$11,863
332611	Spring (heavy gauge) manufacturing	$16,158	$14,071	$1,927
332612	Spring (light gauge) manufacturing	$60,992	$36,826	$4,960
332618	Other fabricated wire product manufacturing	$144,819	$113,603	$19,946
332710	Machine shops	$1,077,759	$1,032,483	$416,115
332812	Metal coating and allied services	$3,038,935	$2,492,357	$613,903
332911	Industrial valve manufacturing	$150,261	$53,520	$5,886
332912	Fluid power valve and hose fitting manufacturing	$140,213	$41,712	$4,491
332913	Plumbing fixture fitting and trim manufacturing	$45,472	$19,037	$1,505
332919	Other metal valve and pipe fitting manufacturing	$71,354	$30,618	$2,710
332991	Ball and roller bearing manufacturing	$107,338	$13,624	$1,132
332996	Fabricated pipe and pipe fitting manufacturing	$107,219	$74,633	$12,453
332997	Industrial pattern manufacturing	$20,891	$20,767	$8,917
332998	Enameled iron and metal sanitary ware manufacturing	$60,684	$13,779	$3,287
332999	All other miscellaneous fabricated metal product manufacturing	$288,093	$230,825	$55,981
333319	Other commercial and service industry machinery manufacturing	$209,273	$123,816	$19,776
333411	Air purification equipment manufacturing	$58,265	$27,021	$4,745
333412	Industrial and commercial fan and blower manufacturing	$41,212	$27,149	$1,675
333414	Heating equipment (except warm air furnaces) manufacturing	$80,754	$45,308	$6,087
333511	Industrial mold manufacturing	$160,131	$143,216	$43,738
333512	Machine tool (metal cutting types) manufacturing	$68,151	$44,845	$8,756
333513	Machine tool (metal forming types) manufacturing	$33,940	$30,365	$4,666
333514	Special die and tool, die set, jig, and fixture manufacturing	$231,988	$203,742	$65,867
333515	Cutting tool and machine tool accessory manufacturing	$139,916	$104,313	$31,406
333516	Rolling mill machinery and equipment manufacturing	$12,279	$9,604	$1,361

Table V-1: Annualized Costs, by Industry, for All General Industry and Maritime Entities Affected by the Proposed Silica Standard (continued)

NAICS	Industry	All Establish-ments	Small Firms (SBA-defined)	Very Small Entities (<20 Employees)
333518	Other metalworking machinery manufacturing	$50,002	$38,359	$6,766
333612	Speed changer, industrial high-speed drive, and gear manufacturing	$48,452	$25,087	$3,318
333613	Mechanical power transmission equipment manufacturing	$61,197	$26,182	$3,114
333911	Pump and pumping equipment manufacturing	$121,086	$41,360	$7,209
333912	Air and gas compressor manufacturing	$84,518	$23,948	$4,228
333991	Power-driven handtool manufacturing	$34,459	$9,867	$2,212
333992	Welding and soldering equipment manufacturing	$62,401	$23,144	$3,835
333993	Packaging machinery manufacturing	$83,714	$54,872	$9,742
333994	Industrial process furnace and oven manufacturing	$42,523	$34,418	$5,631
333995	Fluid power cylinder and actuator manufacturing	$78,057	$32,249	$3,955
333996	Fluid power pump and motor manufacturing	$53,535	$15,258	$2,670
333997	Scale and balance (except laboratory) manufacturing	$14,822	$12,129	$1,947
333999	All other miscellaneous general purpose machinery manufacturing	$207,006	$123,384	$32,637
334518	Watch, clock, and part manufacturing	$8,740	$6,646	$1,322
335211	Electric housewares and household fans	$13,928	$3,326	$0
335221	Household cooking appliance manufacturing	$30,077	$6,521	$722
335222	Household refrigerator and home freezer manufacturing	$32,118	$32,118	$0
335224	Household laundry equipment manufacturing	$30,521	$30,521	$0
335228	Other major household appliance manufacturing	$24,023	$1,917	$0
336111	Automobile manufacturing	$293,357	$293,357	$2,147
336112	Light truck and utility vehicle manufacturing	$404,778	$404,778	$795
336120	Heavy duty truck manufacturing	$125,181	$125,181	$943
336211	Motor vehicle body manufacturing	$187,131	$187,131	$12,371
336212	Truck trailer manufacturing	$126,512	$54,137	$5,147
336213	Motor home manufacturing	$84,073	$84,073	$1,193
336311	Carburetor, piston, piston ring, and valve manufacturing	$41,219	$10,269	$1,329
336312	Gasoline engine and engine parts manufacturing	$258,625	$65,767	$11,683
336322	Other motor vehicle electrical and electronic equipment manufacturing	$242,586	$71,423	$8,618
336330	Motor vehicle steering and suspension components (except spring) manufacturing	$153,960	$25,492	$2,876
336340	Motor vehicle brake system manufacturing	$132,114	$32,886	$2,386
336350	Motor vehicle transmission and power train parts manufacturing	$327,377	$46,869	$6,390
336370	Motor vehicle metal stamping	$431,985	$159,156	$5,759
336399	All other motor vehicle parts manufacturing	$583,803	$169,401	$16,021
336611	Ship building and repair	$8,749,619	$8,749,619	$212,021
336612	Boat building	$5,479,624	$2,612,088	$391,950

Table V-1: Annualized Costs, by Industry, for All General Industry and Maritime Entities Affected by the Proposed Silica Standard (continued)

NAICS	Industry	All Establish-ments	Small Firms (SBA-defined)	Very Small Entities (<20 Employees)
336992	Military armored vehicle, tank, and tank component manufacturing	$27,227	$27,227	$0
337215	Showcase, partition, shelving, and locker manufacturing	$233,720	$176,800	$28,216
339114	Dental equipment and supplies manufacturing	$351,955	$261,393	$79,876
339116	Dental laboratories	$1,439,004	$1,397,271	$1,040,112
339911	Jewelry (except costume) manufacturing	$1,560,353	$1,392,054	$533,353
339913	Jewelers' materials and lapidary work manufacturing	$320,878	$257,285	$86,465
339914	Costume jewelry and novelty manufacturing	$236,821	$242,158	$100,556
339950	Sign manufacturing	$294,919	$264,810	$89,586
423840	Industrial supplies, wholesalers	$177,299	$143,614	$50,612
482110	Rail transportation	$2,452,073	N/A	N/A
621210	Dental offices	$389,256	$370,174	$320,986
	Total	**$146,726,595**	**$86,520,059**	**$15,745,425**

Source: U.S. Dept. of Labor, OSHA, Directorate of Evaluation and Analysis, Office of Regulatory Analysis, based on ERG (2011).

Table V-2: Annualized Costs, by Industry for Construction Establishments Affected by the Proposed Silica Standard

NAICS	Industry	All Establish-ments	Small Firms (SBA-defined)	Very Small Entities
236100	Residential Building Construction	$23,288,881	$18,527,934	$13,837,293
236200	Nonresidential Building Construction	$39,664,913	$24,443,185	$10,777,269
237100	Utility System Construction	$46,718,413	$30,733,201	$8,578,771
237200	Land Subdivision	$1,110,789	$546,331	$546,331
237300	Highway, Street, and Bridge Construction	$30,807,861	$13,756,992	$4,518,038
237900	Other Heavy and Civil Engineering Construction	$7,164,210	$5,427,484	$1,650,007
238100	Foundation, Structure, and Building Exterior Contractors	$215,907,211	$152,160,159	$81,822,550
238200	Building Equipment Contractors	$4,902,138	$3,399,252	$1,839,588
238300	Building Finishing Contractors	$50,259,239	$36,777,673	$21,884,973
238900	Other Specialty Trade Contractors	$68,003,978	$53,432,213	$30,936,078
999000	State and local governments [a]	$23,338,234	$2,995,955	N/A
	Totals	**$511,165,867**	**$342,200,381**	**$176,390,899**

[a] Applies to state and local governments in State-Plan States.
Source: U.S. Dept. of Labor, OSHA, Directorate of Evaluation and Analysis, Office of Regulatory Analysis, based on ERG (2011).

Control Costs

Unit Control Costs

Methodology

ERG generated cost estimates for specific respirable crystalline silica control measures from product and technical literature, equipment vendors, industrial engineers, industrial hygienists, and other sources, as relevant to each item. Specific sources for each estimate are presented with the cost estimates. Wherever possible, objective cost estimates from recognized technical sources were used. Table V-3 provides details on control specifications and data sources underlying OSHA's unit cost estimates. OSHA invites comment on the accuracy of these unit costs.

Table V-3:
Source Information for the Unit Cost Estimates Used in OSHA's Preliminary Cost Analysis for General Industry and Maritime

Control [a]	Description	Ventilation Airflow (cfm)	Capital Cost [b]	Operating Cost	Annualized Capital Cost	Comment
Saw enclosure	8'x8'x8' wood/plastic	N/A	$487.70	$48.77	$118.95	Fabrication costs associated with in-plant work. Five-year life.
Cab enclosures	Enclosed cabs	N/A	$15,164.82	$5,307.69	$3,698.56	
LEV for hand held grinders	Shrouds + vacuum	N/A	$1,671.63	$585.07	$407.70	Vacuum plus shroud adapter (http://www.proventilation.com/products/productDetail.asp?id=15); 35% for maintenance and operating costs.
Upgraded abrasive blast cabinet	Improved maintenance and purchases for some	N/A	$4,666.10	$1,000.00	$664.35	Additional maintenance (of up to $2,000) or new cabinets ($8,000) (Norton, 2003)
Improved spray booth for pottery	Maintenance time & materials	N/A	$116.65	$114.68	$231.33	Annual: $100 materials plus 4 hours maintenance time
Improved LEV for ceramics spray booth	Increased air flow; per cfm	N/A	$3.21	$0.88	$3.21	25% of installed CFM price
Exhaust for saw, cut stone industry	Based on saw LEV (e.g., pg. 10-158, 159, 160, ACGIH, 2001)	450	$5,774.30	$1,577.35	$822.13	Typical saw cfm requirements.
LEV for hand chipping in cut stone	Granite cutting and finishing; (pg. 10-94, ACGIH, 2001)	600	$7,699.06	$2,103.14	$1,096.17	
Exhaust trimming machine	Based on abrasive cut-off saw; (pg. 10-134) (ACGIH, 2001)	500	$6,415.89	$1,752.61	$913.48	Opening of 2 sq ft assumed, with 250 cfm per ft^2
Bag opening	Bag opening station; (pg. 10-19, ACGIH, 2001)	1,513	$19,414.48	$5,303.41	$2,764.18	3.5'x1.5' opening; with ventilated bag crusher (200 cfm)
Conveyor ventilation	Conveyor belt ventilation; (pg. 10-70, ACGIH, 2001)	700	$8,982.24	$2,453.66	$1,278.87	Per take-off point, 2' wide belt.
Bucket elevator ventilation	Bucket elevator ventilation (pg. 10-68; ACGIH, 2001)	1,600	$20,530.84	$5,608.36	$2,923.13	2'x3'x30' casing; 4 take-offs @250 cfm; 100 cfm per sq ft of cross section

Table V-3: Source Information for the Unit Cost Estimates Used in OSHA's Preliminary Cost Analysis for General Industry and Maritime (continued)

Control [a]	Description	Ventilation Airflow (cfm)	Capital Cost [b]	Operating Cost	Annualized Capital Cost	Comment
Bin and hopper ventilation	Bin and hopper ventilation (pg. 10-69; ACGIH, 2001)	1,050	$13,473.36	$3,680.49	$1,918.30	350 cfm per ft^2; 3' belt width
Screen ventilation	Ventilated screen (pg. 10-173, ACGIH, 2001)	1,200	$15,398.13	$4,206.27	$2,192.35	4'x6' screen; 50 cfm per ft^2
Batch operator workstation	Bin & hopper ventilation for unvented mixers (pg. 10-69, ACGIH, 2001)	1,050	$13,473.36	$3,680.49	$1,918.30	
LEV for hand grinding operator (pottery)	Hand grinding bench (pg. 10-135, ACGIH, 2001)	3,750	$48,119.16	$13,144.60	$6,851.09	
LEV, mixer and muller hood	Mixer & muller hood (pg. 10-87, ACGIH, 2001)	1,050	$13,473.36	$3,680.49	$1,918.30	
LEV for bag filling stations	Bag filling station (pg. 10-15, ACGIH, 2001)	1,500	$19,247.66	$5,257.84	$2,740.43	Includes costs for air shower
Installed manual spray mister	Manual controls, system covers 100 ft of conveyor	N/A	$10,207.09	$1,020.71	$1,453.26	National Environmental Services Company (Kestner, 2003).
Install cleaning hoses, reslope floor, drainage	Plumbing for hose installations, floor resloping and troughs	N/A	$36,412.40	$3,258.87	$5,184.31	Includes cost of water and labor time.
Shakeout conveyor enclosure	Ventilated shakeout conveyor enclosure	10,000	$128,317.75	$35,052.26	$18,269.56	
Shakeout side-draft ventilation	Shakeout double side-draft table (pg. 10-23, ACGIH, 2001)	28,800	$369,555.11	$100,950.52	$52,616.33	
Shakeout enclosing hood	Ventilated enclosing hood (pg. 10-23, ACGIH, 2001); 4'x4' openings	7,040	$90,335.69	$24,676.79	$12,861.77	

Table V-3: Source Information for the Unit Cost Estimates Used in OSHA's Preliminary Cost Analysis for General Industry and Maritime (continued)

Control [a]	Description	Ventilation Airflow (cfm)	Capital Cost [b]	Operating Cost	Annualized Capital Cost	Comment
Small knockout table	Portable grinding table (pg. 10-136, ACGIH, 2001), 3'x3' opening	1,350	$17,322.90	$4,732.06	$2,466.39	
Large knockout table	Hand grinding table (pg. 10-135, ACGIH, 2001), 4'x6' surface	4,800	$61,592.52	$16,825.09	$8,769.39	
Ventilated abrasive cutoff saw	Ventilated cut-off saw (pg. 10-134, ACGIH, 2001), 2'x3' opening	1,500	$19,247.66	$5,257.84	$2,740.43	
Hand grinding bench (foundry)	Bench with LEV (pg. 10-135, ACGIH, 2001); 3'x5'	3,750	$48,119.16	$13,144.60	$6,851.09	250 cfm per ft^2
Forming operator bench (pottery)	Bench with LEV (pg. 10-149, ACGIH, 2001), 3'x4'	1,400	$17,964.48	$4,907.32	$2,557.74	125 cfm per linear foot
Hand grinding bench (pottery)	Bench with LEV (pg. 10-135, ACGIH, 2001); 3'x4'	2,400	$30,796.26	$8,412.54	$4,384.69	200 cfm per ft^2.
Hand tool hardware	Retrofit suction attachment	200	$464.21	$701.05	$66.09	
Clean air island	Clean air supplied directly to worker	2,500	$32,079.44	$8,763.07	$4,567.39	125 cfm per ft^2 for 20 square feet
Water fed chipping equipment drum cleaning	Shop-built water feed equipment	N/A	$116.65	$0.00	$116.65	$100 in annual costs
Ventilation for drum cleaning	Ventilation blower and ducting	N/A	$792.74	$198.18	$193.34	Electric blower (1,277 cfm) and 25 ft. of duct. Northern Safety Co. (p. 193)
Control room	10'x10' ventilated control room with HEPA filter	200	$19,556.79	$701.05	$2,784.45	RSMeans (2003), ACGIH (2001)
Control room improvement	Repair and improve control room enclosure	N/A	$2,240.00	N/A	$318.93	Repairs are 20% of new control room cost.
Improved bag valves	Bags with extended polyethylene valve, incremental cost per bag	N/A	$0.01	N/A	N/A	Cecala et. al., (1986)

Table V-3: Source Information for the Unit Cost Estimates Used in OSHA's Preliminary Cost Analysis for General Industry and Maritime (continued)

Control [a]	Description	Ventilation Airflow (cfm)	Capital Cost [b]	Operating Cost	Annualized Capital Cost	Comment
Dust suppressants	Kleen Products 50 lb poly bag green sweeping compound	N/A	N/A	$634.54	$0.00	$0.28/lb, 2 lbs/day; 5 minutes/day Fastenal (2007).
HEPA vacuum for housekeeping	NILFISK VT60 wet/dry hepa vac, 15 gal	N/A	$3,494.85	$511.20	$852.36	Nilfisk, HEPA vacuum (http://www.sylvane.com/nilfisk.html)
HEPA vacuum for housekeeping	NILFISK, large capacity	N/A	$7,699.06	$988.90	$1,877.73	Nilfisk, HEPA vacuum (McCarthy, 2003)
Yard dust suppression	100 ft, 1" contractor hose and nozzle	N/A	$204.14	$0.00	$112.91	Contactor hose and nozzle; 2 year life; (www.pwmall.com)
Wet methods to clean concrete mixing equip.	10 mins per day per operator	N/A	$0.00	$916.82	$0.00	10 mins per day per mixer operator
HEPA vacuum substitute for compressed air	Incremental time to remove dust by vacuum	N/A	N/A	$494.54	$0.00	5 min per day per affected worker
Spray system for wet concrete finishing	Shop-built sprayer system	N/A	$204.67	$20.47	$113.20	$100 in materials and 4 hours to fabricate. Also 10% for maintenance
Substitute alt., non-silica, blasting media	Alternative media estimated to cost 22 percent more	N/A	$0.00	$33,646.00	$0.00	212,000 square feet of coverage per year per crew

[a] For local exhaust ventilation (LEV), maintenance, and conveyor covers, OSHA applied the following estimates:
LEV: capital cost = $12.83 per cfm; operating cost = $3.51 per cfm; annualized capital cost = $1.83 per cfm; based on current energy prices and the estimates of consultants to ERG (2011)
Maintenance: estimated as 10% of capital cost
Conveyor Covers: estimated as $17.10 per linear foot for 100 ft. (Landola, 2003); capital cost = $19.95 per linear ft., including all hardware; annualized capital cost = $2.84 per linear ft.
[b] Adjusted from 2003 price levels using an inflation factor of 1.166, calculated as the ratio of average annual GDP Implicit Price Deflator for 2009 and 2003.
Source: U.S. Dept. of Labor, OSHA, Directorate of Evaluation and Analysis, Office of Regulatory Analysis, based on ERG (2011).

In developing cost estimates, ERG made a variety of estimates about the size or scope of the engineering or work practice changes necessary to reduce silica exposures. These estimates reflect the representative conditions for the affected workers based on technical literature, judgments of knowledgeable consultants and industry observers, and other sources. The estimates are specified in the cost analysis tables with other cost source information. A detailed list of the specific costing assumptions and information sources for each control, grouped by job category or industry sector, is shown in Appendix V-A, Table V-A-1 (whereas the data in Table V-3 apply across job and sector categories).

In order to estimate costs in a consistent manner and in a way that allowed them to be combined with the exposure profile, OSHA defined all costs on an annual basis. For capital costs, OSHA calculated the annualized capital cost, using a 7 percent discount rate over the expected lifetime of the capital item. The capital costs for long-lasting capital items (such as ventilation system improvements) were annualized over 10 years. OSHA estimated that, in the general industry and maritime sectors, any capital expenditure would also entail maintenance costs equal to 10 percent of the value of the capital investment annually. Some controls required only improved maintenance for existing equipment, such as abrasive blasting booths. In these cases, the costs were based on judgments of the amount of incremental maintenance work required per year.

Per-Worker Basis for Cost Calculations

Following ERG's methodology, OSHA estimated control costs on a per-worker basis, allowing the costs to be related directly to the estimates of overexposed workers. OSHA then multiplied the estimated control cost per worker by the numbers of overexposed workers for both the proposed PEL of 50 $\mu g/m^3$ and the alternative PEL of 100 $\mu g/m^3$, introduced for economic analysis purposes. The numbers of workers needing controls (i.e., workers overexposed) are based on the exposure profiles for at-risk occupations developed in the technological feasibility analysis in Chapter IV of this PEA and estimates of the number of workers employed in these occupations developed in the industry profile in Chapter III of this PEA. This worker-based method is necessary because, even though the Agency has data on the number of firms in each affected industry, on the occupations and industrial activities with worker exposure to silica, on exposure profiles of at-risk occupations, and on the costs of controlling silica exposure for specific industrial activities, OSHA does not have a way to match up these data at the firm level. Nor does OSHA have facility-specific data on worker exposure to silica or even facility-specific data on the level of activity involving worker exposure to silica. Thus, OSHA could not directly estimate per-affected-facility costs, but instead, first had to estimate aggregate compliance costs and then calculate the average per-affected-facility costs by dividing aggregate costs by the number of affected facilities.

In general, OSHA viewed the extent to which exposure controls are already in place to be reflected in the distribution of overexposures among the affected workers. Thus, for example, if 50 percent of workers in a given occupation are found to be overexposed relative to the proposed silica PEL, OSHA judged this equivalent to 50 percent of facilities lacking the relevant exposure controls. The remaining 50 percent of facilities are expected either to have installed the relevant controls or to engage in activities that do not require that the exposure controls be in place. To estimate the need for incremental controls on a per-worker basis, OSHA used the exposure profile information as the best available data.

There are two situations in which the proportionality assumption may oversimplify the estimation of the costs of the needed controls. First, some facilities may have the relevant controls in place but are still unable, for whatever reason, to achieve the PEL under consideration for all employees. ERG's review of the industrial hygiene literature and other source materials (as noted in ERG, 2007b, pg. 3-4), however, suggest that the large majority of overexposed workers lack relevant controls. Thus, OSHA has generally assumed that overexposures occur due to the absence of suitable controls. This assumption could, in some cases, result in an overestimate of costs where employers merely need to upgrade or better maintain existing controls or to improve work practices rather than to install and maintain new controls. Second, there may be situations where facilities do not have the relevant controls in place but nevertheless have only a fraction of all affected employees above the PEL. If, in such situations, an employer would have to install all the controls necessary to meet the PEL, OSHA would have underestimated the control costs. However, OSHA believes that, in general, employers could come into compliance by such methods as checking the work practices of the employee who is above the PEL or installing smaller amounts of LEV at costs that would be more or less proportional to the costs estimated using the assumption that all employees are exposed above the PEL. Nevertheless, there may be situations in which a complete set of controls would be necessary if even one employee in a work area is above the PEL. OSHA welcomes comment on the extent to which the estimation approach may yield underestimates or overestimates of costs.

Number of Workers Covered by a Control

The cost calculations include estimates of the number of workers whose exposures are addressed by each engineering control. Because working arrangements vary within occupations and across facilities of different sizes, there are no definitive data on how many workers are likely to be covered by a given set of controls. In many small facilities, especially those that might operate only one shift per day, some controls will limit exposures for only a single worker. Also, small facilities might have only one worker in certain affected occupational categories. More commonly, however, and especially in the principal production operations, several workers are likely to derive health benefits from each enhanced engineering control.

ERG made case-specific judgments of the number of workers affected by each engineering control (see Table 3-3 in ERG, 2007b). Many controls were estimated to benefit four workers, based on the judgment that there is often multi-shift work and that many work stations are shared by at least one other worker per shift. The costs of engineering controls involving equipment that is usable by multiple employees, such as High-Efficiency Particulate Air (HEPA) vacuums, were spread over larger groups of employees (e.g., six to eight workers).

Ventilation Costs

At many workstations, employers must improve ventilation to reduce silica exposures. Ventilation improvements will take a variety of forms at different workstations and in different facilities and industries. The cost of ventilation enhancements generally reflects the expense of ductwork and other equipment for the immediate workstation or individual location and, potentially, the cost of incremental capacity system-wide enhancements and increased operating costs for the heating, ventilation, and air conditioning (HVAC) system for the facility.

In considering the specific ventilation enhancements for given occupations, ERG (2007b) forecasted the type of local exhaust ventilation (LEV) and the approximate quantity in cubic feet per minute (cfm) of air flow required to reduce worker exposures. Facility-specific information on the extent and characteristics of the existing facility workplace ventilation systems was generally lacking. Nevertheless, OSHA judges that most ventilation enhancements will be incremental to existing workplace ventilation systems. Where workplaces have ventilation systems currently in place, compliant ventilation enhancements will often require that the existing systems be entirely replaced, the reason being that supplementing existing ventilation systems in an incremental fashion is not always cost-effective. Thus, to the extent that there exist ventilation systems where minor enhancement to air flow capacity could help achieve compliance cost-effectively, OSHA's preliminary cost analysis may not give full credit (in terms of cost reductions) for such in-place ventilation systems. In any case, as discussed in Chapter IV of this PEA on technological feasibility, the baseline conditions for most affected workers do not include significant baseline ventilation controls.

To develop generally applicable ventilation cost estimates, ERG worked with industrial hygienists and plant ventilation engineering specialists to derive workstation and facility-wide costs of LEV enhancements. ERG defined a set of workstation-specific and facility-wide ventilation estimates using suggested ventilation approaches described in the Industrial Ventilation Manual, 24th edition (ACGIH, 2001). ERG determined that over a wide range of circumstances, ventilation enhancement costs, which include a cost factor for HEPA filters and baghouses where needed, varied from roughly $9 per cfm to perhaps $18 per cfm. Because ERG lacked detailed data to estimate the specific ventilation installation costs for a given facility, ERG used an estimate of the likely average capital cost per cfm and applied it to all ventilation enhancements. Based on discussion with ventilation specialists, ERG judged that $12.83 per cfm is a reasonable overall representation of the likely capital costs of ventilation enhancements.[3] OSHA recognizes that some installations, including some small facilities, might incur higher capital costs per cfm. Nevertheless, OSHA believes that this unit capital cost ($12.83 per cfm) is suitably representative of the wide range of facilities requiring ventilation enhancements.

OSHA applied the per-cfm capital cost estimate to estimated cfm requirements for each workstation. In using the unit value ($12.83 per cfm), the cost estimates for each ventilation enhancement include both the cost of the LEV enhancement at the workstation

[3] This unit value ($12.83 per cfm) was derived by inflating ERG's 2003 estimate of $11 to 2009 dollars using the implicit price deflator of 1.167.

and the contribution of the enhancement to the overall facility ventilation system requirements. That is, each ventilation enhancement at a workstation will generate costs because of the immediate LEV installation and because of its use of general facility ventilation system capacity.

For operating costs, ERG's engineering consultants analyzed the costs of heating and cooling system operation for 12 widely distributed U.S. cities. The analysis, presented in Table 3-2 in the ERG report (ERG, 2007b), shows the heating and cooling British Thermal Unit (BTU) requirements for 60-hours-a-week operation (12 hours a day, Monday through Friday) or for a continuous 24-hour-a-day, year-round operation, with and without recirculation of plant air. Facilities that recirculate air have much lower ventilation system operating costs because they incur sharply lower costs to condition the air and eliminate the operating costs for the air makeup system.

Ventilation operating costs are based on a weighted average of the costs of four operating scenarios: 1) no recirculated air, continuous operation; 2) no recirculated air, operating 60 hours per week; 3) recirculated HEPA filtered air, continuous operation; and 4) recirculated HEPA filtered air, operating 60 hours per week. These scenarios were chosen to reflect the various types of operating system characteristics likely to be found among affected facilities. The weights and operating costs for each of these scenarios are shown below:

Ventilation Cost Averaging Assumptions		
Type of system	**Average Cost per CFM**	**Share of Total**
No recirculated air, continuous operation	$15.55	5.0%
No recirculated air, operating 60 hours per week	$5.78	15.0%
Recirculated HEPA filtered air, continuous operation	$1.40	20.0%
Recirculated HEPA filtered air, operating 60 hours per week (cost proportional to the number of hours operated)	$0.50	60.0%
Weighted average cost per CFM	**$2.22**	

ERG estimated the national average annual operating cost per cfm at $2.22. This estimate is a weighted average of the operating costs for facilities that recirculate air and those that require make-up air. The operating costs for HEPA-filter recirculated air were estimated at $0.50 cents per cfm for facilities operating 12 hours per day (60 hours per week), and $1.40 per cfm for those continuously operating 24 hours per day. The operating costs for facilities that do not recirculate air are $5.78 per cfm and $15.55 per cfm, respectively. In generating these estimates, ERG judged, on the basis of consultations with industry experts, that 80 percent of facilities would recirculate airflow, and that 75 percent within each group operate for 12 hours per day on weekdays, with the remainder operating continuously year-round for 24 hours a day. The assumptions about air recirculation have a substantial effect on the operating costs for the ventilation system.

ERG also added a maintenance factor to the operating cost estimates, which is equivalent to 10% of the capital cost investments of $12.83 per cfm for ventilation systems.

Underlying the cost results is the assumption that, over the course of the proposed one-year compliance period for engineering controls, employers would schedule installation of ventilation to minimize disruption of production, just as they would with any modification to their plant. OSHA welcomes comment and data on disruptions facilities might experience as a result of engineering control installation.

Other Control Cost Categories

Housekeeping and Dust Suppression Costs

For a number of occupations, the technological feasibility analysis indicates that improved housekeeping practices are needed to reduce silica exposures. The degree of incremental housekeeping depends upon how dusty the operations are and the applicability of HEPA vacuums or other equipment to the dust problem. The incremental costs for most such occupations reflect labor associated with additional housekeeping efforts. Because the incremental housekeeping labor will be required on virtually every work shift by most of the affected occupations, the costs of housekeeping are substantial. Employers also need to purchase HEPA vacuums and to incur the ongoing costs of HEPA vacuum filters. Tables V-A-1, V-A-2, and V-A-3 in Appendix V-A provide detailed specifications on the application of housekeeping and other dust-suppression controls in each occupational category and the sources of OSHA's unit cost data for such controls.

Some workplaces also must eliminate the use of compressed air in housekeeping tasks because it increases potential silica dust exposures. Employers in these workplaces would need to substitute wet cleaning or vacuum methods in place of compressed air. OSHA projects that these changes to controls will generate incremental housekeeping labor costs.

For some indoor dust suppression tasks, ERG assumed that dust suppression mixes are spread over the areas to be swept. These mixes are often sawdust-based with oil or other material that adheres to dust and allows it to be swept up without becoming airborne. For these products, ERG estimated usage rates and the incremental times necessary to employ them in housekeeping tasks.

For outdoor dust suppression, workers must often spray water over storage piles and raw material receiving areas. The methods by which water is provided can vary widely, from water trucks to available hoses. ERG judged that most facilities would make hoses available for spraying and that spraying requires a materials-handling worker to devote part of the workday to lightly spray the area for dust control.

Conveyor Covers and Other Enclosures

The technological feasibility analysis recommends reduction of silica exposures by enclosure of process equipment, such as conveyors, particularly where silica-containing materials are transferred (and notable quantities of dust become airborne), or where dust is generated, such as in sawing or grinding operations. ERG estimated the capital costs of conveyor covers as $19.95 per linear foot for 100 feet, based on Landola (2003), updated to 2009 dollars, and estimated the quantity of conveyors (measured in linear feet) to be covered (as summarized in footnote a in Table V-3).

Substitution of Low- or Non-Silica Inputs

For several industries, employers might lower silica exposures by substituting low- or non-silica inputs for existing inputs. While this option can be an extremely effective method for controlling silica in many industries, ERG did not cost this option. ERG determined that there were often complicating factors that restricted the potential for broad substitution of non-silica inputs throughout industry. For example, some products made with substitute ingredients were judged to be inferior in quality and potentially not viable in the market. In addition, the substitute silica ingredient might introduce adverse health risks of its own. Further, in several instances, the availability for use of reasonably inexpensive alternative non-silica ingredients was well known but the alternative was not selected as a control option by most firms. In light of these concerns, ERG opted not to include the option of non-silica substitutes in estimating the cost of the proposed rule.[4]

Selected Options That Are Not Costed

Consistent with ERG's cost model, OSHA chose not to estimate costs for some control options mentioned in the accompanying technological feasibility analysis in Chapter IV of this PEA. In these cases, ERG judged that other control options for a specific at-risk occupation were sufficient to meet the PEL.

Aggregate Control Costs

Table V-A-2 in Appendix V-A shows, by job category within affected sectors, the capital cost and annualized cost of individual engineering controls, the LEV requirements in cfm (where applicable), the number of workers whose exposure is reduced for each control, and the associated cost per worker. As the table indicates, a large variety of controls must be applied in the affected industrial sectors. Some sectors rely primarily on dust reduction and dust management techniques, with only a few ventilation enhancements. Other sectors, such as the dustiest operations (foundries, structural clay), are expected to require a variety of ventilation enhancements to achieve compliance with the proposed PEL.

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[4] OSHA recognized that some silica substitutes are already being used for some industrial activities. To the extent that the proposed rule induces some firms to switch to less costly silica substitutes, OSHA will have overestimated the costs of the proposed rule. Offsetting OSHA's potential overestimate of costs would be any negative adverse health effects associated with silica substitutes. Thus, the response of affected firms to switch to substitutes could lower both the costs and the benefits of the proposed rule.

Table V-A-1 in Appendix V-A details the sources and bases for each of the specific control cost estimates. Some additional detail about the specific control technologies is provided in Chapter IV of this PEA.

Costs for Abrasive Blasting in Maritime Industries

Based on ERG (2011), OSHA estimated the control costs for abrasive blasters in maritime industries. Table V-4 presents the unit costs and analytical assumptions underlying OSHA's cost analysis of controlling silica exposures during abrasive blasting operations. As shown in the table, after accounting for the number of affected workers, crew size, daily output, blasting cost per square foot, number of blasting days per year, and the percentage of crews using sand, OSHA estimates that baseline annual costs for sand blasting in maritime industries total $85.3 million. According to ERG (2011), the incremental cost for wet blasting is equal to 30 percent of baseline costs; ERG further estimates that 50 percent of crews currently use wet methods. Therefore, the costs to comply with the proposed standard by using wet methods during abrasive sand blasting are expected to total $12.8 million annually, or $2,813 per worker for the approximately 4,550 workers exposed to silica dust.

Table V-4: Unit and Total Compliance Costs and Cost Parameters for Abrasive Blasting Operations - Maritime Industries

Cost Variable		Cost or Parameter	Comment
Numbers of workers in blasting operations [a]			
336611	Ship Building and Repair	2,798	
336612	Boat Building	1,752	
	Total	4,550	
Blasting crew size		4	ERG estimate based on RSMeans (2008)
Output per day (square ft.)		1,500	ERG estimate based on RSMeans (2008)
Blasting cost per square foot (dry blasting)		$2.00	ERG estimate based on RSMeans (2008)
Blasting days per year		125	ERG estimate
Percent of blasting crews using sand		20.0%	ERG estimate
Annual cost of sand blasting		$85,313,512	
Incremental cost for wet blasting		30.0%	ERG estimate based on RSMeans (2008)
Share of blasting currently with wet methods		50.0%	ERG estimate
Cost of requiring all sand blasting to use wet methods		$12,797,027	
Cost per blasting worker		$2,813	
Costs by Industry			
336611	Ship Building and Repair	$7,868,944	
336612	Boat Building	$4,928,083	

[a] Based on 2006 County Business Patterns employment data and the employment shares for construction and maintenance painters and for transportation equipment painters for NAICS 336600 Ship and Boatbuilding derived from BLS, OES data.
Sources: U.S. Dept. of Labor, OSHA, Directorate of Evaluation and Analysis, Office of Regulatory Analysis, based on ERG (2011).

Summary of Control Costs

Table V-5 summarizes the estimated number of at-risk workers and the annualized silica control costs for each industry sector. Control costs in general industry and maritime are expected to total $101.2 million annually at the 50 $\mu g/m^3$ level. As shown, sector-level costs exceed $5.0 million annually for captive foundries, concrete products, cut stone, iron foundries, non-sand casting foundries, ready-mix concrete, shipyards, and structural clay. Costs shown for shipyards reflect the costs of complying with abrasive blasting requirements shown in Table V-4.

Table V-6 shows aggregate annual control costs in general industry and maritime by NAICS code industry. These costs reflect the disaggregation of sector costs among the industries that comprise each sector. (See Table III-1 in Chapter III of this PEA on the profile of affected industries.) As one would expect, those industries with the highest number of workers exposed above the proposed PEL tend to show the highest levels of control costs.

Table V-5: Control Costs in General Industry and Maritime Associated with the Proposed Silica Standard, by Sector (PEL = 50)

Sector	Total Employees	Employees Exposed Above PEL = 50		Control Costs
		Number	Percent	
Asphalt Paving Products	14,471	48	0.3%	$179,111
Asphalt Roofing Materials	12,631	1,963	15.5%	$2,194,150
Captive Foundries	2,407,045	6,850	0.3%	$6,993,368
Concrete Products	112,938	19,204	17.0%	$14,798,966
Costume Jewelry	6,775	459	6.8%	$34,979
Cut Stone	30,633	7,441	24.3%	$5,894,506
Dental Equipment	15,550	274	1.8%	$272,308
Dental Laboratories	864,484	1,329	0.2%	$128,834
Fine Jewelry	30,479	4,121	13.5%	$313,923
Flat Glass	11,003	154	1.4%	$227,805
Iron Foundries	59,209	11,140	18.8%	$11,372,127
Mineral Processing	6,629	891	13.4%	$3,585,439
Mineral Wool	19,241	632	3.3%	$897,980
Nonferrous Sand Casting Foundries	20,150	3,817	18.9%	$3,910,170
Non-Sand Casting Foundries	33,674	6,367	18.9%	$6,522,470
Other Ferrous Sand Casting Foundries	17,722	3,334	18.8%	$3,403,790
Other Glass Products	35,017	1,007	2.9%	$1,532,788
Paint and Coatings	46,209	404	0.9%	$0
Porcelain Enameling	261,594	1,916	0.7%	$2,824,360
Pottery	21,200	4,777	22.5%	$4,088,295
Railroads	NA	5,629	NA	$0
Ready-Mix Concrete	107,190	32,110	30.0%	$7,029,710
Refractories	10,115	823	8.1%	$688,544
Refractory Repair	111,198	153	0.1%	$97,304
Shipyards [a]	142,057	3,250	2.3%	$12,797,027
Structural Clay	22,206	4,377	19.7%	$11,451,554
All sectors [b]	**4,406,990**	**122,472**	**2.8%**	**$101,239,507**

[a] Includes abrasive blasting compliance costs for shipyards (NAICS 336611; 336612)

[b] Adjusted for double counting of industries that are included in more than one sector.

Source: U.S. Dept. of Labor, OSHA, Directorate of Evaluation and Analysis, Office of Regulatory Analysis, based on ERG (2007b) and ERG (2011).

Table V-6: Silica Control Costs by Industry (PEL=50)

NAICS	Industry Title	Total Employees	Employees Exposed Above PEL = 50		Control Costs
			Number	Percent	
324121	Asphalt paving mixture and block manufacturing	14,471	48	0.3%	**$179,111**
324122	Asphalt shingle and	12,631	1,963	15.5%	**$2,194,150**

Table V-6: Silica Control Costs by Industry (PEL=50)

NAICS	Industry Title	Total Employees	Employees Exposed Above PEL = 50		Control Costs
			Number	Percent	
	roofing materials				
325510	Paint and coating manufacturing	46,209	404	0.9%	**$0**
327111	Vitreous china plumbing fixtures & bathroom accessories manufacturing	5,854	1,319	22.5%	**$1,128,859**
327112	Vitreous china, fine earthenware, & other pottery product manufacturing	9,178	2,068	22.5%	**$1,769,953**
327113	Porcelain electrical supply mfg	6,168	1,390	22.5%	**$1,189,482**
327121	Brick and structural clay mfg	13,509	2,663	19.7%	**$6,966,654**
327122	Ceramic wall and floor tile mfg	7,094	1,398	19.7%	**$3,658,389**
327123	Other structural clay product mfg	1,603	316	19.7%	**$826,511**
327124	Clay refractory manufacturing	4,475	364	8.1%	**$304,625**
327125	Nonclay refractory manufacturing	5,640	459	8.1%	**$383,919**
327211	Flat glass manufacturing	11,003	154	1.4%	**$227,805**
327212	Other pressed and blown glass and glassware manufacturing	20,625	593	2.9%	**$902,802**
327213	Glass container manufacturing	14,392	414	2.9%	**$629,986**
327320	Ready-mixed concrete manufacturing	107,190	32,110	30.0%	**$7,029,710**
327331	Concrete block and brick mfg	22,738	3,866	17.0%	**$2,979,495**
327332	Concrete pipe mfg	14,077	2,394	17.0%	**$1,844,576**
327390	Other concrete product mfg	66,095	11,239	17.0%	**$8,660,830**
327991	Cut stone and stone product manufacturing	30,633	7,441	24.3%	**$5,894,506**

Table V-6: Silica Control Costs by Industry (PEL=50) (continued)

NAICS	Industry Title	Total Employees	Employees Exposed Above PEL = 50		Control Costs
			Number	Percent	
327992	Ground or treated mineral and earth manufacturing	6,629	891	13.4%	**$3,585,439**
327993	Mineral wool manufacturing	19,241	632	3.3%	**$897,980**
327999	All other misc. nonmetallic mineral product mfg	10,028	1,705	17.0%	**$1,314,066**
331111	Iron and steel mills	108,592	309	0.3%	**$315,559**
331112	Electrometallurgical ferroalloy product manufacturing	2,198	6	0.3%	**$6,375**
331210	Iron and steel pipe and tube manufacturing from purchased steel	21,543	61	0.3%	**$62,639**
331221	Rolled steel shape manufacturing	10,857	31	0.3%	**$31,618**
331222	Steel wire drawing	14,669	42	0.3%	**$42,648**
331314	Secondary smelting and alloying of aluminum	7,381	21	0.3%	**$21,359**
331423	Secondary smelting, refining, and alloying of copper	1,278	4	0.3%	**$3,655**
331492	Secondary smelting, refining, and alloying of nonferrous metal (except cu & al)	9,383	27	0.3%	**$27,338**
331511	Iron foundries	59,209	11,140	18.8%	**$11,372,127**
331512	Steel investment foundries	16,429	3,100	18.9%	**$3,175,862**
331513	Steel foundries (except investment)	17,722	3,334	18.8%	**$3,403,790**
331524	Aluminum foundries (except die-casting)	26,565	5,032	18.9%	**$5,155,172**
331525	Copper foundries (except die-casting)	6,120	1,159	18.9%	**$1,187,578**
331528	Other nonferrous foundries (except die-casting)	4,710	892	18.9%	**$914,028**
332111	Iron and steel forging	26,596	76	0.3%	**$77,324**
332112	Nonferrous forging	8,814	25	0.3%	**$25,529**
332115	Crown and closure manufacturing	3,243	9	0.3%	**$9,381**
332116	Metal stamping	64,724	184	0.3%	**$188,102**
332117	Powder metallurgy part manufacturing	8,362	24	0.3%	**$24,250**
332211	Cutlery and flatware (except precious) manufacturing	5,779	16	0.3%	**$16,763**
332212	Hand and edge tool manufacturing	36,622	104	0.3%	**$106,344**
332213	Saw blade and handsaw manufacturing	7,304	21	0.3%	**$21,272**
332214	Kitchen utensil, pot, and pan manufacturing	3,928	11	0.3%	**$11,442**
332323	Ornamental and architectural metal work	39,947	19	0.0%	**$28,010**

Table V-6: Silica Control Costs by Industry (PEL=50) (continued)

NAICS	Industry Title	Total Employees	Employees Exposed Above PEL = 50		Control Costs
			Number	Percent	
332439	Other metal container manufacturing	15,195	43	0.3%	**$44,028**
332510	Hardware manufacturing	45,282	129	0.3%	**$131,574**
332611	Spring (heavy gauge) manufacturing	4,059	12	0.3%	**$11,792**
332612	Spring (light gauge) manufacturing	15,336	44	0.3%	**$44,511**
332618	Other fabricated wire product manufacturing	36,364	104	0.3%	**$105,686**
332710	Machine shops	266,597	759	0.3%	**$774,529**
332812	Metal coating and allied services	56,978	1,632	2.9%	**$2,431,996**
332911	Industrial valve manufacturing	38,330	109	0.3%	**$111,334**
332912	Fluid power valve and hose fitting manufacturing	35,519	101	0.3%	**$103,246**
332913	Plumbing fixture fitting and trim manufacturing	11,513	33	0.3%	**$33,484**
332919	Other metal valve and pipe fitting manufacturing	18,112	51	0.3%	**$52,542**
332991	Ball and roller bearing manufacturing	27,197	77	0.3%	**$79,038**
332996	Fabricated pipe and pipe fitting manufacturing	27,201	77	0.3%	**$78,951**
332997	Industrial pattern manufacturing	5,281	15	0.3%	**$15,383**
332998	Enameled iron and metal sanitary ware manufacturing	5,655	38	0.7%	**$46,581**
332999	All other miscellaneous fabricated metal product manufacturing	72,201	205	0.3%	**$209,692**
333319	Other commercial and service industry machinery manufacturing	53,012	151	0.3%	**$154,006**
333411	Air purification equipment manufacturing	14,883	42	0.3%	**$43,190**
333412	Industrial and commercial fan and blower manufacturing	10,506	30	0.3%	**$30,549**
333414	Heating equipment (except warm air furnaces) manufacturing	20,577	59	0.3%	**$59,860**
333511	Industrial mold manufacturing	39,917	114	0.3%	**$116,034**
333512	Machine tool (metal cutting types) manufacturing	17,220	49	0.3%	**$49,965**
333513	Machine tool (metal forming types) manufacturing	8,556	24	0.3%	**$24,850**

Table V-6: Silica Control Costs by Industry (PEL=50) (continued)

NAICS	Industry Title	Total Employees	Employees Exposed Above PEL = 50		Control Costs
			Number	Percent	
333514	Special die and tool, die set, jig, and fixture manufacturing	57,576	164	0.3%	**$167,204**
333515	Cutting tool and machine tool accessory manufacturing	34,922	99	0.3%	**$101,385**
333516	Rolling mill machinery and equipment manufacturing	3,020	9	0.3%	**$8,897**
333518	Other metalworking machinery manufacturing	12,470	35	0.3%	**$36,232**
333612	Speed changer, industrial high-speed drive, and gear manufacturing	12,374	35	0.3%	**$35,962**
333613	Mechanical power transmission equipment manufacturing	15,645	44	0.3%	**$45,422**
333911	Pump and pumping equipment manufacturing	30,764	88	0.3%	**$89,460**
333912	Air and gas compressor manufacturing	21,417	61	0.3%	**$62,241**
333991	Power-driven handtool manufacturing	8,714	25	0.3%	**$25,377**
333992	Welding and soldering equipment manufacturing	15,853	45	0.3%	**$46,136**
333993	Packaging machinery manufacturing	21,179	60	0.3%	**$61,479**
333994	Industrial process furnace and oven manufacturing	10,720	31	0.3%	**$31,154**
333995	Fluid power cylinder and actuator manufacturing	19,887	57	0.3%	**$57,771**
333996	Fluid power pump and motor manufacturing	13,631	39	0.3%	**$39,598**
333997	Scale and balance (except laboratory) manufacturing	3,748	11	0.3%	**$10,853**
333999	All other miscellaneous general purpose machinery manufacturing	52,454	149	0.3%	**$152,444**
334518	Watch, clock, and part manufacturing	2,188	6	0.3%	**$6,389**
335211	Electric housewares and household fans	7,425	8	0.1%	**$11,336**
335221	Household cooking appliance manufacturing	16,033	16	0.1%	**$24,478**
335222	Household refrigerator and home freezer manufacturing	17,121	17	0.1%	**$26,139**
335224	Household laundry equipment manufacturing	16,269	17	0.1%	**$24,839**

Table V-6: Silica Control Costs by Industry (PEL=50) (continued)

NAICS	Industry Title	Total Employees	Employees Exposed Above PEL = 50		Control Costs
			Number	Percent	
335228	Other major household appliance manufacturing	12,806	13	0.1%	**$19,551**
336111	Automobile manufacturing	75,225	214	0.3%	**$218,635**
336112	Light truck and utility vehicle manufacturing	103,815	296	0.3%	**$301,676**
336120	Heavy duty truck manufacturing	32,122	91	0.3%	**$93,229**
336211	Motor vehicle body manufacturing	47,566	135	0.3%	**$138,218**
336212	Truck trailer manufacturing	32,260	92	0.3%	**$93,781**
336213	Motor home manufacturing	21,533	61	0.3%	**$62,548**
336311	Carburetor, piston, piston ring, and valve manufacturing	10,537	30	0.3%	**$30,612**
336312	Gasoline engine and engine parts manufacturing	66,112	188	0.3%	**$192,076**
336322	Other motor vehicle electrical and electronic equipment manufacturing	62,016	176	0.3%	**$180,164**
336330	Motor vehicle steering and suspension components (except spring) manufacturing	39,390	112	0.3%	**$114,457**
336340	Motor vehicle brake system manufacturing	33,782	96	0.3%	**$98,118**
336350	Motor vehicle transmission and power train parts manufacturing	83,756	238	0.3%	**$243,348**
336370	Motor vehicle metal stamping	110,578	315	0.3%	**$321,190**
336399	All other motor vehicle parts manufacturing	149,251	425	0.3%	**$433,579**
336611	Ship building and repair	87,352	1,998	2.3%	**$7,868,944**
336612	Boat building	54,705	1,252	2.3%	**$4,928,083**
336992	Military armored vehicle, tank, and tank component manufacturing	6,899	20	0.3%	**$20,097**
337215	Showcase, partition, shelving, and locker manufacturing	59,080	168	0.3%	**$171,563**
339114	Dental equipment and supplies manufacturing	15,550	274	1.8%	**$272,308**
339116	Dental laboratories	47,088	1,071	2.3%	**$103,876**
339911	Jewelry (except costume) manufacturing	25,280	3,418	13.5%	**$260,378**
339913	Jewelers' materials and lapidary work manufacturing	5,199	703	13.5%	**$53,545**

Table V-6: Silica Control Costs by Industry (PEL=50) (continued)

NAICS	Industry Title	Total Employees	Employees Exposed Above PEL = 50		Control Costs
			Number	Percent	
339914	Costume jewelry and novelty manufacturing	6,775	479	7.1%	**$54,734**
339950	Sign manufacturing	89,360	172	0.2%	**$227,905**
423840	Industrial supplies, wholesalers	111,198	153	0.1%	**$97,304**
482110	Rail transportation	N/A	5,629	N/A	**$0**
621210	Dental offices	817,396	257	0.0%	**$24,957**
	Total	**4,406,990**	**122,472**		**$101,239,507**

Note: Includes abrasive blasting compliance costs for shipyards (NAICS 336611)
Source: U.S. Dept. of Labor, OSHA, Directorate of Evaluation and Analysis, Office of Regulatory Analysis, based on ERG (2007b) and ERG (2011).

Respirator Costs

OSHA's cost estimates assume that implementation of the recommended controls prevents workers in general industry and maritime from being exposed over the PEL in most cases. Specifically, based on its technological feasibility analysis, OSHA expects that the technical controls are adequate to keep exposures at or below the PEL for an alternative PEL of 100 $\mu g/m^3$ (examined for analytical purposes).[5] For the proposed 50 $\mu g/m^3$ PEL, OSHA's feasibility analysis suggests that the controls that employers use, either because of technical limitations or imperfect implementation, might not be adequate in all cases to ensure that worker exposures in all affected job categories are at or below 50 $\mu g/m^3$. For this preliminary cost analysis, OSHA estimated that ten percent of the workers in general industry with current silica exposures above 50 $\mu g/m^3$ would require respirators, at least occasionally, after the implementation of engineering controls to achieve the proposed PEL. After considering the choice of disposable vs. non-disposable respirators as control options for costing purposes, OSHA determined that, with the exception of workers authorized to enter regulated areas, non-disposable respirators would be more cost-effective. For workers in maritime, the only activity with silica exposures above the proposed PEL of 50 $\mu g/m^3$ is abrasive blasting, and maritime workers engaged in abrasive blasting are already required to use respirators under existing OSHA standards. Therefore, OSHA has estimated no additional costs for maritime workers to use respirators as a result of the proposed silica rule.

ERG (2011) used respirator cost information from a 2003 OSHA respirator study to estimate the annual cost of $570.13 (in 2009 dollars) for a non-disposable half-mask, non-powered, air-purifying respirator (ERG, 2003). This unit cost includes expenses for accessories, training, fit testing, and cleaning. (Further discussion of respirator cost estimates and their source is provided in the construction industry section on respirator costs.) As shown in Table V-7, applying this cost to the workers exposed above the 50 μ/m^3 PEL results in total costs for respirator use of $6.8 million annually.[6]

In addition to bearing the costs associated with the provision of respirators, employers will incur a cost burden to establish respirator programs. OSHA projects that this expense will involve an initial 8 hours for establishments with 500 or more employees and 4 hours for all other firms. After the first year, OSHA estimates that 20 percent would revise the program every year, with the largest establishments (500 or more employees) expending 4 hours for program revision, and all other employers expend two hours for program revision. OSHA expects that half of the establishments in general industry and all of the establishments in maritime that require respirator use to achieve compliance already have a respirator program. Table V-7 presents respirator program costs and combines those program costs with the costs for respirator use to produce total annual costs of $6.9 million for respiratory protection in general industry and maritime.

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[5] As a result, OSHA expects that establishments in general industry do not currently use respirators to comply with the current OSHA PEL for quartz of approximately 100 $\mu g/m^3$.

[6] Note that these respirator costs do not include the costs of disposable respirators used in regulated areas. The costs for these disposable respirators are separately estimated in Table V-16 in this chapter as part of regulated area costs.

Table V-7: Respirator Costs for Employers in General Industry and Maritime Affected by OSHA's Proposed Silica Standard

NAICS	Industry	No. of Workers at Risk	No. of Workers Using Respirators [a]	Costs for Respirator Use [b]	Costs for Respirator Programs	Total Costs for Respiratory Protection
324121	Asphalt paving mixture and block manufacturing	48	5	$2,735	$49	**$2,784**
324122	Asphalt shingle and roofing materials	1,963	196	$111,925	$1,999	**$113,924**
325510	Paint and coating manufacturing	404	40	$23,051	$395	**$23,445**
327111	Vitreous china plumbing fixtures & bathroom accessories manufacturing	1,319	132	$75,206	$1,296	**$76,502**
327112	Vitreous china, fine earthenware, & other pottery product manufacturing	2,068	207	$117,917	$2,032	**$119,948**
327113	Porcelain electrical supply mfg	1,390	139	$79,245	$1,365	**$80,610**
327121	Brick and structural clay mfg	2,663	266	$151,804	$2,236	**$154,040**
327122	Ceramic wall and floor tile mfg	1,398	140	$79,716	$1,265	**$80,982**
327123	Other structural clay product mfg	316	32	$18,010	$310	**$18,320**
327124	Clay refractory manufacturing	364	36	$20,750	$358	**$21,108**
327125	Nonclay refractory manufacturing	459	46	$26,152	$451	**$26,602**
327211	Flat glass manufacturing	154	15	$8,808	$152	**$8,960**
327212	Other pressed and blown glass and glassware manufacturing	593	59	$33,815	$583	**$34,398**
327213	Glass container manufacturing	414	41	$23,597	$407	**$24,003**
327320	Ready-mixed concrete manufacturing	32,110	3,211	$1,830,680	$31,541	**$1,862,221**
327331	Concrete block and brick mfg	3,866	387	$220,429	$3,798	**$224,227**
327332	Concrete pipe mfg	2,394	239	$136,465	$2,351	**$138,817**
327390	Other concrete product mfg	11,239	1,124	$640,746	$11,039	**$651,785**
327991	Cut stone and stone product manufacturing	7,441	744	$424,256	$7,502	**$431,758**
327992	Ground or treated mineral and earth manufacturing	891	89	$50,819	$899	**$51,718**

Table V-7: Respirator Costs for Employers in General Industry and Maritime Affected by OSHA's Proposed Silica Standard (continued)

NAICS	Industry	No. of Workers at Risk	No. of Workers Using Respirators [a]	Costs for Respirator Use [b]	Costs for Respirator Programs	Total Costs for Respiratory Protection
327993	Mineral wool manufacturing	632	63	$36,017	$637	**$36,654**

Table V-7: Respirator Costs for Employers in General Industry and Maritime Affected by OSHA's Proposed Silica Standard (continued)

NAICS	Industry	No. of Workers at Risk	No. of Workers Using Respirators [a]	Costs for Respirator Use [b]	Costs for Respirator Programs	Total Costs for Respiratory Protection
327999	All other misc. nonmetallic mineral product mfg	1,705	171	$97,217	$1,719	**$98,936**
331111	Iron and steel mills	309	31	$17,623	$316	**$17,939**
331112	Electrometallurgical ferroalloy product manufacturing	6	1	$356	$6	**$362**
331210	Iron and steel pipe and tube manufacturing from purchased steel	61	6	$3,498	$54	**$3,552**
331221	Rolled steel shape manufacturing	31	3	$1,766	$27	**$1,793**
331222	Steel wire drawing	42	4	$2,382	$37	**$2,419**
331314	Secondary smelting and alloying of aluminum	21	2	$1,193	$20	**$1,213**
331423	Secondary smelting, refining, and alloying of copper	4	0	$204	$3	**$207**
331492	Secondary smelting, refining, and alloying of nonferrous metal (except cu & al)	27	3	$1,527	$25	**$1,551**
331511	Iron foundries	11,140	1,114	$635,102	$10,444	**$645,546**
331512	Steel investment foundries	3,100	310	$176,755	$2,884	**$179,639**
331513	Steel foundries (except investment)	3,334	333	$190,092	$3,102	**$193,194**
331524	Aluminum foundries (except die-casting)	5,032	503	$286,915	$4,657	**$291,571**
331525	Copper foundries (except die-casting)	1,159	116	$66,095	$1,177	**$67,272**
331528	Other nonferrous foundries (except die-casting)	892	89	$50,871	$830	**$51,701**
332111	Iron and steel forging	76	8	$4,318	$75	**$4,393**
332112	Nonferrous forging	25	3	$1,426	$25	**$1,451**
332115	Crown and closure manufacturing	9	1	$524	$8	**$532**
332116	Metal stamping	184	18	$10,505	$171	**$10,676**
332117	Powder metallurgy part manufacturing	24	2	$1,354	$21	**$1,375**
332211	Cutlery and flatware (except precious) manufacturing	16	2	$936	$16	**$952**
332212	Hand and edge tool manufacturing	104	10	$5,939	$102	**$6,041**
332213	Saw blade and handsaw manufacturing	21	2	$1,188	$21	**$1,209**
332214	Kitchen utensil, pot, and pan manufacturing	11	1	$639	$11	**$650**
332323	Ornamental and architectural metal work	19	2	$1,069	$20	**$1,089**
332439	Other metal container manufacturing	43	4	$2,459	$43	**$2,502**
332510	Hardware manufacturing	129	13	$7,348	$128	**$7,476**
332611	Spring (heavy gauge) manufacturing	12	1	$659	$11	**$670**
332612	Spring (light gauge) manufacturing	44	4	$2,486	$43	**$2,529**

Table V-7: Respirator Costs for Employers in General Industry and Maritime Affected by OSHA's Proposed Silica Standard (continued)

NAICS	Industry	No. of Workers at Risk	No. of Workers Using Respirators [a]	Costs for Respirator Use [b]	Costs for Respirator Programs	Total Costs for Respiratory Protection
332618	Other fabricated wire product manufacturing	104	10	$5,902	$103	**$6,005**
332710	Machine shops	759	76	$43,255	$819	**$44,074**
332812	Metal coating and allied services	1,632	163	$93,070	$1,619	**$94,689**
332911	Industrial valve manufacturing	109	11	$6,218	$98	**$6,316**
332912	Fluid power valve and hose fitting manufacturing	101	10	$5,766	$97	**$5,863**
332913	Plumbing fixture fitting and trim manufacturing	33	3	$1,870	$31	**$1,901**
332919	Other metal valve and pipe fitting manufacturing	51	5	$2,934	$49	**$2,984**
332991	Ball and roller bearing manufacturing	77	8	$4,414	$74	**$4,488**
332996	Fabricated pipe and pipe fitting manufacturing	77	8	$4,409	$74	**$4,483**
332997	Industrial pattern manufacturing	15	2	$859	$14	**$874**
332998	Enameled iron and metal sanitary ware manufacturing	38	4	$2,188	$37	**$2,225**
332999	All other miscellaneous fabricated metal product manufacturing	205	21	$11,711	$205	**$11,915**
333319	Other commercial and service industry machinery manufacturing	151	15	$8,601	$140	**$8,741**
333411	Air purification equipment manufacturing	42	4	$2,412	$40	**$2,453**
333412	Industrial and commercial fan and blower manufacturing	30	3	$1,706	$29	**$1,735**
333414	Heating equipment (except warm air furnaces) manufacturing	59	6	$3,343	$56	**$3,399**
333511	Industrial mold manufacturing	114	11	$6,480	$117	**$6,597**
333512	Machine tool (metal cutting types) manufacturing	49	5	$2,790	$49	**$2,839**
333513	Machine tool (metal forming types) manufacturing	24	2	$1,388	$23	**$1,411**
333514	Special die and tool, die set, jig, and fixture manufacturing	164	16	$9,338	$175	**$9,513**
333515	Cutting tool and machine tool accessory manufacturing	99	10	$5,662	$102	**$5,764**
333516	Rolling mill machinery and equipment manufacturing	9	1	$497	$9	**$506**
333518	Other metalworking machinery manufacturing	35	4	$2,023	$37	**$2,060**
333612	Speed changer, industrial high-speed drive, and gear manufacturing	35	4	$2,008	$35	**$2,043**
333613	Mechanical power transmission equipment manufacturing	44	4	$2,537	$44	**$2,581**
333911	Pump and pumping equipment manufacturing	88	9	$4,996	$81	**$5,077**
333912	Air and gas compressor manufacturing	61	6	$3,476	$58	**$3,534**

Table V-7: Respirator Costs for Employers in General Industry and Maritime Affected by OSHA's Proposed Silica Standard (continued)

NAICS	Industry	No. of Workers at Risk	No. of Workers Using Respirators [a]	Costs for Respirator Use [b]	Costs for Respirator Programs	Total Costs for Respiratory Protection
333991	Power-driven handtool manufacturing	25	2	$1,417	$24	**$1,441**
333992	Welding and soldering equipment manufacturing	45	5	$2,577	$45	**$2,622**
333993	Packaging machinery manufacturing	60	6	$3,433	$58	**$3,491**
333994	Industrial process furnace and oven manufacturing	31	3	$1,740	$29	**$1,768**
333995	Fluid power cylinder and actuator manufacturing	57	6	$3,226	$53	**$3,280**
333996	Fluid power pump and motor manufacturing	39	4	$2,211	$35	**$2,247**
333997	Scale and balance (except laboratory) manufacturing	11	1	$606	$10	**$616**
333999	All other miscellaneous general purpose machinery manufacturing	149	15	$8,514	$143	**$8,657**
334518	Watch, clock, and part manufacturing	6	1	$357	$6	**$363**
335211	Electric housewares and household fans	8	1	$429	$8	**$437**
335221	Household cooking appliance manufacturing	16	2	$927	$17	**$944**
335222	Household refrigerator and home freezer manufacturing	17	2	$990	$18	**$1,009**
335224	Household laundry equipment manufacturing	17	2	$941	$17	**$958**
335228	Other major household appliance manufacturing	13	1	$741	$14	**$754**
336111	Automobile manufacturing	214	21	$12,210	$234	**$12,444**
336112	Light truck and utility vehicle manufacturing	296	30	$16,848	$322	**$17,170**
336120	Heavy duty truck manufacturing	91	9	$5,207	$96	**$5,303**
336211	Motor vehicle body manufacturing	135	14	$7,719	$130	**$7,849**
336212	Truck trailer manufacturing	92	9	$5,237	$87	**$5,325**
336213	Motor home manufacturing	61	6	$3,493	$64	**$3,557**
336311	Carburetor, piston, piston ring, and valve manufacturing	30	3	$1,710	$29	**$1,739**
336312	Gasoline engine and engine parts manufacturing	188	19	$10,727	$183	**$10,910**
336322	Other motor vehicle electrical and electronic equipment manufacturing	176	18	$10,062	$172	**$10,233**
336330	Motor vehicle steering and suspension components (except spring) manufacturing	112	11	$6,392	$112	**$6,504**
336340	Motor vehicle brake system manufacturing	96	10	$5,480	$94	**$5,573**
336350	Motor vehicle transmission and power train parts manufacturing	238	24	$13,590	$242	**$13,832**
336370	Motor vehicle metal stamping	315	31	$17,938	$299	**$18,237**

Table V-7: Respirator Costs for Employers in General Industry and Maritime Affected by OSHA's Proposed Silica Standard (continued)

NAICS	Industry	No. of Workers at Risk	No. of Workers Using Respirators [a]	Costs for Respirator Use [b]	Costs for Respirator Programs	Total Costs for Respiratory Protection
336399	All other motor vehicle parts manufacturing	425	42	$24,214	$413	**$24,628**
336611	Ship building and repair	1,998	N/A	N/A	N/A	**N/A**
336612	Boat building	1,252	N/A	N/A	N/A	**N/A**
336992	Military armored vehicle, tank, and tank component manufacturing	20	2	$1,122	$20	**$1,142**
337215	Showcase, partition, shelving, and locker manufacturing	168	17	$9,581	$159	**$9,741**
339114	Dental equipment and supplies manufacturing	274	27	$15,620	$281	**$15,901**
339116	Dental laboratories	1,071	107	$61,085	$1,098	**$62,183**
339911	Jewelry (except costume) manufacturing	3,418	342	$194,881	$3,540	**$198,421**
339913	Jewelers' materials and lapidary work manufacturing	703	70	$40,076	$728	**$40,804**
339914	Costume jewelry and novelty manufacturing	479	48	$27,283	$496	**$27,779**
339950	Sign manufacturing	172	17	$9,794	$178	**$9,972**
423840	Industrial supplies, wholesalers	153	15	$8,732	$179	**$8,910**
482110	Rail transportation	5,629	563	$320,953	$6,223	**$327,176**
621210	Dental offices	257	26	$14,676	$309	**$14,985**
	Totals	**122,472**	**11,922**	**$6,797,184**	**$117,041**	**$6,914,225**

[a] Assumes 10 percent of at-risk employees initially exposed above the PEL will use respirators. The integers in this column are rounded from figures that included decimal places. For example, the "0" referral for NAICS 331423 was rounded from a calculated value of 0.36.
[b] Based on $488.74 annualized cost for a half-mask, including accessories, training, fit testing, and cleaning. See ERG (2003). Costs inflated to $570.13 based on the 2003-2009 GDP implicit price deflator reported by the Bureau of Economic Analysis.
Source: U.S. Dept. of Labor, OSHA, Directorate of Evaluation and Analysis, Office of Regulatory Analysis, based on ERG (2003, 2007b, 2011).

Program Costs

This section presents OSHA's estimated costs for ancillary silica control programs for general industry and maritime as required under the proposed rule. Based on the program requirements contained in the proposed standard, OSHA considered four potential cost elements: exposure assessments (air monitoring), medical surveillance, provision of information and training, and regulated areas.

The worker population affected by each program element varies with the nature of the activity undertaken. The training requirements would apply to all at-risk workers—those with any potential workplace exposure to respirable crystalline silica. Some elements would apply to all workers exposed to silica at or above the action level, as defined by OSHA.[7] This level is below the PEL and therefore affects a larger share of workers. Other elements would apply to a smaller set of workers who are exposed above the PEL. The regulated area program elements triggered by the proposed PEL of 50 $\mu g/m^3$ (and all other program elements triggered by an action level of 50 $\mu g/m^3$ under an alternative PEL of 100 $\mu g/m^3$) would apply to those workers for whom feasible controls are not adequate. For the purposes of this cost analysis, OSHA estimated that, under the proposed rule, 10 percent of all affected workers in general industry and maritime with current exposures above the proposed PEL would fall in this category.

Exposure Assessment Costs

Most establishments wishing to perform exposure monitoring will require the assistance of an outside consulting industrial hygienist (IH) to obtain accurate results. While some firms might already employ or train qualified staff, ERG (2007b) judged that the testing protocols are fairly challenging and that few firms have sufficiently skilled staff to eliminate the need for outside consultants.

Table V-8 shows the unit costs and associated assumptions used to estimate exposure assessment costs. For costing purposes, based on ERG (2007b), OSHA estimated that, on average, there are four workers per work area. OSHA interpreted the initial exposure assessment as requiring first-year testing of at least one worker in each distinct job classification and work area who is, or may reasonably be expected to be, exposed to airborne concentrations of respirable crystalline silica at or above the action level.

For periodic monitoring, the proposed standard provides employers an option of assessing employee exposures either under a fixed schedule (paragraph (d)(3)(i)) or a performance–based schedule (paragraph (d)(3)(ii)). Under the fixed schedule, the proposed standard requires semi-annual periodic sampling for exposures at or above the action level and quarterly sampling for exposures above the 50 $\mu g/m^3$ PEL. Monitoring must be continued until the employer can demonstrate that exposures are no longer at or above the action level. OSHA used the fixed schedule option under the frequency of monitoring requirements to estimate, for costing

[7] In general industry and maritime, approximately 60 percent of at-risk workers are at or above the action level; in construction, approximately 46 percent of at-risk workers are at or above the action level. See Table III-6 in Chapter III of this PEA.

Table V-8: Unit Costs and Analytical Assumptions Associated with Exposure Assessment under the Proposed Silica Standard
(Coverage: All employees exposed at or above action level)

Costs and Parameters				Comments/Assumptions
Direct Costs by Establishment Size				
	Small (<20)	Medium (20-499)	Large (500+)	
IH fees/PBZ sample	$250.00	$83.33	$62.50	Consulting IH technician - rate per sample. Assumes IH rate of $500 per day and samples per day of 2, 6, and 8 for small, medium, and large establishments, respectively.
Lab fees and shipping cost	$133.38	$133.38	$133.38	Lab fees (EMSL Laboratory, 2000) and OSHA estimates. Inflated to 2009 values.
Total - per PBZ sample	$383.38	$216.71	$195.88	
Requirements				
Number of workers per work area	4			ERG assumption
Initial Monitoring Frequency (per year)	1			Based on requirements in proposed standard
Periodic Monitoring Frequency (per year)				
Exposed < Action Level	0			Based on requirements in proposed standard
Exposed ≤ PEL and ≥AL	2			Based on requirements in proposed standard
Exposed >PEL	4			Based on requirements in proposed standard
Percentage of workers requiring reassessment	15 %			ERG assumption
Time Requirements (minutes)				
Lost worker time while attaching and unattaching pump	30			ERG assumption
Recordkeeping by a manager per sample	15			Includes employee notification of monitoring results
Unit Costs by Establishment Size				
	Small (<20)	Medium (20-499)	Large (500+)	
Cost per sample (PBZ) - General Industry				
Direct Costs	$383.38	$216.71	$195.88	
Productivity Loss	$11.96	$11.96	$11.96	
Recordkeeping	$17.10	$17.10	$17.10	
Total	$412.44	$245.78	$224.94	
Cost per sample (PBZ) - Construction				
Direct Costs	$383.38	$216.71	$195.88	
Productivity Loss	$14.82	$14.82	$14.82	
Recordkeeping	$17.28	$17.28	$17.28	
Total	$415.48	$248.81	$227.98	

Source: U.S. Dept. of Labor, OSHA, Directorate of Evaluation and Analysis, Office of Regulatory Analysis, based on ERG (2011).

purposes, that exposure monitoring will be conducted (a) twice a year where initial or subsequent exposure monitoring reveals that employee exposures are at or above the action level but at or below the PEL, and (b) four times a year where initial or subsequent exposure monitoring reveals that employee exposures are above the PEL.[8]

As required under paragraph (d)(4) of the proposed rule, whenever there is a change in the production, process, control equipment, personnel, or work practices that may result in new or additional exposures at or above the action level or when the employer has any reason to suspect that a change may result in new or additional exposures at or above the action level, the employer must conduct additional monitoring. Based on ERG (2007b), OSHA estimated that approximately 15 percent of workers whose initial exposure or subsequent monitoring was at or above the action level would undertake additional monitoring.

ERG (2011) estimated that an IH will spend one day, at a cost of $500, to obtain the following number of personal breathing zone (PBZ) samples: 2 for establishments with fewer than 20 employees; 6 for establishments with 20-499 employees; and 8 for establishments with 500 or more employees. These estimates imply that there are some economies of scale in obtaining exposure samples. Based on the 2000 EMSL Laboratory Testing Catalog, ERG (2007b) estimated that analysis of each sample will cost $133.38 (adjusted to 2009 dollars) in lab fees and shipping costs. When combined with the IH fee, the cost per PBZ sample is projected to range from $195.88 to $383.38 (depending on establishment size).

Other costs per exposure monitoring sample stem from the estimated 30-minute loss in employee time while attaching the pump and the 15 minutes required for recordkeeping (recording the sampling results and notifying the employee of the sampling results). The loss in employee time was multiplied by the employee’s hourly wage rate (to include fringe benefits) to estimate the associated cost. The recordkeeping time was multiplied by a manager’s hourly wage rate (to include fringe benefits) to estimate the associated costs. Overall, OSHA estimates that unit costs will range from approximately $224.94 to $412.44 per sample.

Although OSHA believes that some establishments in general industry and maritime currently conduct exposure monitoring, the Agency has no evidence to support this belief. Therefore for costing purposes for the proposed silica rule, OSHA has assumed no current compliance with the proposed exposure monitoring requirements. OSHA requests information from interested parties on current levels of exposure monitoring in general industry and maritime.

Table V-9 presents the exposure monitoring cost estimates for general industry and maritime, by NAICS industry, for the proposed rule. As shown, the combined cost of the exposure monitoring requirements for general industry and maritime are an estimated $29.9 million annually.

[8] OSHA anticipates that the performance-based schedule option would generally be less expensive than the fixed schedule option for employers that choose the performance-based option; otherwise they wouldn’t have chosen it.

Table V-9: Estimated Annualized Costs for Exposure Assessment in General Industry and Maritime for OSHA's Proposed Silica Standard (all establishments)

NAICS	Industry	Number of Workers At or Above Action Level (25 μg/m^3)	Initial Assessment	Periodic Assessment	Total Annualized Assessment Costs
324121	Asphalt paving mixture and block manufacturing	48	$433	$7,762	**$8,195**
324122	Asphalt shingle and roofing materials	4,395	$39,712	$684,049	**$723,761**
325510	Paint and coating manufacturing	404	$3,795	$66,628	**$70,423**
327111	Vitreous china plumbing fixtures & bathroom accessories manufacturing	2,128	$20,543	$348,934	**$369,478**
327112	Vitreous china, fine earthenware, & other pottery product manufacturing	3,336	$32,210	$547,098	**$579,309**
327113	Porcelain electrical supply mfg	2,242	$21,647	$367,673	**$389,320**
327121	Brick and structural clay mfg	3,476	$30,679	$523,643	**$554,322**
327122	Ceramic wall and floor tile mfg	1,826	$16,963	$289,537	**$306,500**
327123	Other structural clay product mfg	412	$3,982	$68,330	**$72,312**
327124	Clay refractory manufacturing	722	$6,970	$117,420	**$124,390**
327125	Nonclay refractory manufacturing	910	$8,784	$147,985	**$156,769**
327211	Flat glass manufacturing	164	$1,584	$27,523	**$29,108**
327212	Other pressed and blown glass and glassware manufacturing	631	$6,092	$105,819	**$111,912**
327213	Glass container manufacturing	440	$4,251	$73,842	**$78,093**
327320	Ready-mixed concrete manufacturing	32,713	$315,821	$5,501,384	**$5,817,205**
327331	Concrete block and brick mfg	5,489	$52,996	$905,520	**$958,517**
327332	Concrete pipe mfg	3,398	$32,809	$560,599	**$593,408**

Table V-9: Estimated Annualized Costs for Exposure Assessment in General Industry and Maritime for OSHA's Proposed Silica Standard (all establishments) (continued)

Table V-9: Estimated Annualized Costs for Exposure Assessment in General Industry and Maritime for OSHA's Proposed Silica Standard (all establishments) (continued)

NAICS	Industry	Number of Workers At or Above Action Level (25 μg/m³)	Initial Assessment	Periodic Assessment	Total Annualized Assessment Costs
327390	Other concrete product mfg	15,957	$154,050	$2,632,177	**$2,786,227**
327991	Cut stone and stone product manufacturing	10,298	$101,389	$1,734,108	**$1,835,498**
327992	Ground or treated mineral and earth manufacturing	5,051	$49,732	$817,996	**$867,728**
327993	Mineral wool manufacturing	675	$6,646	$115,369	**$122,015**
327999	All other misc. nonmetallic mineral product mfg	2,421	$23,837	$407,175	**$431,012**
331111	Iron and steel mills	456	$3,828	$68,575	**$72,403**
331112	Electrometallurgical ferroalloy product manufacturing	9	$77	$1,385	**$1,463**
331210	Iron and steel pipe and tube manufacturing from purchased steel	90	$805	$13,751	**$14,556**
331221	Rolled steel shape manufacturing	46	$406	$6,941	**$7,348**
331222	Steel wire drawing	62	$548	$9,363	**$9,911**
331314	Secondary smelting and alloying of aluminum	31	$266	$4,642	**$4,908**
331423	Secondary smelting, refining, and alloying of copper	5	$47	$810	**$857**
331492	Secondary smelting, refining, and alloying of nonferrous metal (except cu & al)	39	$352	$6,056	**$6,407**
331511	Iron foundries	16,417	$141,652	$2,471,123	**$2,612,775**
331512	Steel investment foundries	4,570	$40,414	$698,898	**$739,312**
331513	Steel foundries (except investment)	4,914	$43,456	$751,517	**$794,973**
331524	Aluminum foundries (except die-casting)	7,418	$67,254	$1,153,625	**$1,220,879**
331525	Copper foundries (except die-casting)	1,709	$17,223	$292,180	**$309,403**
331528	Other nonferrous foundries (except die-casting)	1,315	$11,631	$201,146	**$212,778**
332111	Iron and steel forging	112	$1,079	$18,426	**$19,505**
332112	Nonferrous forging	37	$356	$6,084	**$6,440**
332115	Crown and closure manufacturing	14	$124	$2,111	**$2,236**
332116	Metal stamping	272	$2,527	$43,068	**$45,595**
332117	Powder metallurgy part manufacturing	35	$319	$5,409	**$5,727**
332211	Cutlery and flatware (except precious) manufacturing	24	$234	$3,995	**$4,229**
332212	Hand and edge tool manufacturing	154	$1,454	$24,902	**$26,356**
332213	Saw blade and handsaw manufacturing	31	$276	$4,813	**$5,090**

Table V-9: Estimated Annualized Costs for Exposure Assessment in General Industry and Maritime for OSHA's Proposed Silica Standard (all establishments) (continued)

NAICS	Industry	Number of Workers At or Above Action Level (25 μg/m^3)	Initial Assessment	Periodic Assessment	Total Annualized Assessment Costs
332214	Kitchen utensil, pot, and pan manufacturing	17	$160	$2,727	**$2,886**
332323	Ornamental and architectural metal work	26	$266	$4,542	**$4,808**
332439	Other metal container manufacturing	64	$614	$10,492	**$11,106**
332510	Hardware manufacturing	190	$1,835	$31,354	**$33,190**
332611	Spring (heavy gauge) manufacturing	17	$164	$2,810	**$2,974**
332612	Spring (light gauge) manufacturing	64	$621	$10,607	**$11,228**
332618	Other fabricated wire product manufacturing	153	$1,474	$25,185	**$26,659**
332710	Machine shops	1,118	$11,734	$199,308	**$211,043**
332812	Metal coating and allied services	2,255	$21,789	$373,417	**$395,206**
332911	Industrial valve manufacturing	161	$1,424	$24,470	**$25,894**
332912	Fluid power valve and hose fitting manufacturing	149	$1,363	$23,491	**$24,854**
332913	Plumbing fixture fitting and trim manufacturing	48	$442	$7,618	**$8,060**
332919	Other metal valve and pipe fitting manufacturing	76	$694	$11,955	**$12,648**
332991	Ball and roller bearing manufacturing	114	$1,043	$17,984	**$19,027**
332996	Fabricated pipe and pipe fitting manufacturing	114	$1,042	$17,964	**$19,006**
332997	Industrial pattern manufacturing	22	$203	$3,500	**$3,703**
332998	Enameled iron and metal sanitary ware manufacturing	56	$510	$8,795	**$9,304**
332999	All other miscellaneous fabricated metal product manufacturing	303	$2,975	$50,628	**$53,603**
333319	Other commercial and service industry machinery manufacturing	222	$2,055	$35,106	**$37,161**
333411	Air purification equipment manufacturing	62	$544	$9,493	**$10,037**
333412	Industrial and commercial fan and blower manufacturing	44	$384	$6,715	**$7,099**
333414	Heating equipment (except warm air furnaces) manufacturing	86	$753	$13,157	**$13,911**
333511	Industrial mold manufacturing	168	$1,684	$28,665	**$30,348**
333512	Machine tool (metal cutting types) manufacturing	72	$675	$11,639	**$12,313**
333513	Machine tool (metal forming types) manufacturing	36	$343	$5,814	**$6,157**
333514	Special die and tool, die	241	$2,492	$42,430	**$44,922**

Table V-9: Estimated Annualized Costs for Exposure Assessment in General Industry and Maritime for OSHA's Proposed Silica Standard (all establishments) (continued)

NAICS	Industry	Number of Workers At or Above Action Level (25 µg/m^3)	Initial Assessment	Periodic Assessment	Total Annualized Assessment Costs
	set, jig, and fixture manufacturing				
333515	Cutting tool and machine tool accessory manufacturing	146	$1,471	$25,046	**$26,517**
333516	Rolling mill machinery and equipment manufacturing	13	$129	$2,198	**$2,327**
333518	Other metalworking machinery manufacturing	52	$526	$8,951	**$9,476**
333612	Speed changer, industrial high-speed drive, and gear manufacturing	52	$444	$7,864	**$8,308**
333613	Mechanical power transmission equipment manufacturing	66	$561	$9,932	**$10,493**
333911	Pump and pumping equipment manufacturing	129	$1,163	$19,976	**$21,139**
333912	Air and gas compressor manufacturing	90	$821	$14,153	**$14,975**
333991	Power-driven handtool manufacturing	37	$335	$5,771	**$6,105**
333992	Welding and soldering equipment manufacturing	67	$586	$10,296	**$10,882**
333993	Packaging machinery manufacturing	89	$828	$14,176	**$15,004**
333994	Industrial process furnace and oven manufacturing	45	$428	$7,266	**$7,694**
333995	Fluid power cylinder and actuator manufacturing	83	$738	$12,795	**$13,532**
333996	Fluid power pump and motor manufacturing	57	$512	$8,784	**$9,296**
333997	Scale and balance (except laboratory) manufacturing	16	$150	$2,538	**$2,688**
333999	All other miscellaneous general purpose machinery manufacturing	220	$2,012	$34,665	**$36,677**
334518	Watch, clock, and part manufacturing	9	$89	$1,507	**$1,596**
335211	Electric housewares and household fans	10	$85	$1,555	**$1,641**
335221	Household cooking appliance manufacturing	22	$184	$3,359	**$3,543**
335222	Household refrigerator and home freezer manufacturing	24	$197	$3,587	**$3,784**
335224	Household laundry equipment manufacturing	23	$187	$3,408	**$3,596**
335228	Other major household appliance manufacturing	18	$147	$2,683	**$2,830**
336111	Automobile manufacturing	316	$2,550	$46,975	**$49,525**
336112	Light truck and utility vehicle manufacturing	436	$3,519	$64,816	**$68,335**
336120	Heavy duty truck manufacturing	135	$1,104	$20,075	**$21,179**
336211	Motor vehicle body	200	$1,785	$30,952	**$32,738**

Table V-9: Estimated Annualized Costs for Exposure Assessment in General Industry and Maritime for OSHA's Proposed Silica Standard (all establishments) (continued)

NAICS	Industry	Number of Workers At or Above Action Level (25 µg/m³)	Initial Assessment	Periodic Assessment	Total Annualized Assessment Costs
	manufacturing				
336212	Truck trailer manufacturing	135	$1,182	$20,604	**$21,786**
336213	Motor home manufacturing	90	$750	$13,533	**$14,284**
336311	Carburetor, piston, piston ring, and valve manufacturing	44	$378	$6,666	**$7,044**
336312	Gasoline engine and engine parts manufacturing	277	$2,373	$41,825	**$44,198**
336322	Other motor vehicle electrical and electronic equipment manufacturing	260	$2,226	$39,231	**$41,457**
336330	Motor vehicle steering and suspension components (except spring) manufacturing	165	$1,394	$24,823	**$26,216**
336340	Motor vehicle brake system manufacturing	142	$1,212	$21,365	**$22,578**
336350	Motor vehicle transmission and power train parts manufacturing	351	$2,956	$52,840	**$55,796**
336370	Motor vehicle metal stamping	464	$3,956	$69,452	**$73,408**
336399	All other motor vehicle parts manufacturing	626	$5,357	$94,412	**$99,769**
336611	Ship building and repair	2,798	$24,059	$388,650	**$412,708**
336612	Boat building	1,752	$15,067	$243,400	**$258,467**
336992	Military armored vehicle, tank, and tank component manufacturing	29	$257	$4,529	**$4,786**
337215	Showcase, partition, shelving, and locker manufacturing	248	$2,321	$39,641	**$41,962**
339114	Dental equipment and supplies manufacturing	274	$2,569	$45,566	**$48,135**
339116	Dental laboratories	5,357	$50,237	$841,930	**$892,167**
339911	Jewelry (except costume) manufacturing	4,883	$48,313	$828,363	$876,676
339913	Jewelers' materials and lapidary work manufacturing	1,004	$9,935	$170,349	$180,284
339914	Costume jewelry and novelty manufacturing	685	$6,773	$116,113	$122,885
339950	Sign manufacturing	249	$2,463	$42,197	$44,660
423840	Industrial supplies, wholesalers	306	$3,397	$57,025	$60,422
482110	Rail transportation	11,248	$90,057	$1,648,341	$1,738,398
621210	Dental offices	1,287	$14,348	$236,698	$251,046
Totals		**175,801**	**$1,638,671**	**$28,230,137**	**$29,868,808**

Source: U.S. Dept. of Labor, OSHA, Directorate of Evaluation and Analysis, Office of Regulatory Analysis, based on ERG (2011).

Medical Surveillance Costs

Paragraph (h) of the proposed standard requires an initial health screening and then triennial periodic screenings for workers exposed above the proposed PEL of 50 $\mu g/m^3$ for 30 days or more per year. ERG (2011) assembled information on representative unit costs of initial and periodic medical surveillance. Separate costs were estimated for current employees and for new hires as a function of the employment size (i.e., 1-19, 20-499, or 500+) of affected establishments. Table V-10 presents ERG's unit cost data and modeling assumptions used by OSHA to estimate medical surveillance costs.

In accordance with paragraph (h)(2) of the proposed rule, the initial (baseline) medical examination would consist of (1) a medical and work history, (2) a physical examination with special emphasis on the respiratory system, (3) a chest x-ray that meets certain standards of the International Labour Organization, (4) a pulmonary function test that meets certain criteria and is administered by a National Institute for Occupational Safety and Health (NIOSH)-certified spirometry technician, (5) testing for latent tuberculosis (TB) infection, and (6) any other tests deemed appropriate by the physician or licensed health care professional (PLHCP).

As shown in Table V-10, the estimated unit cost of the initial health screening for current employees in general industry and maritime ranges from $377.77 to $396.90 and includes direct medical costs, the opportunity cost of worker time (i.e., lost work time, evaluated at the worker's 2009 hourly wage, including fringe benefits) for offsite travel and for the initial health screening itself, and recordkeeping costs. The variation in the unit cost of the initial health screening is due entirely to differences in the percentage of workers expected to travel offsite for the health screening. In OSHA's experience, the larger the establishment the more likely it is that the selected physician or PLHCP would provide the health screening services at the establishment's worksite. OSHA estimates that, on average, 20 percent of establishments with fewer than 20 employees, 75 percent of establishments with 20-499 employees, and 100 percent of establishments with 500 or more employees would have the initial health screening for current employees conducted onsite.

The unit cost components of the initial health screening for new hires in general industry and maritime are identical to those for existing employees with the exception that the percentage of workers expected to travel offsite for the health screening would be somewhat larger (due to fewer workers being screened annually, in the case of new hires, and therefore yielding fewer economies of onsite screening). OSHA estimates, on average, that 10 percent of establishments with fewer than 20 employees, 50 percent of establishments with 20-499 employees, and 90 percent of establishments with 500 or more employees would have the initial health screening for new hires conducted onsite. As shown in Table V-10, the estimated unit cost of the initial health screening for new hires in general industry and maritime ranges from $380.16 to $399.30.

Table V-10: Unit Costs and Analytical Assumptions Applied in OSHA's Cost Model for Health Screening as Part of Medical Surveillance - General Industry and Maritime (Coverage: All employees exposed above PEL)

Screening Tool	Cost Parameter	Initial Screening	Periodic Screening	Comments/Assumptions
Direct Costs				
Complete occupational and health history survey	$33.33	Yes	Yes	Assumed one third of physical exam cost
Triennial review and updating of health history	$33.33	N/A	Yes	Assumed one third of physical exam cost
Physical examination by knowledgeable HCP [a]	$100.00	Yes	Yes	Evaluation and office consultation including detailed examination.
Chest X-ray	$79.61	Yes	Yes	Radiologic examination, chest; stereo, frontal. Costs include consultation and written report.
Chest X-ray classified by a NIOSH-certified B Reader	$39.19	Yes	Yes	Average of three estimates made by B Readers to ERG.
Pulmonary function test	$54.69	Yes	Yes	Spirometry, including graphic record, total and timed vital capacity, expiratory flow rate measurements(s), and/or maximal voluntary ventilation.
Examination by a pulmonary specialist [b]	$190.28	Yes	N/A	Office consultation and evaluation by a pulmonary specialist
Other necessary tests	$60.00	Yes	Yes	Assumed required by 10 percent of workers
Dermal TB Test	$15.00	Yes	Yes	Assumed required by 15 percent of workers

Table V-10: Unit Costs and Analytical Assumptions Applied in OSHA's Cost Model for Health Screening as Part of Medical Surveillance - General Industry and Maritime
(Coverage: All employees exposed above PEL) (continued)

Medical Exam or Other Cost Variable	Cost Parameter				Comments/Assumptions
Time Requirements for Medical Examinations	**Minutes**				
Complete occupational and health history survey and exam, including x-ray	120				Per survey and exam
Health history review and update	30				Per review
Physical exam and tests (without x-ray)	60				Per exam
Chest x-ray	30				Per x-ray
Reading of Dermal TB Test (return exam)	5				
Examination by a pulmonary specialist	60				
Recordkeeping (initial and periodic screenings)	15				Average per screening
Recordkeeping (referrals)	60				Includes time for referrals and notification of NIOSH of new silica-related disease cases
Percentage of employees seeing off-site physician by establishment size					
		Small (<20)	Medium (20-499)	Large (500+)	
-Initial examination		80.0%	25.0%	0.0%	
-New hires		90.0%	50.0%	10.0%	
Travel Times (minutes) – off-site location					
Initial Test	60				
Return for Reading	60				
Separations rate (layoffs, quits, and retirements)	27.2%				2008 separations rate for manufacturing industries. BLS, Job Openings and Labor Turnover Survey (JOLTS)
Share of new hires requiring initial health screening	75.0%				

Establishment Size

Table V-10: Unit Costs and Analytical Assumptions Applied in OSHA's Cost Model for Health Screening as Part of Medical Surveillance - General Industry and Maritime
(Coverage: All employees exposed above PEL) (continued)

Medical Exam or Other Cost Variable	Cost Parameter			Comments/Assumptions
	Small (<20)	Medium (20-499)	Large (500+)	
Initial screening:				
Medical costs	$312.83	$312.83	$312.83	Including components specified above in "Direct Costs": occupational and health history, physical exam, chest x-ray (classified by B Reader), pulmonary function test, and other tests (for 10% of workers)
Lost work time - exam	$47.84	$47.84	$47.84	Based on average production worker wage, adjusted for benefits
Lost work time - travel	$19.13	$5.98	$0.00	Based on average production worker wage, adjusted for benefits
Record keeping	$17.10	$17.10	$17.10	Based on manager's wage rate, adjusted for benefits
Total	**$396.90**	**$383.75**	**$377.77**	
Initial screening: New hires				
Medical costs	$312.83	$312.83	$312.83	Including components specified above in "Direct Costs"
Lost work time - exam	$47.84	$47.84	$47.84	Based on average production worker wage, adjusted for benefits
Lost work time - travel	$21.53	$11.96	$2.39	Based on average production worker wage, adjusted for benefits
Record keeping	$17.10	$17.10	$17.10	Based on manager's wage rate, adjusted for benefits
Total	**$399.30**	**$389.73**	**$380.16**	
Triennial screening				
Medical costs	$312.83	$312.83	$312.83	Including components specified above in "Direct Costs"
Lost work time - exam	$47.84	$47.84	$47.84	Based on average production worker wage, adjusted for benefits (BLS, 2008). Inflated to 2009 value.
Lost work time - travel	$19.13	$5.98	$0.00	Based on average production worker wage, adjusted for benefits (BLS, 2008). Inflated to 2009 value.
Record keeping	$17.10	$17.10	$17.10	Based on manager's wage rate, adjusted for benefits (BLS, 2008). Inflated to 2009 value.
Total	**$396.90**	**$383.75**	**$377.77**	

Table V-10: Unit Costs and Analytical Assumptions Applied in OSHA's Cost Model for Health Screening as Part of Medical Surveillance - General Industry and Maritime
(Coverage: All employees exposed above PEL) (continued)

Medical Exam or Other Cost Variable	Cost Parameter			Comments/Assumptions
Examination by pulmonary specialist				
Medical costs	$190.28	$190.28	$190.28	Including components specified above in "Direct Costs"
Lost work time - exam	$23.92	$23.92	$23.92	Based on average production worker wage, adjusted for benefits (BLS, 2008). Inflated to 2009 value.
Lost work time - travel	$23.92	$23.92	$23.92	Based on average production worker wage, adjusted for benefits (BLS, 2008). Inflated to 2009 value. Assumes all exams are off-site.
Record keeping	$68.41	$68.41	$68.41	Based on manager's wage rate, adjusted for benefits (BLS, 2008). Inflated to 2009 value.
Total	**$306.53**	**$306.53**	**$306.53**	
Initial TB Testing				
Test cost	$15.00	$15.00	$15.00	
Lost work time - exam	$1.99	$1.99	$1.99	
Lost work time - travel	$19.13	$5.98	$0.00	
Total	**$36.13**	**$22.97**	**$16.99**	
New Hire and subsequent TB testing				
Test cost	$15.00	$15.00	$15.00	
Lost work time - exam	$1.99	$1.99	$1.99	
Lost work time - travel	$21.53	$11.96	$2.39	
Total	**$38.52**	**$28.95**	**$19.38**	
Annualized costs – initial testing	$5.14	$3.27	$2.42	
Annualized costs – new hire and subsequent testing	$38.52	$28.95	$19.38	
Percentage of employees tested in initial year				
Current Employees		100.0%		
New Hires		75.0%		
Percentage of employees recommended for periodic TB testing		15.0%		

[a] Typical charge, based on ERG contacts with occupational health providers.

[b] Mean expense per office-based physician visit to a pulmonary specialist for diagnosis and treatment, based on data from the 2004 Medical Expenditure Panel Survey. Inflated to 2009 dollars using the consumer price inflator for medical services.

Other costs for physical exams and tests, chest X-ray, and pulmonary tests are direct medical costs used in bundling services under Medicare (Intellimed, 2003). Costs are inflated by 30% to eliminate the effect of Medicare discounts that are unlikely to apply to occupational medicine environments.

Source: U.S. Dept. of Labor, OSHA, Directorate of Evaluation and Analysis, Office of Regulatory Analysis, based on ERG (2011).

In accordance with paragraph (h)(3) of the proposed rule, the periodic medical examination (every third year after the initial health screening) would consist of (1) a medical and work history review and update, (2) a physical examination with special emphasis on the respiratory system, (3) a chest x-ray that meets certain standards of the International Labour Organization, (4) a pulmonary function test that meets certain criteria and is administered by a NIOSH-certified spirometry technician, (5) testing for latent TB infection, if recommended by the physician or PLHCP, and (6) any other tests deemed appropriate by the physician or PLHCP.

The estimated unit cost of periodic health screening also includes direct medical costs, the opportunity cost of worker time, and recordkeeping costs. As shown in Table V-10, these triennial unit costs vary from $377.77 to $396.90. The variation in the unit cost is due entirely to differences in the percentage of workers expected to travel offsite for the periodic health screening. OSHA estimated that the share of workers traveling offsite, as a function of establishment size, would be the same for the periodic health screening as for the initial health screening for existing employees.

Although OSHA believes that some affected establishments in general industry and maritime currently provide some medical testing to their silica-exposed employees, the Agency doubts that many provide the comprehensive health screening required under the proposed rule. Therefore for costing purposes for the proposed rule, OSHA has assumed no current compliance with the proposed health screening requirements. OSHA requests information from interested parties on the current levels and the comprehensiveness of health screening in general industry and maritime.

In order to estimate turnover rates in general industry and maritime, ERG (2011) used the separations rate (layoffs, quits, retirements) of 27.2 percent as estimated by the Bureau of Labor Statistics (BLS, 2007). However, not all new hires would require initial medical testing. As specified in paragraph (h)(2) of the proposed rule, employees who had received a qualifying medical examination within the previous twelve months would be exempt from the initial medical examination. OSHA estimates that 25 percent of new hires in general industry and maritime would be exempt from the initial medical examination.

Based on a ten-year time horizon, OSHA estimated the total annualized costs in general industry and maritime for health screenings (to include initial health screenings for existing employees and new hires and periodic health screenings) as required by the proposed rule. These estimates, disaggregated by affected NAICS industry, are presented in Table V-11.

Finally, OSHA estimated the unit cost of a medical examination by a pulmonary specialist for those employees found to have signs or symptoms of silica-related disease (1/0 or higher on the ILO scale) or are otherwise referred by the PLHCP. As shown in Table V-10, the estimated unit cost of a medical examination by a pulmonary specialist is $306.53. This cost includes direct medical costs, the opportunity cost of worker time, and recordkeeping costs (to include the cost of the employer’s time to make a referral to a pulmonary specialist). In all cases, OSHA anticipates that the worker will travel offsite to receive the medical examination by a pulmonary specialist.

Based on its calculation of residual risk after the silica rule takes effect, OSHA estimates that there would be 18 new cases a year of silicosis of 2/1 or higher identified as a result of the proposed medical surveillance requirements for general industry and maritime workers. OSHA used the Buchannan et al. (2003) silicosis risk model to estimate that there would be 61 new cases a year of silicosis of 1/0 or higher identified as a result of the proposed medical surveillance requirements for general industry and maritime workers. ERG distributed these disease cases among industries in proportion to the number of at-risk workers. Table V-12, which multiplies the unit cost by the number of referred workers, shows the total annualized cost in general industry and maritime of medical examinations by a pulmonary specialist.

Tables V-13, which combines total health screening costs and the total costs of medical examinations by a pulmonary specialist, shows aggregate annual costs in general industry and maritime, by NAICS industry, for the medical surveillance requirements in the proposed rule. For general industry and maritime, combined over all affected NAICS industries, the estimated cost of these medical surveillance requirements is $3.1 million annually. OSHA requests comment on the direct effects of the proposed medical surveillance requirements as represented by OSHA's estimated costs. OSHA also invites comment on any indirect effects of the medical surveillance requirements in relation to the benefits or costs of additional workplace physical examinations, heightened awareness of silica hazards among the personal physicians of affected workers, avoidance of unnecessary follow-up treatments, or any other indirect impacts.

Table V-11: Estimated Health Screening Costs in General Industry and Maritime for OSHA's Proposed Silica Standard (all establishments)

NAICS	Industry	Number of Respirator Users at or Above PEL (50 μg/m³)	Initial Screening	Screening for New Hires	Triennial Screening	TB Testing	Total Cost
324121	Asphalt paving mixture and block manufacturing	5	$261	$379	$282	$34	**$956**
324122	Asphalt shingle and roofing materials	196	$10,696	$15,495	$11,534	$1,397	**$39,122**
325510	Paint and coating manufacturing	40	$2,213	$3,212	$2,389	$314	**$8,129**
327111	Vitreous china plumbing fixtures & bathroom accessories manufacturing	132	$7,239	$10,511	$7,817	$1,065	**$26,632**
327112	Vitreous china, fine earthenware, & other pottery product manufacturing	207	$11,351	$16,480	$12,256	$1,671	**$41,757**
327113	Porcelain electrical supply mfg	139	$7,628	$11,076	$8,236	$1,123	**$28,063**
327121	Brick and structural clay mfg	266	$14,554	$21,176	$15,711	$2,062	**$53,503**
327122	Ceramic wall and floor tile mfg	140	$7,663	$11,141	$8,275	$1,119	**$28,199**
327123	Other structural clay product mfg	32	$1,734	$2,517	$1,872	$255	**$6,378**
327124	Clay refractory manufacturing	36	$1,997	$2,900	$2,157	$294	**$7,348**
327125	Nonclay refractory manufacturing	46	$2,517	$3,655	$2,718	$371	**$9,261**
327211	Flat glass manufacturing	15	$848	$1,231	$915	$125	**$3,119**
327212	Other pressed and blown glass and glassware manufacturing	59	$3,255	$4,726	$3,515	$479	**$11,975**
327213	Glass container manufacturing	41	$2,271	$3,298	$2,453	$301	**$8,323**
327320	Ready-mixed concrete manufacturing	3,211	$176,220	$255,863	$190,273	$25,936	**$648,292**

Table V-11: Estimated Health Screening Costs in General Industry and Maritime for OSHA's Proposed Silica Standard (all establishments) (continued)

NAICS	Industry	Number of Respirator Users at or Above PEL (50 μg/m³)	Initial Screening	Screening for New Hires	Triennial Screening	TB Testing	Total Cost
327331	Concrete block and brick mfg	387	$21,218	$30,808	$22,910	$3,123	**$78,060**
327332	Concrete pipe mfg	239	$13,136	$19,073	$14,184	$1,933	**$48,326**
327390	Other concrete product mfg	1,124	$61,678	$89,553	$66,596	$9,078	**$226,905**
327991	Cut stone and stone product manufacturing	744	$40,885	$59,346	$44,150	$6,094	**$150,475**
327992	Ground or treated mineral and earth manufacturing	89	$4,897	$7,109	$5,288	$730	**$18,024**
327993	Mineral wool manufacturing	63	$3,471	$5,038	$3,748	$517	**$12,775**
327999	All other misc. nonmetallic mineral product mfg	171	$9,369	$13,599	$10,117	$1,397	**$34,481**
331111	Iron and steel mills	31	$1,673	$2,421	$1,802	$195	**$6,091**
331112	Electrometallurgical ferroalloy product manufacturing	1	$34	$49	$36	$4	**$123**
331210	Iron and steel pipe and tube manufacturing from purchased steel	6	$335	$487	$362	$47	**$1,231**
331221	Rolled steel shape manufacturing	3	$169	$246	$183	$24	**$621**
331222	Steel wire drawing	4	$228	$332	$246	$32	**$838**
331314	Secondary smelting and alloying of aluminum	2	$114	$165	$123	$15	**$416**
331423	Secondary smelting, refining, and alloying of copper	0	$20	$28	$21	$3	**$72**
331492	Secondary smelting, refining, and alloying of nonferrous metal (except cu & al)	3	$146	$212	$158	$20	**$536**
331511	Iron foundries	1,114	$60,595	$87,894	$65,337	$7,806	**$221,632**
331512	Steel investment foundries	310	$16,904	$24,536	$18,235	$2,268	**$61,942**
331513	Steel foundries (except investment)	333	$18,180	$26,387	$19,611	$2,439	**$66,616**
331524	Aluminum foundries (except die-casting)	503	$27,504	$39,946	$29,682	$3,835	**$100,967**
331525	Copper foundries (except die-casting)	116	$6,383	$9,268	$6,895	$980	**$23,525**
331528	Other nonferrous foundries (except die-casting)	89	$4,865	$7,061	$5,248	$653	**$17,827**
332111	Iron and steel forging	8	$416	$603	$449	$61	**$1,529**
332112	Nonferrous forging	3	$137	$199	$148	$20	**$505**
332115	Crown and closure manufacturing	1	$50	$73	$54	$7	**$185**

Table V-11: Estimated Health Screening Costs in General Industry and Maritime for OSHA's Proposed Silica Standard (all establishments) (continued)

NAICS	Industry	Number of Respirator Users at or Above PEL (50 μg/m³)	Initial Screening	Screening for New Hires	Triennial Screening	TB Testing	Total Cost
332116	Metal stamping	18	$1,009	$1,466	$1,090	$146	**$3,711**
332117	Powder metallurgy part manufacturing	2	$130	$189	$140	$19	**$478**
332211	Cutlery and flatware (except precious) manufacturing	2	$90	$131	$97	$13	**$331**
332212	Hand and edge tool manufacturing	10	$571	$828	$616	$82	**$2,097**
332213	Saw blade and handsaw manufacturing	2	$114	$165	$123	$15	**$416**
332214	Kitchen utensil, pot, and pan manufacturing	1	$61	$89	$66	$9	**$226**
332323	Ornamental and architectural metal work	2	$103	$150	$112	$16	**$380**
332439	Other metal container manufacturing	4	$237	$344	$255	$35	**$870**
332510	Hardware manufacturing	13	$707	$1,027	$764	$104	**$2,601**
332611	Spring (heavy gauge) manufacturing	1	$63	$92	$68	$9	**$233**
332612	Spring (light gauge) manufacturing	4	$239	$347	$258	$35	**$880**
332618	Other fabricated wire product manufacturing	10	$568	$825	$613	$83	**$2,089**
332710	Machine shops	76	$4,186	$6,073	$4,523	$656	**$15,439**
332812	Metal coating and allied services	163	$8,957	$13,002	$9,671	$1,313	**$32,943**
332911	Industrial valve manufacturing	11	$595	$865	$642	$81	**$2,184**
332912	Fluid power valve and hose fitting manufacturing	10	$553	$802	$596	$76	**$2,027**
332913	Plumbing fixture fitting and trim manufacturing	3	$179	$260	$193	$25	**$657**
332919	Other metal valve and pipe fitting manufacturing	5	$281	$408	$303	$39	**$1,032**
332991	Ball and roller bearing manufacturing	8	$423	$614	$456	$58	**$1,552**
332996	Fabricated pipe and pipe fitting manufacturing	8	$423	$613	$456	$58	**$1,550**
332997	Industrial pattern manufacturing	2	$82	$119	$89	$11	**$302**
332998	Enameled iron and metal sanitary ware manufacturing	4	$210	$304	$226	$29	**$769**

Table V-11: Estimated Health Screening Costs in General Industry and Maritime for OSHA's Proposed Silica Standard (all establishments) (continued)

NAICS	Industry	Number of Respirator Users at or Above PEL (50 μg/m³)	Initial Screening	Screening for New Hires	Triennial Screening	TB Testing	Total Cost
332999	All other miscellaneous fabricated metal product manufacturing	21	$1,129	$1,639	$1,219	$169	**$4,155**
333319	Other commercial and service industry machinery manufacturing	15	$826	$1,200	$891	$118	**$3,035**
333411	Air purification equipment manufacturing	4	$230	$334	$248	$30	**$842**
333412	Industrial and commercial fan and blower manufacturing	3	$163	$236	$176	$21	**$596**
333414	Heating equipment (except warm air furnaces) manufacturing	6	$319	$463	$344	$41	**$1,167**
333511	Industrial mold manufacturing	11	$625	$908	$675	$95	**$2,303**
333512	Machine tool (metal cutting types) manufacturing	5	$268	$388	$289	$37	**$982**
333513	Machine tool (metal forming types) manufacturing	2	$134	$194	$144	$20	**$492**
333514	Special die and tool, die set, jig, and fixture manufacturing	16	$902	$1,309	$975	$139	**$3,325**
333515	Cutting tool and machine tool accessory manufacturing	10	$546	$793	$590	$83	**$2,012**
333516	Rolling mill machinery and equipment manufacturing	1	$48	$70	$52	$7	**$177**
333518	Other metalworking machinery manufacturing	4	$195	$283	$211	$30	**$719**
333612	Speed changer, industrial high-speed drive, and gear manufacturing	4	$191	$277	$206	$23	**$697**
333613	Mechanical power transmission equipment manufacturing	4	$241	$350	$260	$29	**$881**
333911	Pump and pumping equipment manufacturing	9	$479	$695	$517	$66	**$1,757**

Table V-11: Estimated Health Screening Costs in General Industry and Maritime for OSHA's Proposed Silica Standard (all establishments) (continued)

NAICS	Industry	Number of Respirator Users at or Above PEL (50 μg/m³)	Initial Screening	Screening for New Hires	Triennial Screening	TB Testing	Total Cost
333912	Air and gas compressor manufacturing	6	$333	$484	$359	$46	**$1,222**
333991	Power-driven handtool manufacturing	2	$136	$197	$147	$19	**$498**
333992	Welding and soldering equipment manufacturing	5	$246	$356	$265	$31	**$898**
333993	Packaging machinery manufacturing	6	$330	$479	$356	$47	**$1,211**
333994	Industrial process furnace and oven manufacturing	3	$167	$243	$181	$25	**$617**
333995	Fluid power cylinder and actuator manufacturing	6	$308	$448	$333	$41	**$1,130**
333996	Fluid power pump and motor manufacturing	4	$212	$308	$229	$29	**$777**
333997	Scale and balance (except laboratory) manufacturing	1	$58	$85	$63	$9	**$215**
333999	All other miscellaneous general purpose machinery manufacturing	15	$816	$1,184	$880	$113	**$2,993**
334518	Watch, clock, and part manufacturing	1	$34	$50	$37	$5	**$127**
335211	Electric housewares and household fans	1	$41	$59	$44	$4	**$148**
335221	Household cooking appliance manufacturing	2	$88	$127	$95	$10	**$319**
335222	Household refrigerator and home freezer manufacturing	2	$94	$135	$101	$10	**$341**
335224	Household laundry equipment manufacturing	2	$89	$129	$96	$10	**$324**
335228	Other major household appliance manufacturing	1	$70	$101	$76	$8	**$255**
336111	Automobile manufacturing	21	$1,153	$1,664	$1,241	$119	**$4,177**
336112	Light truck and utility vehicle manufacturing	30	$1,591	$2,296	$1,712	$164	**$5,763**
336120	Heavy duty truck manufacturing	9	$493	$712	$531	$54	**$1,789**
336211	Motor vehicle body manufacturing	14	$738	$1,071	$796	$99	**$2,705**

Table V-11: Estimated Health Screening Costs in General Industry and Maritime for OSHA's Proposed Silica Standard (all establishments) (continued)

NAICS	Industry	Number of Respirator Users at or Above PEL (50 μg/m³)	Initial Screening	Screening for New Hires	Triennial Screening	TB Testing	Total Cost
336212	Truck trailer manufacturing	9	$500	$725	$539	$65	**$1,829**
336213	Motor home manufacturing	6	$331	$479	$357	$37	**$1,204**
336311	Carburetor, piston, piston ring, and valve manufacturing	3	$163	$236	$175	$20	**$594**
336312	Gasoline engine and engine parts manufacturing	19	$1,022	$1,480	$1,101	$127	**$3,730**
336322	Other motor vehicle electrical and electronic equipment manufacturing	18	$958	$1,388	$1,033	$119	**$3,499**
336330	Motor vehicle steering and suspension components (except spring) manufacturing	11	$608	$879	$655	$72	**$2,214**
336340	Motor vehicle brake system manufacturing	10	$522	$756	$562	$65	**$1,905**
336350	Motor vehicle transmission and power train parts manufacturing	24	$1,291	$1,868	$1,391	$152	**$4,701**
336370	Motor vehicle metal stamping	31	$1,709	$2,478	$1,842	$215	**$6,244**
336399	All other motor vehicle parts manufacturing	42	$2,306	$3,341	$2,486	$286	**$8,420**
336611	Ship building and repair	1,998	$108,416	$156,908	$116,817	$13,131	**$395,272**
336612	Boat building	1,252	$67,898	$98,267	$73,159	$8,224	**$247,547**
336992	Military armored vehicle, tank, and tank component manufacturing	2	$107	$155	$115	$14	**$391**
337215	Showcase, partition, shelving, and locker manufacturing	17	$921	$1,337	$994	$133	**$3,384**
339114	Dental equipment and supplies manufacturing	27	$1,498	$2,171	$1,616	$206	**$5,490**
339116	Dental laboratories	107	$5,857	$8,489	$6,319	$806	**$21,470**
339911	Jewelry (except costume) manufacturing	342	$18,774	$27,234	$20,270	$2,773	**$69,051**
339913	Jewelers' materials and lapidary work manufacturing	70	$3,861	$5,600	$4,169	$570	**$14,200**
339914	Costume jewelry and novelty manufacturing	48	$2,628	$3,813	$2,838	$388	**$9,667**

Table V-11: Estimated Health Screening Costs in General Industry and Maritime for OSHA's Proposed Silica Standard (all establishments) (continued)

NAICS	Industry	Number of Respirator Users at or Above PEL (50 μg/m³)	Initial Screening	Screening for New Hires	Triennial Screening	TB Testing	Total Cost
339950	Sign manufacturing	17	$943	$1,369	$1,019	$139	**$3,470**
423840	Industrial supplies, wholesalers	15	$848	$1,229	$916	$137	**$3,130**
482110	Rail transportation	563	$30,279	$43,658	$32,567	$3,032	**$109,536**
621210	Dental offices	26	$1,424	$2,063	$1,539	$228	**$5,255**
Totals		**15,172**	**$828,797**	**$1,201,995**	**$894,159**	**$113,428**	**$3,038,378**

Source: U.S. Dept. of Labor, OSHA, Directorate of Evaluation and Analysis, Office of Regulatory Analysis, based on ERG (2011).

Table V-12: Estimated Costs in General Industry and Maritime for Medical Examinations by a Pulmonary Specialist, as Provided under the Proposed Silica Standard

NAICS	Industry	No. of Workers at Risk	No. of Annual Referrals (a)	Cost
324121	Asphalt paving mixture and block manufacturing	5	0	**$6**
324122	Asphalt shingle and roofing materials	196	1	**$242**
325510	Paint and coating manufacturing	40	0	**$50**
327111	Vitreous china plumbing fixtures & bathroom accessories manufacturing	132	1	**$163**
327112	Vitreous china, fine earthenware, & other pottery product manufacturing	207	1	**$255**
327113	Porcelain electrical supply mfg	139	1	**$171**
327121	Brick and structural clay mfg	266	1	**$328**
327122	Ceramic wall and floor tile mfg	140	1	**$172**
327123	Other structural clay product mfg	32	0	**$39**
327124	Clay refractory manufacturing	36	0	**$45**
327125	Nonclay refractory manufacturing	46	0	**$57**
327211	Flat glass manufacturing	15	0	**$19**
327212	Other pressed and blown glass and glassware manufacturing	59	0	**$73**
327213	Glass container manufacturing	41	0	**$51**
327320	Ready-mixed concrete manufacturing	3,211	13	**$3,957**
327331	Concrete block and brick mfg	387	2	**$476**
327332	Concrete pipe mfg	239	1	**$295**
327390	Other concrete product mfg	1,124	5	**$1,385**
327991	Cut stone and stone product manufacturing	744	3	**$917**
327992	Ground or treated mineral and earth manufacturing	89	0	**$110**
327993	Mineral wool manufacturing	63	0	**$78**
327999	All other misc. nonmetallic mineral product mfg	171	1	**$210**
331111	Iron and steel mills	31	0	**$38**
331112	Electrometallurgical ferroalloy product manufacturing	1	0	**$1**
331210	Iron and steel pipe and tube manufacturing from purchased steel	6	0	**$8**
331221	Rolled steel shape manufacturing	3	0	**$4**
331222	Steel wire drawing	4	0	**$5**
331314	Secondary smelting and alloying of aluminum	2	0	**$3**
331423	Secondary smelting, refining, and alloying of copper	0	0	**$0**
331492	Secondary smelting, refining, and alloying of nonferrous metal (except cu & al)	3	0	**$3**
331511	Iron foundries	1,114	4	**$1,373**

Table V-12: Estimated Costs in General Industry and Maritime for Medical Examinations by a Pulmonary Specialist, as Provided under the Proposed Silica Standard (continued)

NAICS	Industry	No. of Workers at Risk	No. of Annual Referrals (a)	Cost
331512	Steel investment foundries	310	1	**$382**
331513	Steel foundries (except investment)	333	1	**$411**
331524	Aluminum foundries (except die-casting)	503	2	**$620**
331525	Copper foundries (except die-casting)	116	0	**$143**
331528	Other nonferrous foundries (except die-casting)	89	0	**$110**

Table V-12: Estimated Costs in General Industry and Maritime for Medical Examinations by a Pulmonary Specialist, as Provided under the Proposed Silica Standard (continued)

NAICS	Industry	No. of Workers at Risk	No. of Annual Referrals (a)	Cost
332111	Iron and steel forging	8	0	**$9**
332112	Nonferrous forging	3	0	**$3**
332115	Crown and closure manufacturing	1	0	**$1**
332116	Metal stamping	18	0	**$23**
332117	Powder metallurgy part manufacturing	2	0	**$3**
332211	Cutlery and flatware (except precious) manufacturing	2	0	**$2**
332212	Hand and edge tool manufacturing	10	0	**$13**
332213	Saw blade and handsaw manufacturing	2	0	**$3**
332214	Kitchen utensil, pot, and pan manufacturing	1	0	**$1**
332323	Ornamental and architectural metal work	2	0	**$2**
332439	Other metal container manufacturing	4	0	**$5**
332510	Hardware manufacturing	13	0	**$16**
332611	Spring (heavy gauge) manufacturing	1	0	**$1**
332612	Spring (light gauge) manufacturing	4	0	**$5**
332618	Other fabricated wire product manufacturing	10	0	**$13**
332710	Machine shops	76	0	**$94**
332812	Metal coating and allied services	163	1	**$201**
332911	Industrial valve manufacturing	11	0	**$13**
332912	Fluid power valve and hose fitting manufacturing	10	0	**$12**
332913	Plumbing fixture fitting and trim manufacturing	3	0	**$4**
332919	Other metal valve and pipe fitting manufacturing	5	0	**$6**
332991	Ball and roller bearing manufacturing	8	0	**$10**
332996	Fabricated pipe and pipe fitting manufacturing	8	0	**$10**
332997	Industrial pattern manufacturing	2	0	**$2**
332998	Enameled iron and metal sanitary ware manufacturing	4	0	**$5**
332999	All other miscellaneous fabricated metal product manufacturing	21	0	**$25**
333319	Other commercial and service industry machinery manufacturing	15	0	**$19**
333411	Air purification equipment manufacturing	4	0	**$5**
333412	Industrial and commercial fan and blower manufacturing	3	0	**$4**
333414	Heating equipment (except warm air furnaces) manufacturing	6	0	**$7**
333511	Industrial mold manufacturing	11	0	**$14**
333512	Machine tool (metal cutting types) manufacturing	5	0	**$6**
333513	Machine tool (metal forming types) manufacturing	2	0	**$3**
333514	Special die and tool, die set, jig, and fixture manufacturing	16	0	**$20**
333515	Cutting tool and machine tool accessory manufacturing	10	0	**$12**
333516	Rolling mill machinery and equipment manufacturing	1	0	**$1**
333518	Other metalworking machinery manufacturing	4	0	**$4**
333612	Speed changer, industrial high-speed drive, and gear manufacturing	4	0	**$4**
333613	Mechanical power transmission equipment manufacturing	4	0	**$5**
333911	Pump and pumping equipment manufacturing	9	0	**$11**
333912	Air and gas compressor manufacturing	6	0	**$8**
333991	Power-driven handtool manufacturing	2	0	**$3**

Table V-12: Estimated Costs in General Industry and Maritime for Medical Examinations by a Pulmonary Specialist, as Provided under the Proposed Silica Standard (continued)

NAICS	Industry	No. of Workers at Risk	No. of Annual Referrals (a)	Cost
333992	Welding and soldering equipment manufacturing	5	0	**$6**
333993	Packaging machinery manufacturing	6	0	**$7**
333994	Industrial process furnace and oven manufacturing	3	0	**$4**
333995	Fluid power cylinder and actuator manufacturing	6	0	**$7**
333996	Fluid power pump and motor manufacturing	4	0	**$5**
333997	Scale and balance (except laboratory) manufacturing	1	0	**$1**
333999	All other miscellaneous general purpose machinery manufacturing	15	0	**$18**
334518	Watch, clock, and part manufacturing	1	0	**$1**
335211	Electric housewares and household fans	1	0	**$1**
335221	Household cooking appliance manufacturing	2	0	**$2**
335222	Household refrigerator and home freezer manufacturing	2	0	**$2**
335224	Household laundry equipment manufacturing	2	0	**$2**
335228	Other major household appliance manufacturing	1	0	**$2**
336111	Automobile manufacturing	21	0	**$26**
336112	Light truck and utility vehicle manufacturing	30	0	**$36**
336120	Heavy duty truck manufacturing	9	0	**$11**
336211	Motor vehicle body manufacturing	14	0	**$17**
336212	Truck trailer manufacturing	9	0	**$11**
336213	Motor home manufacturing	6	0	**$8**
336311	Carburetor, piston, piston ring, and valve manufacturing	3	0	**$4**
336312	Gasoline engine and engine parts manufacturing	19	0	**$23**
336322	Other motor vehicle electrical and electronic equipment manufacturing	18	0	**$22**
336330	Motor vehicle steering and suspension components (except spring) manufacturing	11	0	**$14**
336340	Motor vehicle brake system manufacturing	10	0	**$12**
336350	Motor vehicle transmission and power train parts manufacturing	24	0	**$29**
336370	Motor vehicle metal stamping	31	0	**$39**
336399	All other motor vehicle parts manufacturing	42	0	**$52**
336611	Ship building and repair	1,998	8	**$2,463**
336612	Boat building	1,252	5	**$1,542**
336992	Military armored vehicle, tank, and tank component manufacturing	2	0	**$2**
337215	Showcase, partition, shelving, and locker manufacturing	17	0	**$21**
339114	Dental equipment and supplies manufacturing	27	0	**$34**
339116	Dental laboratories	107	0	**$132**
339911	Jewelry (except costume) manufacturing	342	1	**$421**
339913	Jewelers' materials and lapidary work manufacturing	70	0	**$87**
339914	Costume jewelry and novelty manufacturing	48	0	**$59**
339950	Sign manufacturing	17	0	**$21**
423840	Industrial supplies, wholesalers	15	0	**$19**
482110	Rail transportation	563	2	**$694**
621210	Dental offices	26	0	**$32**
	Totals	**15,172**	**61**	**$18,698**

(a) The integers in this column are rounded from figures that included decimal places. For example, the “0” referral for NAICS 324121 was rounded from a calculated value of 0.018. See the text immediately preceding Tables V-11 and V-12 for an explanation of the methodology for calculating the number of referrals.

Source: U.S. Dept. of Labor, OSHA, Directorate of Evaluation and Analysis, Office of Regulatory Analysis, based on ERG (2011).

Table V-13: Aggregate Costs in General Industry and Maritime, by NAICS Industry, for the Medical Surveillance Requirements in the Proposed Silica Rule

NAICS	Industry	Total Cost of Examinations	Cost of Pulmonary Specialist Examinations	Total Cost
324121	Asphalt paving mixture and block manufacturing	$956	$6	**$962**
324122	Asphalt shingle and roofing materials	$39,122	$242	**$39,364**
325510	Paint and coating manufacturing	$8,129	$50	**$8,179**
327111	Vitreous china plumbing fixtures & bathroom accessories manufacturing	$26,632	$163	**$26,795**
327112	Vitreous china, fine earthenware, & other pottery product manufacturing	$41,757	$255	**$42,012**
327113	Porcelain electrical supply mfg	$28,063	$171	**$28,234**
327121	Brick and structural clay mfg	$53,503	$328	**$53,831**
327122	Ceramic wall and floor tile mfg	$28,199	$172	**$28,371**
327123	Other structural clay product mfg	$6,378	$39	**$6,417**
327124	Clay refractory manufacturing	$7,348	$45	**$7,393**
327125	Nonclay refractory manufacturing	$9,261	$57	**$9,318**
327211	Flat glass manufacturing	$3,119	$19	**$3,138**
327212	Other pressed and blown glass and glassware manufacturing	$11,975	$73	**$12,048**
327213	Glass container manufacturing	$8,323	$51	**$8,374**
327320	Ready-mixed concrete manufacturing	$648,292	$3,957	**$652,249**
327331	Concrete block and brick mfg	$78,060	$476	**$78,536**
327332	Concrete pipe mfg	$48,326	$295	**$48,621**
327390	Other concrete product mfg	$226,905	$1,385	**$228,290**
327991	Cut stone and stone product manufacturing	$150,475	$917	**$151,392**
327992	Ground or treated mineral and earth manufacturing	$18,024	$110	**$18,134**
327993	Mineral wool manufacturing	$12,775	$78	**$12,852**
327999	All other misc. nonmetallic mineral product mfg	$34,481	$210	**$34,691**
331111	Iron and steel mills	$6,091	$38	**$6,129**
331112	Electrometallurgical ferroalloy product manufacturing	$123	$1	**$124**
331210	Iron and steel pipe and tube manufacturing from purchased steel	$1,231	$8	**$1,239**
331221	Rolled steel shape manufacturing	$621	$4	**$625**
331222	Steel wire drawing	$838	$5	**$843**
331314	Secondary smelting and alloying of aluminum	$416	$3	**$419**
331423	Secondary smelting, refining, and alloying of copper	$72	$0	**$72**
331492	Secondary smelting, refining, and alloying of nonferrous metal (except cu & al)	$536	$3	**$539**
331511	Iron foundries	$221,632	$1,373	**$223,005**

Table V-13: Aggregate Costs in General Industry and Maritime, by NAICS Industry, for the Medical Surveillance Requirements in the Proposed Silica Rule (continued)

NAICS	Industry	Total Cost of Examinations	Cost of Pulmonary Specialist Examinations	Total Cost
331512	Steel investment foundries	$61,942	$382	**$62,324**
331513	Steel foundries (except investment)	$66,616	$411	**$67,027**
331524	Aluminum foundries (except die-casting)	$100,967	$620	**$101,588**
331525	Copper foundries (except die-casting)	$23,525	$143	**$23,668**
331528	Other nonferrous foundries (except die-casting)	$17,827	$110	**$17,937**
332111	Iron and steel forging	$1,529	$9	**$1,538**
332112	Nonferrous forging	$505	$3	**$508**
332115	Crown and closure manufacturing	$185	$1	**$186**
332116	Metal stamping	$3,711	$23	**$3,734**
332117	Powder metallurgy part manufacturing	$478	$3	**$481**
332211	Cutlery and flatware (except precious) manufacturing	$331	$2	**$333**
332212	Hand and edge tool manufacturing	$2,097	$13	**$2,110**
332213	Saw blade and handsaw manufacturing	$416	$3	**$418**
332214	Kitchen utensil, pot, and pan manufacturing	$226	$1	**$228**
332323	Ornamental and architectural metal work	$380	$2	**$383**
332439	Other metal container manufacturing	$870	$5	**$876**
332510	Hardware manufacturing	$2,601	$16	**$2,617**
332611	Spring (heavy gauge) manufacturing	$233	$1	**$235**
332612	Spring (light gauge) manufacturing	$880	$5	**$885**
332618	Other fabricated wire product manufacturing	$2,089	$13	**$2,102**
332710	Machine shops	$15,439	$94	**$15,533**
332812	Metal coating and allied services	$32,943	$201	**$33,145**
332911	Industrial valve manufacturing	$2,184	$13	**$2,197**
332912	Fluid power valve and hose fitting manufacturing	$2,027	$12	**$2,040**
332913	Plumbing fixture fitting and trim manufacturing	$657	$4	**$661**
332919	Other metal valve and pipe fitting manufacturing	$1,032	$6	**$1,038**
332991	Ball and roller bearing manufacturing	$1,552	$10	**$1,561**
332996	Fabricated pipe and pipe fitting manufacturing	$1,550	$10	**$1,560**
332997	Industrial pattern manufacturing	$302	$2	**$304**
332998	Enameled iron and metal sanitary ware manufacturing	$769	$5	**$774**
332999	All other miscellaneous fabricated metal product manufacturing	$4,155	$25	**$4,181**
333319	Other commercial and service industry machinery manufacturing	$3,035	$19	**$3,053**
333411	Air purification equipment manufacturing	$842	$5	**$847**
333412	Industrial and commercial fan and blower manufacturing	$596	$4	**$599**
333414	Heating equipment (except warm air furnaces) manufacturing	$1,167	$7	**$1,174**
333511	Industrial mold manufacturing	$2,303	$14	**$2,317**
333512	Machine tool (metal cutting types) manufacturing	$982	$6	**$988**
333513	Machine tool (metal forming types) manufacturing	$492	$3	**$495**
333514	Special die and tool, die set, jig, and fixture manufacturing	$3,325	$20	**$3,346**
333515	Cutting tool and machine tool accessory manufacturing	$2,012	$12	**$2,025**
333516	Rolling mill machinery and equipment manufacturing	$177	$1	**$178**
333518	Other metalworking machinery manufacturing	$719	$4	**$724**

Table V-13: Aggregate Costs in General Industry and Maritime, by NAICS Industry, for the Medical Surveillance Requirements in the Proposed Silica Rule (continued)

NAICS	Industry	Total Cost of Examinations	Cost of Pulmonary Specialist Examinations	Total Cost
333612	Speed changer, industrial high-speed drive, and gear manufacturing	$697	$4	**$702**
333613	Mechanical power transmission equipment manufacturing	$881	$5	**$886**
333911	Pump and pumping equipment manufacturing	$1,757	$11	**$1,767**
333912	Air and gas compressor manufacturing	$1,222	$8	**$1,230**
333991	Power-driven handtool manufacturing	$498	$3	**$501**
333992	Welding and soldering equipment manufacturing	$898	$6	**$904**
333993	Packaging machinery manufacturing	$1,211	$7	**$1,219**
333994	Industrial process furnace and oven manufacturing	$617	$4	**$620**
333995	Fluid power cylinder and actuator manufacturing	$1,130	$7	**$1,137**
333996	Fluid power pump and motor manufacturing	$777	$5	**$782**
333997	Scale and balance (except laboratory) manufacturing	$215	$1	**$216**
333999	All other miscellaneous general purpose machinery manufacturing	$2,993	$18	**$3,012**
334518	Watch, clock, and part manufacturing	$127	$1	**$127**
335211	Electric housewares and household fans	$148	$1	**$149**
335221	Household cooking appliance manufacturing	$319	$2	**$321**
335222	Household refrigerator and home freezer manufacturing	$341	$2	**$343**
335224	Household laundry equipment manufacturing	$324	$2	**$326**
335228	Other major household appliance manufacturing	$255	$2	**$256**
336111	Automobile manufacturing	$4,177	$26	**$4,203**
336112	Light truck and utility vehicle manufacturing	$5,763	$36	**$5,799**
336120	Heavy duty truck manufacturing	$1,789	$11	**$1,800**
336211	Motor vehicle body manufacturing	$2,705	$17	**$2,722**
336212	Truck trailer manufacturing	$1,829	$11	**$1,841**
336213	Motor home manufacturing	$1,204	$8	**$1,212**
336311	Carburetor, piston, piston ring, and valve manufacturing	$594	$4	**$598**
336312	Gasoline engine and engine parts manufacturing	$3,730	$23	**$3,753**
336322	Other motor vehicle electrical and electronic equipment manufacturing	$3,499	$22	**$3,520**
336330	Motor vehicle steering and suspension components (except spring) manufacturing	$2,214	$14	**$2,228**
336340	Motor vehicle brake system manufacturing	$1,905	$12	**$1,917**
336350	Motor vehicle transmission and power train parts manufacturing	$4,701	$29	**$4,730**
336370	Motor vehicle metal stamping	$6,244	$39	**$6,282**
336399	All other motor vehicle parts manufacturing	$8,420	$52	**$8,472**
336611	Ship building and repair	$395,272	$2,463	**$397,735**
336612	Boat building	$247,547	$1,542	**$249,089**
336992	Military armored vehicle, tank, and tank component manufacturing	$391	$2	**$394**
337215	Showcase, partition, shelving, and locker manufacturing	$3,384	$21	**$3,405**
339114	Dental equipment and supplies manufacturing	$5,490	$34	**$5,524**
339116	Dental laboratories	$21,470	$132	**$21,602**
339911	Jewelry (except costume) manufacturing	$69,051	$421	**$69,472**
339913	Jewelers' materials and lapidary work manufacturing	$14,200	$87	**$14,287**

Table V-13: Aggregate Costs in General Industry and Maritime, by NAICS Industry, for the Medical Surveillance Requirements in the Proposed Silica Rule (continued)

NAICS	Industry	Total Cost of Examinations	Cost of Pulmonary Specialist Examinations	Total Cost
339914	Costume jewelry and novelty manufacturing	$9,667	$59	**$9,726**
339950	Sign manufacturing	$3,470	$21	**$3,491**
423840	Industrial supplies, wholesalers	$3,130	$19	**$3,149**
482110	Rail transportation	$109,536	$694	**$110,229**
621210	Dental offices	$5,255	$32	**$5,286**
	Totals	**$3,038,378**	**$18,698**	**$3,057,076**

Source: U.S. Dept. of Labor, OSHA, Directorate of Evaluation and Analysis, Office of Regulatory Analysis,
based on ERG (2011).

Information and Training Costs

As specified in paragraph (i) of the proposed rule and 29 CFR 1910.1200, training is required for all employees in general industry and maritime in jobs where there is potential exposure to respirable crystalline silica. In addition, new hires would require training before starting work. ERG (2011) provided an estimate of the new-hire rate in general industry and maritime, based on the BLS-estimated separations rate of 27.2 percent in manufacturing (BLS, 2008). OSHA estimated separate costs for training current employees and for training new hires. Given that new-hire training might need to be performed frequently during the year, OSHA estimated a smaller class size for new hires.

OSHA anticipates that training, in accordance with the requirements of the proposed rule (to include hazard communication under proposed paragraph (i)(1) and employee information and training under proposed paragraph (i)(2)), will be conducted by in-house safety or supervisory staff with the use of training modules or videos and will last, on average, one hour. ERG (2007b) judged that establishments could purchase sufficient training materials at an average cost of $2 per worker, encompassing the cost of handouts, video presentations, and training manuals and exercises. ERG (2011) included in the cost estimates for training the value of worker and trainer time as measured by 2009 hourly wage rates (to include fringe benefits) for employees and supervisors, respectively. ERG also developed estimates of average class sizes as a function of establishment size.

For initial training, ERG estimated an average class size of 5 workers for establishments with fewer than 20 employees; 10 workers for establishments with 20 to 499 employees; and 20 workers for establishments with 500 or more employees. For new-hire training, ERG estimated an average class size of 2 workers for establishments with fewer than 20 employees; 5 workers for establishments with 20 to 499 employees; and 10 workers for establishments with 500 or more employees. Based on ERG's work, OSHA estimated the annualized cost (annualized over 10 years) of initial training at between $3.02 and $3.57 per employee and the annual cost of new-hire training at between $22.50 and $32.72 per employee, depending on establishment size. These parameters are averages, and establishment training costs per employee may be higher or lower depending on the total number of employees requiring training. In some industries within the captive foundry sector, the estimated number of at-risk employees in the smallest establishment group was less than the specified average size class (5). However, this result is not based on published data but is only an artifact of the methodology ERG (2007b) used to identify those industries with captive foundries and to impute the number of affected foundry workers in each such industry. The unit costs of training are presented below in Table V-14.

OSHA notes that the training requirements—and the Agency's estimate of training costs—do not include planning and research by management to determine how to come into compliance with the rule. However, costs have been included for management to provide the training, which would presumably allow management to become familiar with the rule and anticipate what changes might be needed to come into compliance. Also, since this is a modification of an existing rule, OSHA anticipates that management would have some familiarization with available compliance technology and practices. Finally, the cost of control equipment is an installed cost, which would include normal design and installation costs. OSHA invites comment on this issue and, if additional management planning and research costs are recommended, any evidence on what the magnitude of these additional costs would be.

OSHA recognizes that many affected establishments in general industry and maritime currently provide training on the hazards of respirable crystalline silica in the workplace. Consistent with some estimates developed by ERG (2007b), OSHA estimates that 50 percent of affected establishments already provide such training. However, some of the training specified in the proposed rule requires that workers be familiar with the training and medical surveillance provisions in the rule. OSHA expects that this training is not currently being provided. Therefore, for costing purposes for the proposed rule, OSHA has estimated that 50 percent of affected establishments currently provide their workers, and would provide new hires, with training that would comply with approximately 50 percent of the training requirements. In other words, OSHA estimates that those (50 percent of) establishments currently providing training on workplace silica hazards would provide an additional 30 minutes of training to comply with the proposed rule; the remaining (50 percent of) establishments would provide 60 minutes of training to comply with the proposed rule. OSHA also recognizes that many new hires in general industry and maritime may have been previously employed in the same industry, and in some cases by the same establishment, so that they might have already received (partial) silica training. However, for costing purposes, OSHA estimates that all new hires will receive the full silica training from the new employer. OSHA requests comments from interested parties on the reasonableness of these estimates.

Table V-15 summarizes the annual costs in general industry and maritime, by NAICS industry, of the training requirements in the proposed rule. For general industry and maritime, combined over all NAICS industries, the cost of the training requirements is $3.0 million annually.

Table V-14: Unit Costs and Analytical Assumptions in General Industry and Maritime for Training Requirements in OSHA's Proposed Silica Standard
(Coverage: Applies to all employees potentially at risk)

Cost Category	Cost			Comments/Assumptions
Direct Costs				
Instructor cost per hour	$34.09			Based on supervisor wage, adjusted for fringe benefits (BLS, 2008, updated to 2009 dollars)
Materials for class per attendee	$2.00			Estimated cost of $2 per worker for the training/reading materials.
Labor Costs				
Time spent in class	Minutes			ERG estimates.
Establishments without existing silica training	60			
Establishments with existing silica training	30			
	Establishment Size			
	Small (<20)	Medium (20-499)	Large (500+)	
Initial training class size	5	10	20	
New hire training class size	2	5	10	
Value of worker time spent in class	$17.94	$17.94	$17.94	Based on worker wage, adjusted for fringe benefits (BLS, 2008, updated to 2009 dollars)
Annualized Training Cost per Employee by Establishment Size				
	Small (<20)	Medium (20-499)	Large (500+)	
Initial training				
Value of instructor's time	$5.11	$2.56	$1.28	
Value of employee's time	$17.94	$17.94	$17.94	
Cost of materials	$2.00	$2.00	$2.00	
Total	$25.05	$22.50	$21.22	
Annualized total	$3.57	$3.20	$3.02	
New hire training				
Value of instructor's time	$12.78	$5.11	$2.56	
Value of employee's time	$17.94	$17.94	$17.94	
Cost of materials	$2.00	$2.00	$2.00	
Total	$32.72	$25.05	$22.50	
Separations rate (layoffs, quits, and retirements)	27.2%			2008 annual hire rate for the manufacturing industry (BLS *Job Openings and Labor Turnover Survey*)

Source: U.S. Dept. of Labor, OSHA, Directorate of Evaluation and Analysis, Office of Regulatory Analysis, based on ERG (2007b and 2011).

Table V-15: Estimated Training Costs in General Industry and Maritime for OSHA's Proposed Silica Standard (all establishments)

NAICS	Industry	Number of At-Risk Workers	Initial Training	New Hire Training	Total Cost
324121	Asphalt paving mixture and block manufacturing	5,043	$15,969	$34,010	**$49,979**
324122	Asphalt shingle and roofing materials	4,395	$13,919	$29,644	**$43,563**
325510	Paint and coating manufacturing	3,285	$10,580	$22,902	**$33,482**
327111	Vitreous china plumbing fixtures & bathroom accessories manufacturing	2,802	$9,104	$19,902	**$29,006**
327112	Vitreous china, fine earthenware, & other pottery product manufacturing	4,394	$14,274	$31,205	**$45,479**
327113	Porcelain electrical supply mfg	2,953	$9,593	$20,971	**$30,564**
327121	Brick and structural clay mfg	5,132	$16,460	$35,106	**$51,566**
327122	Ceramic wall and floor tile mfg	2,695	$8,721	$18,878	**$27,599**
327123	Other structural clay product mfg	609	$1,978	$4,324	**$6,302**
327124	Clay refractory manufacturing	1,646	$5,349	$11,694	**$17,043**
327125	Nonclay refractory manufacturing	2,075	$6,741	$14,738	**$21,479**
327211	Flat glass manufacturing	271	$879	$1,921	**$2,800**
327212	Other pressed and blown glass and glassware manufacturing	1,034	$3,361	$7,347	**$10,708**
327213	Glass container manufacturing	722	$2,345	$5,127	**$7,472**
327320	Ready-mixed concrete manufacturing	43,920	$142,691	$311,939	**$454,630**
327331	Concrete block and brick mfg	10,962	$35,615	$77,858	**$113,473**
327332	Concrete pipe mfg	6,787	$22,049	$48,201	**$70,250**

Table V-15: Estimated Training Costs in General Industry and Maritime for OSHA's Proposed Silica Standard (all establishments) (continued)

NAICS	Industry	Number of At-Risk Workers	Initial Training	New Hire Training	Total Cost
327390	Other concrete product mfg	31,865	$103,525	$226,318	**$329,844**
327991	Cut stone and stone product manufacturing	12,085	$39,407	$86,657	**$126,064**
327992	Ground or treated mineral and earth manufacturing	5,051	$16,471	$36,220	**$52,692**
327993	Mineral wool manufacturing	1,090	$3,556	$7,820	**$11,376**
327999	All other misc. nonmetallic mineral product mfg	4,835	$15,766	$34,669	**$50,435**
331111	Iron and steel mills	614	$1,899	$3,937	**$5,836**
331112	Electrometallurgical ferroalloy product manufacturing	12	$38	$80	**$118**
331210	Iron and steel pipe and tube manufacturing from purchased steel	122	$390	$832	**$1,222**
331221	Rolled steel shape manufacturing	61	$197	$420	**$617**
331222	Steel wire drawing	83	$265	$567	**$832**
331314	Secondary smelting and alloying of aluminum	42	$131	$275	**$406**
331423	Secondary smelting, refining, and alloying of copper	7	$23	$48	**$71**
331492	Secondary smelting, refining, and alloying of nonferrous metal (except cu & al)	53	$169	$361	**$531**
331511	Iron foundries	22,111	$69,660	$146,568	**$216,228**
331512	Steel investment foundries	5,934	$18,853	$40,038	**$58,892**
331513	Steel foundries (except investment)	6,618	$21,026	$44,653	**$65,679**
331524	Aluminum foundries (except die-casting)	9,633	$30,860	$66,146	**$97,006**
331525	Copper foundries (except die-casting)	2,219	$7,288	$16,159	**$23,448**
331528	Other nonferrous foundries (except die-casting)	1,708	$5,426	$11,523	**$16,949**
332111	Iron and steel forging	150	$488	$1,067	**$1,555**
332112	Nonferrous forging	50	$161	$352	**$513**
332115	Crown and closure manufacturing	18	$59	$127	**$186**
332116	Metal stamping	366	$1,181	$2,555	**$3,736**
332117	Powder metallurgy part manufacturing	47	$152	$327	**$479**
332211	Cutlery and flatware (except precious) manufacturing	33	$106	$231	**$337**

Table V-15: Estimated Training Costs in General Industry and Maritime for OSHA's Proposed Silica Standard (all establishments) (continued)

NAICS	Industry	Number of At-Risk Workers	Initial Training	New Hire Training	Total Cost
332212	Hand and edge tool manufacturing	207	$668	$1,450	**$2,118**
332213	Saw blade and handsaw manufacturing	41	$131	$280	**$411**
332214	Kitchen utensil, pot, and pan manufacturing	22	$72	$158	**$230**
332323	Ornamental and architectural metal work	54	$177	$395	**$572**
332439	Other metal container manufacturing	86	$278	$607	**$885**
332510	Hardware manufacturing	256	$831	$1,815	**$2,646**
332611	Spring (heavy gauge) manufacturing	23	$74	$163	**$237**
332612	Spring (light gauge) manufacturing	87	$281	$614	**$895**
332618	Other fabricated wire product manufacturing	205	$667	$1,458	**$2,125**
332710	Machine shops	1,506	$4,981	$11,175	**$16,157**
332812	Metal coating and allied services	4,695	$15,243	$33,319	**$48,563**
332911	Industrial valve manufacturing	216	$690	$1,469	**$2,159**
332912	Fluid power valve and hose fitting manufacturing	201	$642	$1,378	**$2,021**
332913	Plumbing fixture fitting and trim manufacturing	65	$208	$447	**$655**
332919	Other metal valve and pipe fitting manufacturing	102	$327	$701	**$1,028**
332991	Ball and roller bearing manufacturing	154	$492	$1,055	**$1,547**
332996	Fabricated pipe and pipe fitting manufacturing	154	$491	$1,054	**$1,545**
332997	Industrial pattern manufacturing	30	$96	$205	**$301**
332998	Enameled iron and metal sanitary ware manufacturing	96	$308	$661	**$969**
332999	All other miscellaneous fabricated metal product manufacturing	408	$1,330	$2,925	**$4,256**
333319	Other commercial and service industry machinery manufacturing	299	$965	$2,081	**$3,046**

Table V-15: Estimated Training Costs in General Industry and Maritime for OSHA's Proposed Silica Standard (all establishments) (continued)

NAICS	Industry	Number of At-Risk Workers	Initial Training	New Hire Training	Total Cost
333411	Air purification equipment manufacturing	84	$265	$559	**$823**
333412	Industrial and commercial fan and blower manufacturing	59	$187	$395	**$582**
333414	Heating equipment (except warm air furnaces) manufacturing	116	$367	$774	**$1,141**
333511	Industrial mold manufacturing	226	$739	$1,636	**$2,375**
333512	Machine tool (metal cutting types) manufacturing	97	$312	$673	**$985**
333513	Machine tool (metal forming types) manufacturing	48	$157	$343	**$500**
333514	Special die and tool, die set, jig, and fixture manufacturing	325	$1,070	$2,388	**$3,458**
333515	Cutting tool and machine tool accessory manufacturing	197	$646	$1,429	**$2,075**
333516	Rolling mill machinery and equipment manufacturing	17	$57	$125	**$182**
333518	Other metalworking machinery manufacturing	70	$231	$511	**$742**
333612	Speed changer, industrial high-speed drive, and gear manufacturing	70	$218	$456	**$674**
333613	Mechanical power transmission equipment manufacturing	88	$276	$576	**$852**
333911	Pump and pumping equipment manufacturing	174	$556	$1,190	**$1,746**
333912	Air and gas compressor manufacturing	121	$387	$831	**$1,219**
333991	Power-driven handtool manufacturing	49	$158	$339	**$497**
333992	Welding and soldering equipment manufacturing	90	$282	$597	**$879**
333993	Packaging machinery manufacturing	120	$385	$833	**$1,218**
333994	Industrial process furnace and oven manufacturing	61	$197	$429	**$626**

Table V-15: Estimated Training Costs in General Industry and Maritime for OSHA's Proposed Silica Standard (all establishments) (continued)

NAICS	Industry	Number of At-Risk Workers	Initial Training	New Hire Training	Total Cost
333995	Fluid power cylinder and actuator manufacturing	112	$356	$756	**$1,113**
333996	Fluid power pump and motor manufacturing	77	$246	$526	**$772**
333997	Scale and balance (except laboratory) manufacturing	21	$69	$150	**$218**
333999	All other miscellaneous general purpose machinery manufacturing	296	$949	$2,036	**$2,985**
334518	Watch, clock, and part manufacturing	12	$40	$89	**$129**
335211	Electric housewares and household fans	22	$66	$136	**$203**
335221	Household cooking appliance manufacturing	47	$143	$295	**$438**
335222	Household refrigerator and home freezer manufacturing	50	$153	$315	**$468**
335224	Household laundry equipment manufacturing	47	$145	$299	**$444**
335228	Other major household appliance manufacturing	37	$115	$235	**$350**
336111	Automobile manufacturing	425	$1,290	$2,624	**$3,914**
336112	Light truck and utility vehicle manufacturing	587	$1,780	$3,620	**$5,400**
336120	Heavy duty truck manufacturing	181	$555	$1,138	**$1,692**
336211	Motor vehicle body manufacturing	269	$854	$1,819	**$2,674**
336212	Truck trailer manufacturing	182	$576	$1,215	**$1,791**
336213	Motor home manufacturing	122	$375	$773	**$1,147**
336311	Carburetor, piston, piston ring, and valve manufacturing	60	$186	$390	**$576**
336312	Gasoline engine and engine parts manufacturing	373	$1,169	$2,447	**$3,616**
336322	Other motor vehicle electrical and electronic equipment manufacturing	350	$1,096	$2,295	**$3,392**

Table V-15: Estimated Training Costs in General Industry and Maritime for OSHA's Proposed Silica Standard (all establishments) (continued)

NAICS	Industry	Number of At-Risk Workers	Initial Training	New Hire Training	Total Cost
336330	Motor vehicle steering and suspension components (except spring) manufacturing	223	$691	$1,437	**$2,128**
336340	Motor vehicle brake system manufacturing	191	$597	$1,250	**$1,847**
336350	Motor vehicle transmission and power train parts manufacturing	473	$1,467	$3,044	**$4,510**
336370	Motor vehicle metal stamping	624	$1,958	$4,099	**$6,057**
336399	All other motor vehicle parts manufacturing	843	$2,638	$5,523	**$8,162**
336611	Ship building and repair	2,798	$8,725	$18,248	**$26,973**
336612	Boat building	1,752	$5,464	$11,428	**$16,892**
336992	Military armored vehicle, tank, and tank component manufacturing	39	$123	$260	**$383**
337215	Showcase, partition, shelving, and locker manufacturing	334	$1,077	$2,334	**$3,412**
339114	Dental equipment and supplies manufacturing	411	$1,316	$2,841	**$4,157**
339116	Dental laboratories	33,214	$106,382	$229,602	**$335,984**
339911	Jewelry (except costume) manufacturing	7,813	$25,442	$55,972	**$81,414**
339913	Jewelers' materials and lapidary work manufacturing	1,607	$5,232	$11,510	**$16,742**
339914	Costume jewelry and novelty manufacturing	1,088	$3,543	$7,794	**$11,337**
339950	Sign manufacturing	496	$1,617	$3,556	**$5,173**
423840	Industrial supplies, wholesalers	383	$1,280	$2,919	**$4,199**
482110	Rail transportation	16,895	$51,036	$103,375	**$154,412**
621210	Dental offices	7,980	$26,629	$60,779	**$87,408**
Totals		**294,886**	**$947,554**	**$2,048,346**	**$2,995,900**

Source: U.S. Dept. of Labor, OSHA, Directorate of Evaluation and Analysis, Office of Regulatory Analysis, based on ERG (2007b and 2011).

Regulated Area Costs

Paragraph (e)(1) of the proposed standard requires that wherever an employee's exposure to airborne concentrations of respirable crystalline silica is, or can reasonably be expected to be, in excess of the PEL, each employer shall establish and implement either a regulated area in accordance with paragraph (e)(2) or an access control plan in accordance with paragraph (e)(3).

For costing purposes, OSHA estimated that employers in general industry and maritime would typically prefer and choose option (e)(2) and would therefore establish regulated areas when an employee's exposure to airborne concentrations of silica exceeds, or can reasonably be expected to exceed, the PEL. OSHA believes that general industry and maritime employers will prefer this option as it is expected to be the most practical alternative in fixed worksites. Requirements in the proposed rule for a regulated area include demarcating the boundaries of the regulated area (as separate from the rest of the workplace) (paragraph (e)(2)), limiting access to the regulated area (paragraph (e)(3)), providing an appropriate respirator to each employee entering the regulated area (paragraph (e)(4)), and providing protective clothing as needed in the regulated area (paragraph (e)(5)). OSHA estimated costs for establishing and maintaining regulated areas to comply with these requirements.

Based on ERG (2007b), OSHA estimated that one area would be necessary for every eight workers in general industry and maritime exposed above the PEL. Unit costs were also derived from ERG (2007b). They included planning time (estimated at an initial seven hours of supervisor time and one hour for changes annually); material costs for signs and boundary markers (annualized at $63.64 in 2009 dollars); and costs of $500 annually for two disposable respirators per day to be used by authorized persons (other than those who regularly work in the regulated area) who might need to enter the area in the course of their job duties. In addition, for costing purposes, OSHA estimated that, in response to the protective work clothing requirements in regulated areas, ten percent of employees in regulated areas would wear disposable protective clothing daily, estimated at $5.50 per suit, for an annual clothing cost of $1,100 per regulated area. Table V-16 shows the cost assumptions and unit costs applied in OSHA's cost model for regulated areas in general industry and maritime. Overall, OSHA estimates that each regulated area in general industry and maritime would, on average, cost employers $1,732 annually. Table V-17 shows total estimated costs for regulated areas in general industry and maritime of $2.7 million annually for the proposed rule and also provides a breakdown of costs by NAICS industry.

Table V-16: Unit Costs and Analytical Assumptions in General Industry and Maritime for Regulated Area Requirements in OSHA's Proposed Silica Standard

Cost Variable	Parameter	Unit cost	Comment
Regulated area setup			
Time to set up regulated area (hours) – First year only	7	$238.63	Estimated by ERG. Valued at supervisor's wage (BLS, 2008, updated to 2009 dollars)
Annual time for changes to regulated areas	1	$34.09	Estimated by ERG. Valued at supervisor's wage (BLS, 2008, updated to 2009 dollars)
Annualized regulated area set up costs		$68.07	
Respirators			
Respirators for authorized persons	2		Assumes 2 disposable respirators used per day
Cost - disposable particulate respirator (N95)		$1.00	$1.00 per respirator per day, typical cost for N95 disposable respirator (Lab Safety Supply, 2010).
Respirator cost - annual		$500	Per crew
Disposable clothing		$5.50	Per suit (Lab Supply, 2010)
Disposable clothing – annual cost		$1,100	Assumes daily clothing for 10% of workers
Materials			
Hazard tape per regulated area for annual set-up (300 ft)		$5.80	(Lab Safety Supply, 2010)
Warning signs (6)		$151.80	$25.30 per sign (Lab Safety Supply, 2010)
Warning signs - annualized cost		$57.84	Assumes 3 year life
Annualized materials cost per regulated area		$63.64	Sum of hazard tape and annualized warning sign costs
Total annualized cost per regulated area		$1,732	Sum of respirator, materials, and labor cost
Assumptions			
Average number of workers above the PEL per regulated area	8		
Number of working days per year	250		
Share of workers exposed above the PEL needing regulated areas (percentage of at-risk workers initially exposed above the PEL)	10.0%		

Source: U.S. Dept. of Labor, OSHA, Directorate of Evaluation and Analysis, Office of Regulatory Analysis, based on ERG (2011).

Table V-17: Estimated Costs for Regulated Area Requirements in OSHA's Proposed Silica Standard -- General Industry and Maritime

NAICS	Industry	Affected Workers [a]	Annual Costs
324121	Asphalt paving mixture and block manufacturing	5	**$1,038**
324122	Asphalt shingle and roofing materials	196	**$42,495**
325510	Paint and coating manufacturing	40	**$8,752**
327111	Vitreous china plumbing fixtures & bathroom accessories manufacturing	132	**$28,554**
327112	Vitreous china, fine earthenware, & other pottery product manufacturing	207	**$44,770**
327113	Porcelain electrical supply mfg	139	**$30,087**
327121	Brick and structural clay mfg	266	**$57,636**
327122	Ceramic wall and floor tile mfg	140	**$30,266**
327123	Other structural clay product mfg	32	**$6,838**
327124	Clay refractory manufacturing	36	**$7,878**
327125	Nonclay refractory manufacturing	46	**$9,929**
327211	Flat glass manufacturing	15	**$3,344**
327212	Other pressed and blown glass and glassware manufacturing	59	**$12,839**
327213	Glass container manufacturing	41	**$8,959**
327320	Ready-mixed concrete manufacturing	3,211	**$695,065**
327331	Concrete block and brick mfg	387	**$83,692**
327332	Concrete pipe mfg	239	**$51,813**
327390	Other concrete product mfg	1,124	**$243,276**
327991	Cut stone and stone product manufacturing	744	**$161,080**
327992	Ground or treated mineral and earth manufacturing	89	**$19,295**
327993	Mineral wool manufacturing	63	**$13,675**
327999	All other misc. nonmetallic mineral product mfg	171	**$36,911**
331111	Iron and steel mills	31	**$6,691**
331112	Electrometallurgical ferroalloy product manufacturing	1	**$135**
331210	Iron and steel pipe and tube manufacturing from purchased steel	6	**$1,328**
331221	Rolled steel shape manufacturing	3	**$670**
331222	Steel wire drawing	4	**$904**
331314	Secondary smelting and alloying of aluminum	2	**$453**
331423	Secondary smelting, refining, and alloying of copper	0	**$78**
331492	Secondary smelting, refining, and alloying of nonferrous metal (except copper & aluminum)	3	**$580**
331511	Iron foundries	1,114	**$241,133**
331512	Steel investment foundries	310	**$67,110**
331513	Steel foundries (except investment)	333	**$72,174**

Table V-17: Estimated Costs for Regulated Area Requirements in OSHA's Proposed Silica Standard -- General Industry and Maritime (continued)

NAICS	Industry	Affected Workers [a]	Annual Costs
331524	Aluminum foundries (except die-casting)	503	**$108,935**
331525	Copper foundries (except die-casting)	116	**$25,095**
331528	Other nonferrous foundries (except die-casting)	89	**$19,314**
332111	Iron and steel forging	8	**$1,640**
332112	Nonferrous forging	3	**$541**
332115	Crown and closure manufacturing	1	**$199**
332116	Metal stamping	18	**$3,988**
332117	Powder metallurgy part manufacturing	2	**$514**
332211	Cutlery and flatware (except precious) manufacturing	2	**$355**
332212	Hand and edge tool manufacturing	10	**$2,255**
332213	Saw blade and handsaw manufacturing	2	**$451**
332214	Kitchen utensil, pot, and pan manufacturing	1	**$243**
332323	Ornamental and architectural metal work	2	**$406**
332439	Other metal container manufacturing	4	**$934**
332510	Hardware manufacturing	13	**$2,790**
332611	Spring (heavy gauge) manufacturing	1	**$250**
332612	Spring (light gauge) manufacturing	4	**$944**
332618	Other fabricated wire product manufacturing	10	**$2,241**
332710	Machine shops	76	**$16,423**
332812	Metal coating and allied services	163	**$35,337**
332911	Industrial valve manufacturing	11	**$2,361**
332912	Fluid power valve and hose fitting manufacturing	10	**$2,189**
332913	Plumbing fixture fitting and trim manufacturing	3	**$710**
332919	Other metal valve and pipe fitting manufacturing	5	**$1,114**
332991	Ball and roller bearing manufacturing	8	**$1,676**
332996	Fabricated pipe and pipe fitting manufacturing	8	**$1,674**
332997	Industrial pattern manufacturing	2	**$326**
332998	Enameled iron and metal sanitary ware manufacturing	4	**$831**
332999	All other miscellaneous fabricated metal product manufacturing	21	**$4,446**
333319	Other commercial and service industry machinery manufacturing	15	**$3,266**
333411	Air purification equipment manufacturing	4	**$916**
333412	Industrial and commercial fan and blower manufacturing	3	**$648**
333414	Heating equipment (except warm air furnaces) manufacturing	6	**$1,269**
333511	Industrial mold manufacturing	11	**$2,460**
333512	Machine tool (metal cutting types) manufacturing	5	**$1,059**
333513	Machine tool (metal forming types) manufacturing	2	**$527**
333514	Special die and tool, die set, jig, and fixture manufacturing	16	**$3,545**
333515	Cutting tool and machine tool accessory manufacturing	10	**$2,150**
333516	Rolling mill machinery and equipment manufacturing	1	**$189**
333518	Other metalworking machinery manufacturing	4	**$768**
333612	Speed changer, industrial high-speed drive, and gear manufacturing	4	**$763**
333613	Mechanical power transmission equipment manufacturing	4	**$963**
333911	Pump and pumping equipment manufacturing	9	**$1,897**
333912	Air and gas compressor manufacturing	6	**$1,320**
333991	Power-driven handtool manufacturing	2	**$538**
333992	Welding and soldering equipment manufacturing	5	**$978**

Table V-17: Estimated Costs for Regulated Area Requirements in OSHA's Proposed Silica Standard -- General Industry and Maritime (continued)

NAICS	Industry	Affected Workers [a]	Annual Costs
333993	Packaging machinery manufacturing	6	**$1,304**
333994	Industrial process furnace and oven manufacturing	3	**$661**
333995	Fluid power cylinder and actuator manufacturing	6	**$1,225**
333996	Fluid power pump and motor manufacturing	4	**$840**
333997	Scale and balance (except laboratory) manufacturing	1	**$230**
333999	All other miscellaneous general purpose machinery manufacturing	15	**$3,232**
334518	Watch, clock, and part manufacturing	1	**$135**
335211	Electric housewares and household fans	1	**$163**
335221	Household cooking appliance manufacturing	2	**$352**
335222	Household refrigerator and home freezer manufacturing	2	**$376**
335224	Household laundry equipment manufacturing	2	**$357**
335228	Other major household appliance manufacturing	1	**$281**
336111	Automobile manufacturing	21	**$4,636**
336112	Light truck and utility vehicle manufacturing	30	**$6,397**
336120	Heavy duty truck manufacturing	9	**$1,977**
336211	Motor vehicle body manufacturing	14	**$2,931**
336212	Truck trailer manufacturing	9	**$1,989**
336213	Motor home manufacturing	6	**$1,326**
336311	Carburetor, piston, piston ring, and valve manufacturing	3	**$649**
336312	Gasoline engine and engine parts manufacturing	19	**$4,073**
336322	Other motor vehicle electrical and electronic equipment manufacturing	18	**$3,820**
336330	Motor vehicle steering and suspension components (except spring) manufacturing	11	**$2,427**
336340	Motor vehicle brake system manufacturing	10	**$2,080**
336350	Motor vehicle transmission and power train parts manufacturing	24	**$5,160**
336370	Motor vehicle metal stamping	31	**$6,810**
336399	All other motor vehicle parts manufacturing	42	**$9,194**
336611	Ship building and repair	200	**$43,259**
336612	Boat building	125	**$27,092**
336992	Military armored vehicle, tank, and tank component manufacturing	2	**$426**
337215	Showcase, partition, shelving, and locker manufacturing	17	**$3,638**
339114	Dental equipment and supplies manufacturing	27	**$5,930**
339116	Dental laboratories	107	**$23,193**
339911	Jewelry (except costume) manufacturing	342	**$73,992**
339913	Jewelers' materials and lapidary work manufacturing	70	**$15,216**
339914	Costume jewelry and novelty manufacturing	48	**$10,359**
339950	Sign manufacturing	17	**$3,718**
423840	Industrial supplies, wholesalers	15	**$3,315**
482110	Rail transportation	563	**$121,858**
621210	Dental offices	26	**$5,572**
	Total - General Industry and Maritime	**12,247**	**$2,651,079**

[a] Estimated as ten percent of workers originally exposed over 50 μg/m^3.
Source: U.S. Dept. of Labor, OSHA, Directorate of Evaluation and Analysis, Office of Regulatory Analysis, based on ERG (2011).

SBREFA Comments on Compliance Costs in General Industry and Maritime

The Small Entity Representatives (SERs) who participated in the 2003 SBREFA Panel process on OSHA's draft standards for silica provided many comments on OSHA's estimated compliance costs in the Preliminary Initial Regulatory Flexibility Analysis (PIRFA) for general industry and maritime (OSHA, 2003b). The SER comments may be summarized as focusing on several specific concerns: (1) OSHA's choice of data and methodology (often accompanied by a SER's estimates of its own control costs); (2) OSHA's failure to estimate costs specific to small entities; and (3) OSHA's underestimate of certain programmatic costs, particularly for exposure monitoring and medical surveillance.[9, 10]

In response, OSHA carefully reviewed its cost estimates and evaluated the alternative estimates and methodologies suggested by the SERs. OSHA updated all unit costs to reflect the most recent cost data available and inflated all costs to 2009 dollars, but generally determined that its control cost estimates were based on sound methods and reliable data sources.

SERs from several industries provided comments on the costs of complying with the current and proposed silica PEL. Some SERs in the foundry industry and in brick manufacturing (i.e., in the structural clay industry) also provided estimates of the costs they had incurred to meet the current PEL or would incur to meet the proposed PEL.

One SER, whose foundry meets the PEL of 100 except in two operations, provided an estimate of $280,000 for ventilation equipment to meet a lower PEL. Another foundry SER reported that after building a new facility, the company had to invest more than $200,000 in additional ventilation systems to make the current PEL. The SER said that achieving a lower PEL would require an additional $50,000 investment.

One SER in the structural clay industry reported investment costs of $200,000 in controls for silica dust in high exposure jobs in brick manufacturing, but still needed respiratory protection to meet the current PEL. Another SER reported an investment of $600,000 - $700,000 to install several dust control systems, including the use of water, baffles, and other measures, to meet the current PEL. Another reported spending $200,000 in a new facility for three ventilation systems. SERs in the structural clay industry also reported that it would require significantly more investment to meet a lower PEL, if in fact it could be achieved.

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[9] The SERs also provided numerous comments on the hygiene provisions contained in the 2003 draft silica standards. Those provisions would have required, among other things, change rooms, shower facilities, and lunch rooms. These specific hygiene provisions have been removed from the proposed rule.

[10] These SERs' concerns, and OSHA's response to them, apply equally well to OSHA's estimated compliance costs in the PIRFA on construction. However, in the following section of this chapter devoted to the costs of the proposed rule on the construction sector, OSHA focuses on more detailed and technical comments provided during the SBREFA Panel process specific to the Agency's estimate of costs in construction._

OSHA reviewed these cost estimates for small entities in the foundry and structural clay industries and, given that the SERs with cost estimates did not report their own size, the Agency concludes that the compliance costs reported by SERs in general industry are not incompatible with OSHA's own estimates of the costs of engineering controls to comply with the PEL. For example, OSHA estimates for first year costs for ventilation in the foundry industry would range from $171,000 to $530,000 for small entities with between 50 and 500 employees, with total first-year engineering control costs ranging from $197,000 to $966,000. OSHA estimates for first year costs for ventilation in the structural clay industry would range from $275,000 to $2,500,000 for small entities with between 50 and 500 employees, with total first-year engineering control costs ranging from $414,000 to $3,845,000. In fact, while the SERs indicated that the meeting the proposed PEL would be expensive, they did not assert that OSHA's cost estimates were too low.

OSHA also developed cost estimates in this PEA as a function of the size of the establishment for exposure monitoring, medical surveillance, and training. In each case, OSHA's cost estimates now reflect the fact that smaller entities will tend to experience larger unit costs. As described earlier, OSHA estimated higher exposure monitoring costs for small entities because an industrial hygienist could not take as many samples a day in a small establishment as in a large one; higher medical surveillance costs for small entities because smaller establishments would be more likely to send the workers off-site for medical testing; and higher training costs for small entities because of smaller-sized training classes.

In addition, OSHA significantly increased the total costs of exposure sampling and x-rays in medical surveillance by assuming no existing compliance with the those provisions in the proposed rule (as compared to an average of 32.6 percent and 34.8 percent existing compliance, respectively, in the PIRFA) and significantly increased training costs by assuming only half compliance for half of the affected establishments (compared to an average of 56 percent existing compliance for all establishments in the PIRFA).

OSHA solicits comment on all issues associated with OSHA's estimates of compliance costs in general industry and maritime.

Combined Control, Respirator, and Program Costs

Table V-18 shows that the combined compliance costs for general industry and maritime to comply with the proposed silica rule are approximately $146.7 million annually. These costs include $101.2 million annually for controls and $6.9 million annually for respirators to meet the proposed PEL of 50 $\mu g/m^3$. The remaining $38.6 million annually are to meet the ancillary provisions of the proposed rule. These ancillary annual costs consist of $29.9 million for exposure monitoring; $3.1 million for medical surveillance; $3.0 million for training; and $2.7 million for restricted areas.

Table V-B-1 in Appendix B presents estimated compliance costs by NAICS industry code and program element for small business entities (as defined by the Small Business Act and the Small Business Administration's implementing regulations; see 15 U.S.C. 632 and 13 CFR 121.201) in general industry and maritime, while Table V-B-2 presents estimated compliance costs, by NAICS code and program element, for very small entities (fewer than twenty employees) in general industry and maritime.

Table V-18: Total Costs for All General Industry and Maritime Establishments Affected by the Proposed Silica Standard

NAICS	Industry	Engineering Controls (includes Abrasive Blasting)	Respirators	Exposure Assessment	Medical Surveillance	Training	Regulated Areas	Total
324121	Asphalt paving mixture and block manufacturing	$179,111	$2,784	$8,195	$962	$49,979	$1,038	**$242,070**
324122	Asphalt shingle and roofing materials	$2,194,150	$113,924	$723,761	$39,364	$43,563	$42,495	**$3,157,257**
325510	Paint and coating manufacturing	$0	$23,445	$70,423	$8,179	$33,482	$8,752	**$144,281**
327111	Vitreous china plumbing fixtures & bathroom accessories manufacturing	$1,128,859	$76,502	$369,478	$26,795	$29,006	$28,554	**$1,659,194**
327112	Vitreous china, fine earthenware, & other pottery product manufacturing	$1,769,953	$119,948	$579,309	$42,012	$45,479	$44,770	**$2,601,471**
327113	Porcelain electrical supply mfg	$1,189,482	$80,610	$389,320	$28,234	$30,564	$30,087	**$1,748,297**
327121	Brick and structural clay mfg	$6,966,654	$154,040	$554,322	$53,831	$51,566	$57,636	**$7,838,050**
327122	Ceramic wall and floor tile mfg	$3,658,389	$80,982	$306,500	$28,371	$27,599	$30,266	**$4,132,107**
327123	Other structural clay product mfg	$826,511	$18,320	$72,312	$6,417	$6,302	$6,838	**$936,699**

Table V-18: Total Costs for All General Industry and Maritime Establishments Affected by the Proposed Silica Standard (continued)

NAICS	Industry	Engineering Controls (includes Abrasive Blasting)	Respirators	Exposure Assessment	Medical Surveillance	Training	Regulated Areas	Total
327124	Clay refractory manufacturing	$304,625	$21,108	$124,390	$7,393	$17,043	$7,878	**$482,438**
327125	Nonclay refractory manufacturing	$383,919	$26,602	$156,769	$9,318	$21,479	$9,929	**$608,017**
327211	Flat glass manufacturing	$227,805	$8,960	$29,108	$3,138	$2,800	$3,344	**$275,155**
327212	Other pressed and blown glass and glassware manufacturing	$902,802	$34,398	$111,912	$12,048	$10,708	$12,839	**$1,084,706**
327213	Glass container manufacturing	$629,986	$24,003	$78,093	$8,374	$7,472	$8,959	**$756,888**
327320	Ready-mixed concrete manufacturing	$7,029,710	$1,862,221	$5,817,205	$652,249	$454,630	$695,065	**$16,511,080**
327331	Concrete block and brick mfg	$2,979,495	$224,227	$958,517	$78,536	$113,473	$83,692	**$4,437,939**
327332	Concrete pipe mfg	$1,844,576	$138,817	$593,408	$48,621	$70,250	$51,813	**$2,747,484**
327390	Other concrete product mfg	$8,660,830	$651,785	$2,786,227	$228,290	$329,844	$243,276	**$12,900,251**
327991	Cut stone and stone product manufacturing	$5,894,506	$431,758	$1,835,498	$151,392	$126,064	$161,080	**$8,600,298**
327992	Ground or treated mineral and earth manufacturing	$3,585,439	$51,718	$867,728	$18,134	$52,692	$19,295	**$4,595,006**
327993	Mineral wool manufacturing	$897,980	$36,654	$122,015	$12,852	$11,376	$13,675	**$1,094,552**
327999	All other misc. nonmetallic mineral product mfg	$1,314,066	$98,936	$431,012	$34,691	$50,435	$36,911	**$1,966,052**
331111	Iron and steel mills	$315,559	$17,939	$72,403	$6,129	$5,836	$6,691	**$424,557**
331112	Electrometallurgical ferroalloy product manufacturing	$6,375	$362	$1,463	$124	$118	$135	**$8,577**

Table V-18: Total Costs for All General Industry and Maritime Establishments Affected by the Proposed Silica Standard (continued)

NAICS	Industry	Engineering Controls (includes Abrasive Blasting)	Respirators	Exposure Assessment	Medical Surveillance	Training	Regulated Areas	Total
331210	Iron and steel pipe and tube manufacturing from purchased steel	$62,639	$3,552	$14,556	$1,239	$1,222	$1,328	**$84,537**
331221	Rolled steel shape manufacturing	$31,618	$1,793	$7,348	$625	$617	$670	**$42,672**
331222	Steel wire drawing	$42,648	$2,419	$9,911	$843	$832	$904	**$57,557**
331314	Secondary smelting and alloying of aluminum	$21,359	$1,213	$4,908	$419	$406	$453	**$28,757**
331423	Secondary smelting, refining, and alloying of copper	$3,655	$207	$857	$72	$71	$78	**$4,940**
331492	Secondary smelting, refining, and alloying of nonferrous metal (except cu & al)	$27,338	$1,551	$6,407	$539	$531	$580	**$36,946**
331511	Iron foundries	$11,372,127	$645,546	$2,612,775	$223,005	$216,228	$241,133	**$15,310,815**
331512	Steel investment foundries	$3,175,862	$179,639	$739,312	$62,324	$58,892	$67,110	**$4,283,138**
331513	Steel foundries (except investment)	$3,403,790	$193,194	$794,973	$67,027	$65,679	$72,174	**$4,596,837**
331524	Aluminum foundries (except die-casting)	$5,155,172	$291,571	$1,220,879	$101,588	$97,006	$108,935	**$6,975,150**
331525	Copper foundries (except die-casting)	$1,187,578	$67,272	$309,403	$23,668	$23,448	$25,095	**$1,636,463**
331528	Other nonferrous foundries (except die-casting)	$914,028	$51,701	$212,778	$17,937	$16,949	$19,314	**$1,232,708**
332111	Iron and steel forging	$77,324	$4,393	$19,505	$1,538	$1,555	$1,640	**$105,955**
332112	Nonferrous forging	$25,529	$1,451	$6,440	$508	$513	$541	**$34,982**
332115	Crown and closure manufacturing	$9,381	$532	$2,236	$186	$186	$199	**$12,720**
332116	Metal stamping	$188,102	$10,676	$45,595	$3,734	$3,736	$3,988	**$255,832**

Table V-18: Total Costs for All General Industry and Maritime Establishments Affected by the Proposed Silica Standard (continued)

NAICS	Industry	Engineering Controls (includes Abrasive Blasting)	Respirators	Exposure Assessment	Medical Surveillance	Training	Regulated Areas	Total
332117	Powder metallurgy part manufacturing	$24,250	$1,375	$5,727	$481	$479	$514	**$32,828**
332211	Cutlery and flatware (except precious) manufacturing	$16,763	$952	$4,229	$333	$337	$355	**$22,970**
332212	Hand and edge tool manufacturing	$106,344	$6,041	$26,356	$2,110	$2,118	$2,255	**$145,223**
332213	Saw blade and handsaw manufacturing	$21,272	$1,209	$5,090	$418	$411	$451	**$28,851**
332214	Kitchen utensil, pot, and pan manufacturing	$11,442	$650	$2,886	$228	$230	$243	**$15,678**
332323	Ornamental and architectural metal work	$28,010	$1,089	$4,808	$383	$572	$406	**$35,267**
332439	Other metal container manufacturing	$44,028	$2,502	$11,106	$876	$885	$934	**$60,330**
332510	Hardware manufacturing	$131,574	$7,476	$33,190	$2,617	$2,646	$2,790	**$180,292**
332611	Spring (heavy gauge) manufacturing	$11,792	$670	$2,974	$235	$237	$250	**$16,158**
332612	Spring (light gauge) manufacturing	$44,511	$2,529	$11,228	$885	$895	$944	**$60,992**
332618	Other fabricated wire product manufacturing	$105,686	$6,005	$26,659	$2,102	$2,125	$2,241	**$144,819**
332710	Machine shops	$774,529	$44,074	$211,043	$15,533	$16,157	$16,423	**$1,077,759**
332812	Metal coating and allied services	$2,431,996	$94,689	$395,206	$33,145	$48,563	$35,337	**$3,038,935**
332911	Industrial valve manufacturing	$111,334	$6,316	$25,894	$2,197	$2,159	$2,361	**$150,261**
332912	Fluid power valve and hose fitting manufacturing	$103,246	$5,863	$24,854	$2,040	$2,021	$2,189	**$140,213**

Table V-18: Total Costs for All General Industry and Maritime Establishments Affected by the Proposed Silica Standard (continued)

NAICS	Industry	Engineering Controls (includes Abrasive Blasting)	Respirators	Exposure Assessment	Medical Surveillance	Training	Regulated Areas	Total
332913	Plumbing fixture fitting and trim manufacturing	$33,484	$1,901	$8,060	$661	$655	$710	**$45,472**
332919	Other metal valve and pipe fitting manufacturing	$52,542	$2,984	$12,648	$1,038	$1,028	$1,114	**$71,354**
332991	Ball and roller bearing manufacturing	$79,038	$4,488	$19,027	$1,561	$1,547	$1,676	**$107,338**
332996	Fabricated pipe and pipe fitting manufacturing	$78,951	$4,483	$19,006	$1,560	$1,545	$1,674	**$107,219**
332997	Industrial pattern manufacturing	$15,383	$874	$3,703	$304	$301	$326	**$20,891**
332998	Enameled iron and metal sanitary ware manufacturing	$46,581	$2,225	$9,304	$774	$969	$831	**$60,684**
332999	All other miscellaneous fabricated metal product manufacturing	$209,692	$11,915	$53,603	$4,181	$4,256	$4,446	**$288,093**
333319	Other commercial and service industry machinery manufacturing	$154,006	$8,741	$37,161	$3,053	$3,046	$3,266	**$209,273**
333411	Air purification equipment manufacturing	$43,190	$2,453	$10,037	$847	$823	$916	**$58,265**
333412	Industrial and commercial fan and blower manufacturing	$30,549	$1,735	$7,099	$599	$582	$648	**$41,212**
333414	Heating equipment (except warm air furnaces) manufacturing	$59,860	$3,399	$13,911	$1,174	$1,141	$1,269	**$80,754**
333511	Industrial mold manufacturing	$116,034	$6,597	$30,348	$2,317	$2,375	$2,460	**$160,131**

Table V-18: Total Costs for All General Industry and Maritime Establishments Affected by the Proposed Silica Standard (continued)

NAICS	Industry	Engineering Controls (includes Abrasive Blasting)	Respirators	Exposure Assessment	Medical Surveillance	Training	Regulated Areas	Total
333512	Machine tool (metal cutting types) manufacturing	$49,965	$2,839	$12,313	$988	$985	$1,059	**$68,151**
333513	Machine tool (metal forming types) manufacturing	$24,850	$1,411	$6,157	$495	$500	$527	**$33,940**
333514	Special die and tool, die set, jig, and fixture manufacturing	$167,204	$9,513	$44,922	$3,346	$3,458	$3,545	**$231,988**
333515	Cutting tool and machine tool accessory manufacturing	$101,385	$5,764	$26,517	$2,025	$2,075	$2,150	**$139,916**
333516	Rolling mill machinery and equipment manufacturing	$8,897	$506	$2,327	$178	$182	$189	**$12,279**
333518	Other metalworking machinery manufacturing	$36,232	$2,060	$9,476	$724	$742	$768	**$50,002**
333612	Speed changer, industrial high-speed drive, and gear manufacturing	$35,962	$2,043	$8,308	$702	$674	$763	**$48,452**
333613	Mechanical power transmission equipment manufacturing	$45,422	$2,581	$10,493	$886	$852	$963	**$61,197**
333911	Pump and pumping equipment manufacturing	$89,460	$5,077	$21,139	$1,767	$1,746	$1,897	**$121,086**
333912	Air and gas compressor manufacturing	$62,241	$3,534	$14,975	$1,230	$1,219	$1,320	**$84,518**
333991	Power-driven handtool manufacturing	$25,377	$1,441	$6,105	$501	$497	$538	**$34,459**

Table V-18: Total Costs for All General Industry and Maritime Establishments Affected by the Proposed Silica Standard (continued)

NAICS	Industry	Engineering Controls (includes Abrasive Blasting)	Respirators	Exposure Assessment	Medical Surveillance	Training	Regulated Areas	Total
333992	Welding and soldering equipment manufacturing	$46,136	$2,622	$10,882	$904	$879	$978	**$62,401**
333993	Packaging machinery manufacturing	$61,479	$3,491	$15,004	$1,219	$1,218	$1,304	**$83,714**
333994	Industrial process furnace and oven manufacturing	$31,154	$1,768	$7,694	$620	$626	$661	**$42,523**
333995	Fluid power cylinder and actuator manufacturing	$57,771	$3,280	$13,532	$1,137	$1,113	$1,225	**$78,057**
333996	Fluid power pump and motor manufacturing	$39,598	$2,247	$9,296	$782	$772	$840	**$53,535**
333997	Scale and balance (except laboratory) manufacturing	$10,853	$616	$2,688	$216	$218	$230	**$14,822**
333999	All other miscellaneous general purpose machinery manufacturing	$152,444	$8,657	$36,677	$3,012	$2,985	$3,232	**$207,006**
334518	Watch, clock, and part manufacturing	$6,389	$363	$1,596	$127	$129	$135	**$8,740**
335211	Electric housewares and household fans	$11,336	$437	$1,641	$149	$203	$163	**$13,928**
335221	Household cooking appliance manufacturing	$24,478	$944	$3,543	$321	$438	$352	**$30,077**
335222	Household refrigerator and home freezer manufacturing	$26,139	$1,009	$3,784	$343	$468	$376	**$32,118**
335224	Household laundry equipment manufacturing	$24,839	$958	$3,596	$326	$444	$357	**$30,521**

Table V-18: Total Costs for All General Industry and Maritime Establishments Affected by the Proposed Silica Standard (continued)

NAICS	Industry	Engineering Controls (includes Abrasive Blasting)	Respirators	Exposure Assessment	Medical Surveillance	Training	Regulated Areas	Total
335228	Other major household appliance manufacturing	$19,551	$754	$2,830	$256	$350	$281	**$24,023**
336111	Automobile manufacturing	$218,635	$12,444	$49,525	$4,203	$3,914	$4,636	**$293,357**
336112	Light truck and utility vehicle manufacturing	$301,676	$17,170	$68,335	$5,799	$5,400	$6,397	**$404,778**
336120	Heavy duty truck manufacturing	$93,229	$5,303	$21,179	$1,800	$1,692	$1,977	**$125,181**
336211	Motor vehicle body manufacturing	$138,218	$7,849	$32,738	$2,722	$2,674	$2,931	**$187,131**
336212	Truck trailer manufacturing	$93,781	$5,325	$21,786	$1,841	$1,791	$1,989	**$126,512**
336213	Motor home manufacturing	$62,548	$3,557	$14,284	$1,212	$1,147	$1,326	**$84,073**
336311	Carburetor, piston, piston ring, and valve manufacturing	$30,612	$1,739	$7,044	$598	$576	$649	**$41,219**
336312	Gasoline engine and engine parts manufacturing	$192,076	$10,910	$44,198	$3,753	$3,616	$4,073	**$258,625**
336322	Other motor vehicle electrical and electronic equipment manufacturing	$180,164	$10,233	$41,457	$3,520	$3,392	$3,820	**$242,586**
336330	Motor vehicle steering and suspension components (except spring) manufacturing	$114,457	$6,504	$26,216	$2,228	$2,128	$2,427	**$153,960**
336340	Motor vehicle brake system manufacturing	$98,118	$5,573	$22,578	$1,917	$1,847	$2,080	**$132,114**

Table V-18: Total Costs for All General Industry and Maritime Establishments Affected by the Proposed Silica Standard (continued)

NAICS	Industry	Engineering Controls (includes Abrasive Blasting)	Respirators	Exposure Assessment	Medical Surveillance	Training	Regulated Areas	Total
336350	Motor vehicle transmission and power train parts manufacturing	$243,348	$13,832	$55,796	$4,730	$4,510	$5,160	**$327,377**
336370	Motor vehicle metal stamping	$321,190	$18,237	$73,408	$6,282	$6,057	$6,810	**$431,985**
336399	All other motor vehicle parts manufacturing	$433,579	$24,628	$99,769	$8,472	$8,162	$9,194	**$583,803**
336611	Ship building and repair	$7,868,944	NA	$412,708	$397,735	$26,973	$43,259	**$8,749,619**
336612	Boat building	$4,928,083	NA	$258,467	$249,089	$16,892	$27,092	**$5,479,624**
336992	Military armored vehicle, tank, and tank component manufacturing	$20,097	$1,142	$4,786	$394	$383	$426	**$27,227**
337215	Showcase, partition, shelving, and locker manufacturing	$171,563	$9,741	$41,962	$3,405	$3,412	$3,638	**$233,720**
339114	Dental equipment and supplies manufacturing	$272,308	$15,901	$48,135	$5,524	$4,157	$5,930	**$351,955**
339116	Dental laboratories	$103,876	$62,183	$892,167	$21,602	$335,984	$23,193	**$1,439,004**
339911	Jewelry (except costume) manufacturing	$260,378	$198,421	$876,676	$69,472	$81,414	$73,992	**$1,560,353**
339913	Jewelers' materials and lapidary work manufacturing	$53,545	$40,804	$180,284	$14,287	$16,742	$15,216	**$320,878**
339914	Costume jewelry and novelty manufacturing	$54,734	$27,779	$122,885	$9,726	$11,337	$10,359	**$236,821**
339950	Sign manufacturing	$227,905	$9,972	$44,660	$3,491	$5,173	$3,718	**$294,919**
423840	Industrial supplies, wholesalers	$97,304	$8,910	$60,422	$3,149	$4,199	$3,315	**$177,299**
482110	Rail transportation	$0	$327,176	$1,738,398	$110,229	$154,412	$121,858	**$2,452,073**
621210	Dental offices	$24,957	$14,985	$251,046	$5,286	$87,408	$5,572	**$389,256**

Table V-18: Total Costs for All General Industry and Maritime Establishments Affected by the Proposed Silica Standard (continued)

NAICS	Industry	Engineering Controls (includes Abrasive Blasting)	Respirators	Exposure Assessment	Medical Surveillance	Training	Regulated Areas	Total
Total		**$101,239,507**	**$6,914,225**	**$29,868,808**	**$3,057,076**	**$2,995,900**	**$2,651,079**	**$146,726,595**

Source: U.S. Dept. of Labor, OSHA, Directorate of Evaluation and Analysis, Office of Regulatory Analysis, based on ERG (2011).

COSTS FOR THE CONSTRUCTION INDUSTRY

Estimation of the costs of the proposed rule for the construction industry is broken out in this section for three categories of costs: (1) control costs to comply with the proposed PEL of 50 μg/m^3; (2) respirator costs, in those cases where engineering controls are not sufficient to guarantee compliance with the proposed PEL; and (3) “program” costs to comply with the ancillary provisions of the rule.

Control Costs

For the purpose of estimating control costs in construction, OSHA judged that only employers with workers exposed above the proposed silica PEL would require (additional) engineering controls and that, in order to minimize exposure monitoring costs, employers would select appropriate controls from Table 1 in the proposed rule. The costs of applying appropriate engineering controls to construction activities as required by Table 1 of the proposed standard are estimated below. These costs are generated by the application of known dust-reducing technology, such as the application of wet methods or ventilation systems, as detailed in the technological feasibility analysis in Chapter IV of this PEA.

OSHA adopted the control cost methodology developed by ERG (2007a). In order to provide some guidance on that cost methodology, OSHA itemizes below the three major steps, with sub-tasks, used to estimate control costs in construction:

- Step 1: Baseline daily costs, relative costs of controls, and labor share of value
    - Use RSMeans (2008) data to estimate the baseline daily cost for every representative job associated with each silica task (Table V-19).
    - Use unit labor and equipment costs (Table V-20) to estimate the daily costs of each representative job with silica controls in place (Tables V-21 and V-22).
    - Calculate the incremental cost (in percentage terms) of implementing silica controls for each representative job (Table V-24).
    - Calculate the labor share of total cost for each representative job with controls in place (Table V-24).
    - Calculate the weighted average incremental cost (in percentage terms) and labor share of total costs for each silica task using the assumed distribution of associated representative jobs (Table V-25).

- Step 2: Total value of silica tasks
    - Using occupational employment data from BLS Occupational Employment Statistics (OES) survey, estimate the full-time-equivalent number of employees by occupation working on each silica task. This is based on assumed percentages of key employees for each task and the associated ratio of supporting workers (Tables V-26 and V-27).
    - Based on the distribution of occupational employment by industry from OES, distribute the full-time-equivalent employment totals for each task by NAICS

construction industry (Table V-28).

- o Based on mean hourly wage data from OES, adjusted for fringe benefits, calculate the annual labor value of each silica task by NAICS construction industry (Table V-29).
- o Using the labor share of value calculated for each silica task (from the last sub-task in Step 1), estimate the total value of each silica task by industry (Table V-30).

- Step 3: Aggregate silica control costs
  - o Use the results from the exposure profile to estimate the percentage of workers for each task exposed above the proposed PEL (Table III-5).
  - o Multiply the total value of silica tasks for each industry by the percentage of task workers exposed above the proposed PEL to calculate the value of construction work requiring controls (Table V-32).
  - o Multiply the total value of construction tasks requiring controls by the percentage incremental cost associated with the controls required for each silica task (from the last sub-task in Step 1), to calculate the total control costs by task and industry (Table V-33).

Unit Control Costs

Representative Jobs

Using RSMeans *Heavy Construction Cost Data* (RSMeans, 2008), ERG (2007a) defined representative jobs for each silica-generating activity described in the feasibility analysis. These activities and jobs are directly related to the silica-related construction activities described in Chapter IV of this PEA. ERG (2007a) specified each job in terms of the type of work being performed (e.g., concrete demolition), the makeup of the crew necessary to do the work, and the requisite equipment. For example, for the impact drilling activity, ERG defined three representative jobs for various types of demolition work. For each job, ERG derived crew composition and equipment requirement data from the RSMeans (2008) guide and then calculated the per-day baseline cost from the labor rates, equipment charges, material costs, and overhead and profit markups presented in the cost estimating guide.

Table V-19 shows the specifications for each representative job and the associated daily labor, equipment, and material costs.[11] Table V-20 provides a summary of the labor rates and equipment charges used to estimate the daily cost of each representative construction job. Note that the data on hourly wages with overhead and profit in Table V-20, obtained from RSMeans (2008), are employed here to be consistent with other RSMeans cost parameters to estimate the baseline costs of representative jobs. These estimates are later used only to determine the labor share of the costs of representative construction jobs and the percentage increase in the cost of each representative job due to the addition of controls to comply with the proposed PEL. Everywhere else in this cost chapter, OSHA used BLS wage data, which include fringe benefits but not overhead and profit.

[11] In one case, drywall finishing, a basic job description is presented twice in order to allow analysis of two different control options later in the analysis.

For example, as shown in Table V-19, Job 1 for the drywall finishing category involves a simple crew (i.e., only two drywall installers). Other crews, such as that for impact drilling (Job 12), involve several workers, including an equipment operator, a labor foreman, and laborers. The daily labor cost for the drywall installers is calculated at $991.20. The total daily costs of labor, equipment, and materials for representative jobs range from $427.42 per day for hand-held milling (Job 9) to $3,515.08 for removal of indoor masonry walls (Job 14) to $107,500 for an underground construction work crew capable of tunnel work (Job 22).

Baseline Job Safety Practices

OSHA’s cost estimates address the extent to which current construction practices incorporate silica dust control measures. Thus, OSHA has attempted to use an accurate baseline reflecting such safety measures as are currently employed. To the limited extent that silica dust control measures are already being employed, OSHA has reduced the estimates of the incremental costs of silica control measures to comply with the proposed PEL.

Table V-19: Representative Job Categories and Unit Labor and Equipment Costs Applied in OSHA's Silica Construction Cost Model

	Task Category/ Job Description	Labor				Equipment			Total Daily Costs			
		Title	No. of Workers	Daily Wage	Wage Per Min.	Description	No.	Daily Rate	Labor	Equip.	Material	Total
Drywall finishing												
1	Drywall, gypsum plasterboard, nailed or screwed to studs, 5/8" thick, taped and finished	Drywall installers	2	$991.20	$2.07	Tool cost included in labor rate [a]		$0.00	$991.20	$0.00	$0.00	$991.20
		Total	2									
2	Drywall, gypsum plasterboard, nailed or screwed to studs, 5/8" thick, taped and finished (Identical to job 1; included so costs of a different control option can be estimated)	Drywall installers	2	$991.20	$2.07	Tool cost included in labor rate [a]		$0.00	$991.20	$0.00	$0.00	$991.20
		Total	2									
Earth drilling												
3	Drilling only, 2" hole for rock bolts, average	Blast foreman	1	$416.80	$0.87	Air track drill 4"	1	$770.35	$1,278.40	$1,209.15	$0.00	$2,487.55
		Driller	1	$392.00	$0.82	Air compressor, 600 cfm	1	$411.65				
		Equipment operator (light)	1	$469.60	$0.98	50' air hoses, 3" diameter	2	$27.15				
		Total	3									
4	Pier holes, 1500 cubic yards of media removed	Blast foreman	1	$416.80	$0.87	Air track drill 4"	1	$770.35	$1,278.40	$1,209.15	$39.60	$2,527.15
		Driller	1	$392.00	$0.82	Air compressor, 600 cfm	1	$411.65				
		Equipment operator (light)	1	$469.60	$0.98	50' air hoses, 3" diameter	2	$27.15				
		Total	3									

Table V-19: Representative Job Categories and Unit Labor and Equipment Costs Applied in OSHA's Silica Construction Cost Model (continued)

	Task Category/ Job Description	Labor				Equipment			Total Daily Costs			
		Title	No. of Workers	Daily Wage	Wage Per Min.	Description	No.	Daily Rate	Labor	Equip.	Material	Total
Earth drilling, contd.												
5	Borings, casing borings in earth, no samples, 21/2" diameter	Laborers	2	$784.00	$1.63	Auger 4"-36" diameter	1	$636.98	$1,165.20	$869.60	$0.00	$2,034.80
		Truck driver (light)	1	$381.20	$0.79	Flatbed truck, 3 ton	1	$232.63				
		Total	3									
Grinding and tuckpointing using hand-held tools												
6	Floors, 1/4" thick, patching concrete	Cement finisher	2	$896.80	$1.87	Tool cost included in labor rate [a]		$0.00	$896.80	$0.00	$0.00	$896.80
		Total	2									
7	Crack repair, including chipping, sand blasting, and cleaning; Epoxy injection up to 1/4" wide	Labor foreman (outside)	1	$416.80	$0.87	Air tools and accessories	2	$14.65	$1,984.80	$177.08	$15.20	$2,177.08
						Air compressor, 250 cfm	1	$151.90				
		Laborers	4	$1,568.00	$3.27	50' air hoses, 1.5" diameter	2	$10.53				
		Total	5									
8	Cut and repoint brick, hard mortar, common bond	Bricklayer	1	$491.60	$1.02	Tool cost included in labor rate [a]		$0.00	$491.60	$0.00	$19.25	$510.85
		Total	1									
9	Hand-held milling, wall grinding	Laborer	1	$392.00	$0.82	Wall grinder	1	$35.42	$392.00	$35.42	$0.00	$427.42
Heavy construction equipment operating												
10	Backfill, structural, from existing stockpile, no compaction, 50' haul, sand and gravel	Equip. operator (medium)	1	$497.20	$1.04	Dozer, 200 hp	1	$970.68	$693.20	$970.68	$0.00	$1,663.88
		Laborers	0.5	$196.00	$0.41							
		Total	1.5									
Hole drilling using held-held drills												
11	Drilling for anchors, up to 4" in diameter including bit and layout in concrete or brick walls, no anchor. 3/4" diameter	Carpenter	1	$495.60	$1.03	Tool cost included in labor rate [a]		$0.00	$495.60	$0.00	$6.30	$501.90
		Total	1									

Table V-19: Representative Job Categories and Unit Labor and Equipment Costs Applied in OSHA's Silica Construction Cost Model (continued)

Task Category/ Job Description		Labor: Title	Labor: No. of Workers	Labor: Daily Wage	Labor: Wage Per Min.	Equipment: Description	Equipment: No.	Equipment: Daily Rate	Total Daily Costs: Labor	Total Daily Costs: Equip.	Total Daily Costs: Material	Total Daily Costs: Total
Impact drilling												
12	Drilling bituminous material, with hand-held air equipment, up to 6 inches thick	Labor foreman (outside)	1	$416.80	$0.87	Breakers, pavement, 60 lb	2	$14.65	$2,454.40	$177.08	$0.00	$2,631.48
						Air compressor, 250 cfm	1	$151.90				
		Laborers	4	$1,568.00	$3.27	50' air hoses, 1.5" diameter	2	$10.53				
		Equip. operator, light	1	$469.60	$0.98							
		Total	6									
13	Cutout demolition, elevated slab, bar reinforced, under 6 c.f.	Labor foreman (outside)	1	$416.80	$0.87	Breakers, pavement, 60 lb	2	$14.65	$1,984.80	$177.08	$0.00	$2,161.88
						Air compressor, 250 cfm	1	$151.90				
		Laborers	4	$1,568.00	$3.27	50' air hoses, 1.5" diameter	2	$10.53				
		Total	5									
14	Remove masonry walls, block, solid (presumed indoor environment)	Labor foreman (outside)	1	$416.80	$0.87	Air tools and accessories	2	$14.65	$2,979.20	$535.88	$0.00	$3,515.08
						Air compressor, 250 cfm	1	$151.90				
		Laborers	4	$1,568.00	$3.27	50' air hoses, 1.5" diameter	2	$10.53				
		Equip. operators	2	$994.40	$2.07	Front-end loader	1	$358.80				
		Total	7									
Masonry cutting using portable saws												
15	Demolition, concrete slabs, mesh reinforcing, up to 3" deep (walk-behind saw)	Equipment operator (light)	1	$469.60	$0.98	Stakebody truck, 3 ton	1	$232.63	$861.60	$378.80	$333.20	$1,573.60
						Concrete saw (walk-behind)	1	$130.68				
		Laborer	1	$392.00	$0.82	Water tank, 65 gal	1	$15.50				
		Total	2									
16	Saw cutting, brick or masonry, with hand-held saw, per inch of depth	Building laborer	1	$392.00	$0.82	Saw, portable cut-off, 8 hp	1	$30.26	$392.00	$30.26	$31.25	$453.51
		Total	1									

Table V-19: Representative Job Categories and Unit Labor and Equipment Costs Applied in OSHA's Silica Construction Cost Model (continued)

Task Category/ Job Description		Labor: Title	Labor: No. of Workers	Labor: Daily Wage	Labor: Wage Per Min.	Equipment: Description	Equipment: No.	Equipment: Daily Rate	Total Daily Costs: Labor	Total Daily Costs: Equip.	Total Daily Costs: Material	Total Daily Costs: Total
Masonry cutting using portable saws, contd.												
17	Saw cutting, concrete walls, hydraulic saw, plain, per inch of depth	Equip. operator (light)	1	$469.60	$0.98	Wall saw, hydraulic, 10 hp	1	$89.70	$850.80	$652.15	$75.00	$1,577.95
						Generator, diesel 100 kw	1	$314.33				
		Truck driver (light)	1	$381.20	$0.79	Water tank, 65 gal	1	$15.50				
		Total	2			Flatbed truck, 3 ton	1	$232.63				
Masonry cutting using stationary saws												
18	Sawing brick or block, per inch in depth	Bricklayer	1	$491.60	$1.02	Tool cost included in labor rate [a]		$0.00	$491.60	$0.00	$0.00	$491.60
		Total	1									
Milling using portable or mobile machines												
19	Asphalt cold planing & cleaning, 1" to 3" asphalt, over 25,000 square yards	Labor foreman	1	$416.80	$0.87	Pavement profiler	1	$3,372.90	$3,084.40	$4,211.45	$0.00	$7,295.85
		Laborers	3	$1,176.00	$2.45	Road sweeper	1	$541.60				
		Equip. oper. (med)	3	$1,491.60	$3.11	Front-end loader (1.75 CY)	1	$296.95				
		Total	7									
20	Concrete surface repair	Labor foreman (outside)	1	$416.80	$0.87	Concrete grinder, floor, electric	1	$70.75	$808.80	$70.75	$0.00	$879.55
		Laborers	1	$392.00	$0.82							
		Total	2									
Rock crushing machine tending												
21	Rock crushing, excavation projects	Labor foreman	1	$416.80	$0.87	Rock crushing equipment	1	$3,372.90	$3,084.40	$4,169.85	$0.00	$7,254.25
		Laborers	3	$1,176.00	$2.45	Front-end loader (1.75 CY)	1	$296.95				
		Equip. operator (medium)	3	$1,491.60	$3.11	Truck, dump, 3 axle, 16 ton payload	1	$500.00				
		Total	7									
Underground (tunnel) construction work												

Table V-19: Representative Job Categories and Unit Labor and Equipment Costs Applied in OSHA's Silica Construction Cost Model (continued)

Task Category/ Job Description		Labor				Equipment			Total Daily Costs			
		Title	No. of Workers	Daily Wage	Wage Per Min.	Description	No.	Daily Rate	Labor	Equip.	Material	Total
22	Tunnel construction, bored tunnels including mucking, 20' in diameter , rock excavation (average cost; assumes 100 feet/day)	Total daily crew cost, including equipment ($1,075 per linear foot)	N/A	$16,125.00	$33.59	Tunnel boring machine and support system	1	$91,375.00	$16,125.00	$91,375.00	$0.00	$107,500.00

[a] Costs for smaller hand-held tools are not separately provided, but are included in the labor rate.
Source: U.S. Dept. of Labor, OSHA, Directorate of Evaluation and Analysis, Office of Regulatory Analysis, based on ERG (2007a) and RSMeans (2008).

Table V-20: Labor Wages and Equipment Rates Applied in OSHA's Silica Construction Cost Model

Labor Categories	Hourly Wage [a]	Hourly Wage With Overhead & Profit [b]
Blast foreman	$33.60	$52.10
Building laborer	$31.60	$49.00
Bricklayer	$40.50	$61.45
Carpenter	$39.95	$61.95
Cement finisher	$38.30	$56.05
Driller	$31.60	$49.00
Drilling foreman	$33.60	$52.10
Equipment operator (heavy)	$42.55	$63.95
Equipment operator (medium)	$41.35	$62.15
Equipment operator (light)	$39.05	$58.70
Labor foreman (outside)	$33.60	$52.10
Laborers	$31.60	$49.00
Equipment operator (oiler)	$36.80	$55.30
Skilled worker	$40.85	$63.25
Truck driver (light)	$30.95	$47.65
Equipment Categories	**Daily Equipment Rate [c]**	**Daily Rate With Overhead & Profit [b]**
Air compressor, 250 cfm	$147.40	$151.90
Air compressor, 600 cfm	$401.90	$411.65
Air tools and accessories	$6.95	$7.33
Auger 4"-36" diameter	$606.85	$636.98
Breakers, pavement, 60 lb	$6.95	$7.33
Core drill, large	$92.45	$97.58
Concrete saw	$126.25	$130.68
Concrete grinder, floor, electric	$66.10	$70.75
Air track drill 4"	$736.10	$770.35
Crawler dozer, 200 HP	$923.05	$970.68
Dust control, quarry drill	$16.47	$17.33
50' air hoses, 1.5" diameter	$4.83	$5.27
50' air hoses, 3" diameter	$12.45	$13.58
Flatbed truck, 3 ton	$228.35	$232.63
Front-end loader (1.75 CY)	$283.70	$296.95
Front-end loader (2.5 CY)	$342.80	$358.80
Generator, diesel 100 kw	$308.95	$314.33
Hose (water), 20', 2" diameter	$1.51	$1.65

Table V-20: Labor Wages and Equipment Rates Applied in OSHA's Silica Construction Cost Model (continued)

Equipment Categories	Daily Equipment Rate [c]	Daily Rate With Overhead & Profit [b]
Hose (water), 200', 2" diameter	$15.10	$16.45[d]
Pavement profiler	$3,219.40	$3,372.90
Quarry drill, 5" drifter	$850.00	$887.00
Road sweeper	$515.60	$541.60
Rock crushing equipment	$3,219.40	$3,372.90[e]
Stakebody truck, 3 ton	$228.35	$232.63
Saw, portable cut-off, 8 HP	$29.00	$30.26
Tunnel boring machine and accessories	N/E	$91,375.00[f]
Truck, dump, 3 axle, 16 ton	$486.00	$500.00
Vacuum, HEPA, 16 gal., wet/dry	$14.66	$15.47
Wall grinder, electric	$33.09	$35.42
Wall saw, hydraulic, 10 hp	$87.00	$89.70
Water tank, 65 gal	$14.21	$15.50
Water tank, engine driven discharge, 5000 gal.	$115.00	$121.50

N/E=Not estimated
[a] Hourly wage includes fringe benefits.

[b] "Overhead" includes workers' compensation, unemployment costs, social security taxes, builder's risk insurance, and other unspecified costs. ERG (2007a) assumed a profit rate of 10 percent. Overhead and profit markups for wages as given by RSMeans (2008) vary between 46 percent and 55 percent depending on the labor category.
[c] Based on monthly rental costs averaged over 20 days. Includes operation cost. Per RSMeans, a 10 percent markup is applied to equipment daily rental costs (but not operating costs).

[d] 10 times the cost of 20' hose

[e] Based on costs for pavement profiler.
[f Estimated at 90 percent of total daily crew and equipment cost, as estimated in RSMeans (2008).

Source: U.S. Dept. of Labor, OSHA, Directorate of Evaluation and Analysis, Office of Regulatory Analysis, based on ERG (2007a) and RSMeans (2008).

Engineering Controls

ERG (2007a) defined silica dust control measures for each representative job. Generally, these controls involve either a dust collection system or a water-spray approach (wet method) to capture and suppress the release of respirable silica dust. Wet-method controls require a water source (e.g., tank) and hoses. The size of the tank varies with the nature of the job and ranges from a small hand-pressurized tank (Job 15) to a large tank for earth drilling operations (Job 4).[12] Depending on the tool, dust collection methods entail vacuum equipment, including a vacuum unit and hoses, and either a dust shroud or an extractor. For example, concrete grinding operations using hand-held tools (Jobs 6 and 7) require dust shroud adapters for each tool and a vacuum. The capacity of the vacuum depends on the type and size of tool being used. Some equipment, such as concrete floor grinders, comes equipped with a dust collection system and a port for a vacuum hose. The estimates of control costs for those jobs using dust collection methods assume that an HEPA filter will be required.

For each job, ERG estimated the annual cost of the appropriate controls and translated this cost to a daily charge, based on an assumed use of 150 days per year (30 weeks).[13] The unit costs for control equipment were based on price information collected from manufacturers and vendors. In some cases, control equipment costs were based on data from RSMeans (2008) on equipment rental charges. Table V-21 shows the general unit control equipment costs and the assumptions that OSHA used to estimate the costs of specific types of jobs.

Table V-22, developed using the cost data presented in Tables V-19 and V-21, summarizes the control method and costs per day for each representative job.[14] These costs include incremental equipment costs and indirect labor costs due to productivity losses (penalties) associated with the use of the control equipment. These productivity penalties are discussed below in the text.

[12] See Chapter IX in this PEA for a discussion on the environmental impacts resulting from the use of wet methods for controlling exposure to silica.

[13] In response to comments received during the SBREFA Panel process, ERG used 150 days per year, rather than 240 days per year, of control equipment usage because of significantly reduced construction activity in cold weather months.

[14] For example, for Task 1 in Table V-22, drywall finishing, the needed engineering controls for each worker include a 10 to15 gallon vacuum with a HEPA filter and a dustless drywall sander. As shown in Table V-21, the annualized daily costs for these pieces of equipment are $3.23 and $1.08, respectively. For a crew of two, as shown in Table V-22, the incremental daily equipment costs are, therefore, $8.62. Use of this equipment is estimated to reduce worker productivity by 4%. Given the $991.20 daily wage of the two-man drywall crew shown in Table V-19, the daily productivity penalty would be $39.65. Combined, the incremental daily compliance cost is $48.27.

Table V-21: Unit Equipment Control Costs and Analytical Assumptions Applied in OSHA's Construction Silica Cost Model

Equipment Category	Equipment Cost	Average Lifetime (yrs)	Average Annualized Cost	Average Annual Cost/ Day of Use [a]	Maintenance and Operating Cost/Day [b]	Total Annual Cost/ Day of Use	Source, Comments
Wet kit, with water tank	$226.73	2	$125.40	$0.84	$0.18	$1.01	Contractors Direct (2009); Berland (2009); mytoolstore.com (2009)
Dust shrouds: grinder	$97.33	1	$97.33	$0.65	$0.14	$0.79	Contractors Direct (2009); Berland (2009); Dust-Buddy (2009); Martin (2008)
Water tank, portable (unspec. capacity)	N/A	N/A	N/A	$15.50[c]	$0.00[c]	$15.50	RSMeans - based on monthly rental cost
Water tank, small capacity (hand pressurized)	$73.87	1	$79.04	$0.53	$0.11	$0.64	Contractors Direct (2009); mytoolstore.com (2009)
Hose (water), 20', 2" diameter	N/A	N/A	N/A	$1.65[c]	$0.41	$2.06	RSMeans - based on monthly cost
Custom water spray nozzle and attachments	$363	1	$388.68	$2.59	$0.54	$3.14	New Jersey Laborers' Health and Safety Fund (2007)
Hose (water), 200', 2" diameter	N/A	N/A	N/A	$16.45[c]	$0.00[c]	$16.45	RSMeans - based on monthly rental cost
Vacuum, 10-15 gal with HEPA	$725	2	$400.99	$2.67	$0.56	$3.23	ICS (2009); Dust Collection (2009); EDCO (2009); CS Unitec (2009)
Vacuum, large capacity with HEPA	$2,108	2	$1,165.92	$7.77	$1.63	$9.41	ICS (2009); EDCO (2009); Aramsco (2009)
Dust extraction kit (rotary hammers)	$215	1	$214.81	$1.43	$0.30	$1.73	Grainger (2009); mytoolstore.com (2009); Toolmart (2009)
Dust control/quarry drill	N/A	N/A	N/A	$17.33[c]	$0.00[c]	$17.33	RSMeans Heavy Construction Cost Data (2008)
Dustless drywall sander	$133	1	$133.33	$0.89	$0.19	$1.08	Home Depot (2009); LSS (2009); Dustless Tech (2009)

Table V-21: Unit Equipment Control Costs and Analytical Assumptions Applied in OSHA's Construction Silica Cost Model (continued)

Equipment Category	Equipment Cost	Average Lifetime (yrs)	Average Annualized Cost	Average Ann. Cost/ Day of Use [a]	Maintenance and Operating Cost/Day [b]	Total Ann. Cost/ Day of Use	Source, Comments
Cab enclosure /w ventilation and air conditioning	$13,000	10	$1,850.91	$12.34	$2.59	$14.93	Estimates from equipment suppliers and retrofitters
Foam dust suppression system	$14,550	10	$2,071.59	$13.81	$162.07	$175.88	Midyette (2003).
Water tank, engine driven discharge, 5000 gal.	N/A	N/A	N/A	$121.50[c]	$0.00[c]	$121.50	RSMeans (2008) - based on monthly rental cost
Tunnel dust suppression system supplement	$7,928	5	$1,933.47	$12.89	$2.71	$15.60	Raring (2003).

N/A=Not applicable. For cost items that are assumed to be leased or rented (as on a per job basis), equipment lifetimes are not relevant and have not been defined.

[a] Except where noted, daily equipment cost is based on the annualized equipment cost divided by 150 to reflect the assumed average number days of use per year.

[b] Except where noted, daily operating and maintenance costs are calculated as 25% and 10%, respectively, of annualized equipment costs divided by 150.

[c] Daily equipment costs derived from RS Means (2008) monthly rental rates, which include maintenance and operating costs.

Source: U.S. Dept. of Labor, OSHA, Directorate of Evaluation and Analysis, Office of Regulatory Analysis, based on ERG estimates of vendors' equipment prices and RSMeans (2008).

Table V-22: Control Methods Modeled for OSHA's Silica Construction Cost Analysis, Specified by Activity

	Task Category/ Task Description	Control Method	Control Method Cost Summary	Indirect Labor Cost/Day (Due to productivity penalty)				Incremental Equipment Cost/Day		Total	Total Incre-mental Cost
				Title	Percentage Productivity Penalty	Cost per Worker Affected	Productivity Penalty Cost	Description	Daily Cost [a]		
Drywall finishing											
1	Drywall, gypsum plasterboard, nailed or screwed to studs, 5/8" thick, taped and finished	Dust collection	Setup and operate dust control system	Drywall installers	4.0%	$39.65	$39.65	Vacuum, 10-15 gal with HEPA	$6.47	$8.62	$48.27
								Dustless drywall sander (one each per worker)	$2.15		
2	Drywall, gypsum plasterboard, nailed or screwed to studs, 5/8" thick, taped and finished (Identical job w/different control)	Use non-silica finishing compound	Use of substitute (Identical job assumed w/ different control)	N/A	0.0%	$0.00	$0.00	Use of substitute finishing compound	N/A	$0.00	$0.00
Earth drilling											
3	Drilling only, 2" diameter hole for rock bolts, average	Dust collection	Setup and operate dust control system	Blast foreman	0.0%	$0.00	$0.00	Dust control/quarry drill	$17.33	$38.01	$38.01
				Driller		$0.00		Water tank, portable (unspec. capacity)	$15.50		
				Equip. operator, light		$0.00		Hose (water), 20', 2" diameter	$2.06		
								Custom water spray nozzle	$3.14		
4	Pier holes, 1500 cubic yards of media removed	Dust collection	Setup and operate dust control system	Blast foreman	0.0%	$0.00	$0.00	Dust control/quarry drill	$17.33	$38.01	$38.01
				Driller		$0.00		Water tank, portable (unspec. capacity)	$15.50		
				Equip. operator, light		$0.00		Hose (water), 20', 2" diameter	$2.06		
								Custom water spray nozzle	$3.14		

Table V-22: Control Methods Modeled for OSHA's Silica Construction Cost Analysis, Specified by Activity (continued)

Task Category/ Task Description		Control Method	Control Method Cost Summary	Indirect Labor Cost/Day (Due to productivity penalty)				Incremental Equipment Cost/Day			Total Incremental Cost
				Title	Percentage Productivity Penalty	Cost per Worker Affected	Productivity Penalty Cost	Description	Daily Cost [a]	Total	
5	Borings, casing borings in earth, no samples, 2 1/2" diameter	Dust collection	Setup and operate dust control system	Laborers Truck driver (light)	0.0%	$0.00 $0.00	$0.00	Dust control/quarry drill Water tank, portable (unspec. capacity) Hose (water), 20', 2" diameter Custom water spray nozzle	$17.33 $15.50 $2.06 $3.14	$38.01	$38.01
Grinding and tuckpointing using hand-held tools											
6	Floors, 1/4" thick, patching concrete	Dust collection	Setup and operate dust control system	Cement finisher	5.0%	$44.84	$44.84	Vacuum, large capacity with HEPA Dust shroud adapter	$9.41 $0.79	$10.19	$55.03
7	Crack repair, including chipping, sand blasting, and cleaning. Epoxy injection up to 1/4" wide.	Dust collection	Setup and operate dust control system	Labor foreman (outside) Laborers	5.0%	$20.84 $78.40	$99.24	Vacuum, large capacity with HEPA Dust shroud adapter (4; 1 per worker)	$9.41 $3.14	$12.55	$111.79
8	Cut and repoint brick, hard mortar, common bond.	Dust collection	Setup and operate dust control system	Bricklayer	5.0%	$24.58	$24.58	Dust Shroud Vacuum, 10-15 gal with HEPA	$0.79 $3.23	$4.02	$28.60
9	Hand-held milling, wall grinding	Dust collection	Setup and operate dust control system	Laborer	5.0%	$7.84	$7.84	Vacuum, 10-15 gal with HEPA	$3.23	$3.23	$11.07
Heavy construction equipment operation											
10	Backfill, structural, from existing stockpile, no compaction, 50' haul, sand and gravel	Cab enclosure	N/A	Equip. operator, (medium) Laborers	0.0%	$0.00 $0.00	$0.00	Incremental cost for enclosed cab	$12.81	$12.81	$12.81
Hole drilling using held-held drills											

Table V-22: Control Methods Modeled for OSHA's Silica Construction Cost Analysis, Specified by Activity (continued)

	Task Category/ Task Description	Control Method	Control Method Cost Summary	Indirect Labor Cost/Day (Due to productivity penalty)				Incremental Equipment Cost/Day			Total Incre-mental Cost
				Title	Percentage Productivity Penalty	Cost per Worker Affected	Productivity Penalty Cost	Description	Daily Cost [a]	Total	
11	Drilling for anchors, up to 4" in diameter including bit and layout in concrete or brick walls, no anchor. 3/4" diameter	Dust collection	Setup and operate dust control system	Carpenter	2.0%	$9.91	$9.91	Dust extraction kit Vacuum, 10-15 gal with HEPA	$1.73 $3.23	$4.97	$14.88
Impact drilling											
12	Drilling bituminous material, with hand-held air equipment, up to 6 inches thick	Wet methods	Setup and operate hose/sprayer	Labor foreman (outside) Laborers Equip. operator, light	3.0%	$12.50 $47.04 $14.09	$73.63	Hose (water), 20', 2" diameter Air tools and accessories Custom water spray nozzle	$15.50 $2.06 $3.14	$20.69	$94.32
13	Cutout demolition, elevated slab, bar reinforced, under 6 c.f.	Wet methods	Setup and operate hose/sprayer	Labor foremen Laborer	3.0%	$12.50 $47.04	$59.54	Water tank, portable (unspec. capacity) Hose (water), 20', 2" diameter Custom water spray nozzle	$15.50 $2.06 $3.14	$20.69	$80.23
14	Remove masonry walls, block, solid (indoor environment)	Dust collection	Setup and operate dust control system	Labor foremen Laborer Equip. operators	5.0%	$20.84 $78.40 $49.72	$148.96	Vacuum, large capacity Dust shroud adapter (2; 1 per equip. oper.)	$9.41 $1.57	$10.98	$159.94
Masonry cutting using portable saws											
15	Demolition, concrete slabs, mesh reinforcing, up to 3" deep	Baseline includes controls, but additional efforts needed	Properly maintain wet-method control	Equip. operator, light Laborer	2.0%	$9.39 $7.84	$17.23	Only incremental maintenance required -- captured in productivity penalty	$0.00	$0.00	$17.23
16	Saw cutting, brick or masonry, with hand-held saw, per inch of depth	Wet methods	Setup and operate water attachment accessory	Building laborer	2.0%	$7.84	$7.84	Wet kit with water tank	$1.01	$1.01	$8.85

Table V-22: Control Methods Modeled for OSHA's Silica Construction Cost Analysis, Specified by Activity (continued)

Task Category/ Task Description		Control Method	Control Method Cost Summary	Indirect Labor Cost/Day (Due to productivity penalty)				Incremental Equipment Cost/Day			Total Incre-mental Cost
				Title	Percentage Productivity Penalty	Cost per Worker Affected	Productivity Penalty Cost	Description	Daily Cost [a]	Total	
17	Saw cutting, concrete walls, hydraulic saw, plain, per inch of depth	Baseline includes controls, but additional efforts needed	Properly maintain wet-method control	Equip. operator, light Truck driver (light)	2.0%	$9.39 $7.62	$17.02	Only incremental maintenance required -- captured in productivity penalty	$0.00	$0.00	$17.02
Masonry cutting using stationary saws											
18	Sawing brick or block, per inch in depth	Baseline includes controls, but additional efforts needed	N/A	Bricklayer	2.0%	$9.83	$9.83	Only incremental maintenance required. Captured in productivity penalty	$0.00	$0.00	$9.83
19	Asphalt cold planing & cleaning, 1" to 3" asphalt, over 25,000 square yards	Baseline includes controls, but additional efforts needed	Properly maintain wet-method control	Labor foreman Laborers Equip. oper. (med)	2.0%	$8.34 $23.52 $29.83	$61.69	Only incremental maintenance required -- captured in productivity penalty	$0.00	$0.00	$61.69
20	Concrete surface repair	Wet methods	Setup and operate water attachment accessory	Labor foreman (outside) Laborers	2.0%	$8.34 $7.84	$16.18	Vacuum, large capacity with HEPA	$9.41	$9.41	$25.58
Rock crushing / machine tending											
21	Rock crushing, excavation projects	Wet method	Setup and operate foam dust suppression system	Labor foreman Laborers Equip. operator	0.0%	$0.00 $0.00 $0.00	$0.00	Foam dust suppression system	$175.88	$175.88	$175.88

Table V-22: Control Methods Modeled for OSHA's Silica Construction Cost Analysis, Specified by Activity (continued)

	Task Category/ Task Description	Control Method	Control Method Cost Summary	Indirect Labor Cost/Day (Due to productivity penalty)				Incremental Equipment Cost/Day			Total Incre-mental Cost
				Title	Percentage Productivity Penalty	Cost per Worker Affected	Productivity Penalty Cost	Description	Daily Cost [a]	Total	
Underground (tunnel) construction work											
22	Tunnel construction, bored tunnels including mucking, 20' in diameter, rock excavation (average cost; assumes 100 feet/day)	Supplement-al spray points in dust control system	Install 3 additional spray points in material handling	Tunnel crew	0.0%	$0.00	$0.00	Equipment cost of supplemental water spray points in dust control system	$15.60	$15.60	$15.60

[a] See Table V-21.

Source: U.S. Dept. of Labor, OSHA, Directorate of Evaluation and Analysis, Office of Regulatory Analysis, based on ERG (2007a) and Tables V-20 and V-21.

Incremental Labor Costs and Productivity Impacts

In addition to incremental equipment costs, OSHA estimated the incremental labor costs generated by implementing silica dust controls. The labor costs are generated by (1) the extra time needed for workers to set up the control equipment, (2) potential reductions in productivity stemming from use of the controls, (3) additional time to service vacuum dust control equipment, and (4) additional housekeeping time associated with or generated by the need to reduce exposures. All labor costs related to the use of controls have been subsumed into a single additional labor productivity penalty estimate for the representative job categories. To compile data on labor productivity impacts, ERG interviewed equipment dealers, selected construction contractors, industry safety personnel, and researchers working on construction health topics.

Because most silica dust controls are not widely used, knowledge about the impact of dust controls on productivity was uneven and quite limited. More precisely, few individuals that ERG interviewed were in any position to compare productivity with and without controls and the literature on this topic appear deficient in this regard. Overall, telephone contacts produced a variety of opinions on labor productivity effects, but very few quantitative estimates. Of all sources contacted, equipment rental agencies and construction firms estimated the largest (negative) productivity impacts. Some equipment vendors suggested that there are positive productivity effects from control equipment due to improved worker comfort (from the reduction in dust levels). Others suggested that the use of dust collection equipment reduces or eliminates the need to clean up dust after job completion.

The estimation of labor productivity effects is also complicated by the highly job- and site-specific factors that influence silica dust exposures and requirements for silica dust control. Potential exposures vary widely with hard-to-predict characteristics of some specific work tasks (e.g., characteristics of materials being drilled), environmental factors (e.g., wet or dry conditions, soil conditions, wind conditions), work locations (e.g., varying dust control and dust cleanup requirements for inside or outside jobs), and other factors. Generalizations about productivity impacts, therefore, are hampered by the range of silica dust control requirements and work circumstances.

After considering the existing evidence, ERG judged that labor productivity impacts are often likely to occur. Depending on the general likelihood of productivity impacts for each activity, ERG selected a productivity impact ranging from zero to a negative 5 percent of output. The factors influencing each selection are described below.

Table V-23 summarizes the labor productivity estimates. While quantitative data are quite limited on productivity, it is possible to gauge the relative productivity effects across the principal control options. For example, ERG judged that there is no productivity penalty for certain controls, such as enclosing an operator's cab on heavy construction equipment. (In that case, the productivity impacts might be positive.) In Table V-24, productivity effects, termed "lost production time", are shown by task category and are factors in OSHA's estimate of incremental cost per day.

Table V-23: Productivity Penalty Estimates for Construction Projects Affected by OSHA's Proposed Silica Standard

Productivity Penalty	Source/Rationale for Productivity Impacts	Job Categories Affected
None	Dust control is well-integrated into equipment; control set-up can be accomplished with little or no additional effort or as part of substantial set-up effort. (In some cases, dust control can improve worker comfort and might enhance productivity.)	Earth drilling; Rock crushing; Operators of tractors and heavy equipment; Drywall finishing (where non-silica finishing compound is used); Underground (tunnel) construction workers
2% (approximately 10 minutes/day)	(1) Dust control requires incremental set-up time, or (2) Incremental maintenance, or (3) Additional clean-up. (Controls have little impact on job performance.)	Millers using portable or mobile machines (when wet methods are used); Hole drilling using hand-held drills; Masonry cutting using stationary saws; Masonry cutting using portable saws
3% (approximately 15 minutes/day)	Dust control requires incremental set-up time and some increase in maintenance or clean-up requirements.	Impact drilling (wet methods)
4% (approximately 19 minutes/day)	Dust control requires incremental set-up time and regular maintenance during day, but reduces job cleanup.	Drywall finishing (when LEV is used)
5% (approximately 24 minutes/day)	Dust control requires incremental set-up time and regular maintenance during day.	Impact drilling (where LEV is used); Grinding and tuck-pointing; Millers using portable or mobile machines (when LEV is used)

Source: U.S. Dept. of Labor, OSHA, Directorate of Evaluation and Analysis, Office of Regulatory Analysis, based on ERG (2007a).

Productivity Impact Estimates, by Task

Drywall Finishing

To reduce respirable silica dust exposures during drywall finishing, workers can use non-silica-containing drywall compound or LEV attachments. In the first case, there is no incremental cost or productive impact. OSHA expects this control approach to be the most common.

For the latter case, workers must use sanders (either powered or hand) with a port for a vacuum attachment. This requirement does not impose design limitations on the sanding head, so the changes to tool design do not generate productivity impacts. Studies by NIOSH on the effectiveness of dust controls during short-duration tests showed no significant productivity impacts associated with dust controls (Mead et al., 1995). In selected circumstances, the dust control equipment might also reduce the need to seal work areas to prevent dust migration to other areas. Reduced dust may also facilitate subsequent painting because less surface cleaning is needed. Further, NIOSH has theorized that workers in cleaner work environments would tend to be more productive, would take fewer breaks for fresh air, and would be absent less frequently (NIOSH, 1999).

Nevertheless, based on its various contacts with knowledgeable industry personnel and researchers, ERG judged that worker use of an attached vacuum hose will generally slow workers, and hourly output will be reduced. Furthermore, workers must periodically empty vacuum bags or barrels and, possibly, clean and unplug filters. These incremental task requirements might sometimes be partly offset by a reduction in the time required to clean up after the job. Nevertheless, some dust cleanup is still likely to be required.

Based on these considerations, ERG judged that there would be a net negative productivity impact equal to 4 percent of the labor time associated with use of drywall sanding dust controls.

Earth Drilling

This activity category covers a range of drilling activities using truck-mounted and similar drilling equipment, such as quarry drills and crawler-type drills. Dust control requires use of either a dust collection system or wet drilling methods. Studies of the effectiveness of available dust collection systems have not addressed performance issues, but ERG judged that their use does not affect drilling productivity. While workers must service the dust control equipment during the workday, this activity generally does not affect the rate of drilling, except perhaps for short-duration jobs. The wet drilling methods are integrated into drilling equipment and also should not adversely affect the drilling rate. Thus, OSHA estimates that there will be no lost production time for this activity category.

Grinding and Tuckpointing

According to ERG's search of the literature, grinding tools can be retrofitted with dust control shrouds that connect to a vacuum system (Buser, 2001 and Buser, 2002). Studies on the use of these controls indicate that extra time is required to install the shroud and periodically clean, empty, or replace the vacuum drums, filters, or bags. The estimated time to install the shroud may be as short as five minutes, although some types of shrouds take longer to install. Once installed, however, the shroud can be left in place, so this activity need not take place at the initiation of each grinding job.

For interior jobs and for exterior work that requires site cleanup of grinding debris, the additional work time required to use a vacuum system might be partially offset by savings in the time required to seal work areas (to prevent dust migration) and to clean the work area after task completion. Overall, clean-up times will vary depending on the size of the job site, the quantity of grinding debris, and the strength and capacity of the vacuum.

Grinding without a dust-control shroud can generate clouds of dust that might impair a worker's views of the grinding area. Whereas metal shrouds also block the view of the grinding area, plastic shrouds allow workers a view of the work area. Some contractors have noted, however, that use of shrouds does not allow for the precision required for certain tasks, such as grinding an inside corner (Lattery, 2001).

For exterior jobs where cleanup is not required and where the work area is not sealed, the use of vacuum equipment imposes a clear productivity penalty for servicing the vacuum collectors. If, for example, five minutes were required to empty the vacuums every two hours, production time would decline about 4 percent, due simply to dumping the accumulated dust.

At some construction sites, vacuums have been used during the grinding process, but without shrouds. In these cases, one worker typically holds the vacuum nozzle near the grinding tool, which another worker operates. Switching to shrouds with a direct vacuum attachment would eliminate the need for this assistant and is a more productive operation.

Manufacturers and vendors cited other benefits from using the shroud-vacuum systems. Because dust does not build up on and clog the surface of the grinding wheel, the wheels last longer, resulting in an approximate 40 percent savings on the grinding discs (Eurovac, 2001). Another source contacted by ERG estimated that shrouds can increase the abrasive life of a grinding wheel by more than 500 percent (Buser, 2002). In this regard, workers would spend slightly less time replacing wheels over the life of the equipment.

ERG concluded that while the productivity impacts of vacuum systems can sometimes be partly offset by other factors, net productivity impacts are likely to remain negative. For exterior work, productivity is clearly lower when workers use a vacuum system. Overall, based on ERG's research, OSHA added 5-percent for lost production time in calculating compliance costs associated with grinding operations in construction.

For a tuckpointing project, NIOSH researchers examined the use of vacuum system controls at a large college building complex (Gressel et al., 1999). Workers used a shroud-vacuum system with an integral impeller and a fabric dust collection bag. This system required emptying the collection bags about once an hour. The authors reported some problems caused by blocking and kinking of the hose and occasional separations of the hose from the tool. Some of these problems can be attributed to the design of the dust control system and might be rectified by future design innovations. Overall, the vacuum control systems appeared to reduce worker output.

Manufacturers and vendors contacted by ERG estimated that polyurethane shroud-vacuum systems with tuck-pointing equipment, similar to those for hand-held grinders, actually enhance productivity. Among the reasons provided for productivity improvements were: (1) fewer workers were required, (2) cleanup times were reduced, and (3) workers had improved visibility of the work surface and longer blade life (Buser, 2002; Caperton, 2002; Eurovac, 2001; Williams, 2002). These observations on productivity applied to tuck pointers with 2- to 8-inch diameter wheels; in addition, effects on worker productivity have also been reported for shrouds that fit on 5-inch and 7- to 8-inch (18-lb) tuck pointers with integrated dust-collection systems. In the equipment with 5- to 8-inch wheels, an impeller inside the tool housing pushes dust down a hose into a reusable dust-collection bag. It has been estimated that the operational productivity of these tools is no different from that of the same tool without dust control capability. Workers would still be required, however, to periodically empty dust bags, although other clean-up time might be somewhat reduced. Because tuck-pointing work is almost exclusively exterior work, however, clean-up is often not required.

Based on the considerations for hand-held grinding tools discussed above and the findings from the NIOSH tuck-pointing study, ERG judged that use of a vacuum system during tuck-pointing operations would impose, on average, a 5-percent productivity impact. Based on these findings and because manufacturer optimism about any positive productivity impacts has not been documented in controlled studies, OSHA applied a 5-percent negative productivity impact for tuckpointing operations.

Heavy Construction Equipment Operation

The proposed control method is to enclose and ventilate the operator’s cab. Using an enclosed cab will not require maintenance beyond the general equipment necessary to maintain the integrity of the cab enclosure. Therefore, no productivity loss will be incurred.

Some equipment operators might experience an increase in productivity due to improved comfort. According to ERG, most vendors of heavy construction equipment or retrofit cab enclosures contend that such gains will occur. Similar arguments have also been made when equipment cabs have been enclosed for other reasons, including for noise control (Meitl, 2000). The size of the productivity gain at any particular site will depend upon many factors, including the interaction of heavy equipment operation with other job site activities. Productivity benefits will not result when the heavy equipment work is not on the critical path for advancing the day’s outputs (i.e., such as when the equipment operator works in conjunction with other workers and must frequently wait for other workers to complete complementary tasks).

ERG was unable to identify quantitative studies of the productivity increase from enclosing the cab. Therefore, OSHA has conservatively chosen not to assign any productivity gain for this control measure in heavy construction equipment operation.

Hole Drilling Using Hand-Held Tools

Activities in this category range from core drilling to drilling anchor holes in concrete. Core drills are designed with a water flushing capability, while other drills and rotary hammers use a shroud and vacuum arrangement to control dust. Core drilling (large diameter holes) in concrete is typically done wet, and the equipment is designed for the recovery of the water coolant.

One rock-drill manufacturer asserts that use of vacuum systems speeds the drilling by continuously removing the drill cuttings from the hole, obviating the need for workers to periodically stop drilling to accomplish this task (Atlas-Copco, 2001). On the other hand, the connection and servicing of the vacuum equipment requires incremental work that could reduce productivity. If the construction project at hand involves interior work, this impact might be offset by reductions in the time necessary for cleanup (i.e., interior work would require cleanup, while exterior drilling probably would not). Overall, following ERG, OSHA applied a 2-percent productivity penalty in estimating compliance costs.

Impact Drilling

Silica exposures generated during pavement breaking, concrete demolition, and other concrete work using jack hammers, pavement breakers, and other similar tools are controlled through the use of wet methods. Because the work area generally cannot be presoaked effectively (i.e., dust is generated once impact drillers break through the surface), ERG judged that adequate dust control requires a constant spray of water to the work area. Thus, dust control requires that a water sprayer be mounted onto the jackhammer (or that a mobile sprayer be set up that can move along with the work). Alternatively, a crew member can use a water hose to spray and wet the concrete and asphalt surfaces being broken, although the productivity loss could be substantial, and construction firms would likely try to avoid that approach.

However, ERG judged that the incremental productivity impact from the spraying activity is modest because various crew members could occasionally be enlisted to keep the water spray directed in the correct location. Further, because of the interactive nature of the various crew member activities, the time to move the water sprayer is unlikely to affect the overall crew output. In addition, incremental cleanup costs generally would not be significant since most drilling projects are performed outside. Nevertheless, to allow for some incremental work related to supplying water and positioning the spray, OSHA estimated a 3-percent productivity decline.

Masonry Cutting Using Portable (Hand-Held and Walk-Behind) Saws

Large, walk-behind saws have an integrated water tank, and the sawing is almost always done wet. Wet sawing keeps the blade from overheating, with the water acting as coolant. No incremental costs or productivity impacts are forecast for use of this equipment.

As has been noted, most portable hand-held concrete saws are designed with wet-sawing capability. These saws have a water hookup for a hose attachment, but might also be used for dry cutting. (Dry-cut diamond blades for dry cutting are available; these are made especially so that the tips do not separate during dry cutting.)

A construction equipment distributor judged that there are no operational productivity advantages for dry cutting, as opposed to wet. Wet cutting, however, requires access to water (water line or pressurized tank), and some time is needed to connect the equipment. Further, the water hose hookup can be cumbersome and interfere with the work (Healy, 2002). For these reasons, OSHA assigned a cost of 2-percent in lost production time for using wet methods for hand-held concrete saws.

Masonry Cutting Using Stationary Saws

Stationary saws for masonry, brick, and tile cutting come equipped with water systems for wet cutting, which is the conventional, baseline method for this type of work. Some modest incremental time is needed to provide for and connect the water supply and to maintain the water nozzles and spray system. This incremental time was the basis for OSHA to estimate a 2-percent cost in lost production.

Milling Using Portable or Mobile Machines

These activities range from cold planing and cleaning of asphalt to surface planing or grinding of concrete. In large-scale projects, such as street resurfacing, baseline practices are judged to control silica dust exposures. No additional controls would be needed, and therefore no negative productivity impacts are expected.

While some grinding machines designed for milling concrete surfaces have built-in dust collection or wet-method systems, others must be attached to external vacuum equipment. ERG reviewed the available literature and found no evidence that the grinding operation is slowed when such vacuum equipment is attached. Nevertheless, workers must devote some time to setting up equipment, changing vacuum bags or barrels, and cleaning filters. ERG estimated that there would be a 2-percent productivity penalty for milling using wet methods and a 5-percent productivity penalty when using LEV systems.

Rock Crushing Machines and Tenders

ERG forecast that rock crushing units will be modified to operate automatic dust suppression systems. Once installed, these systems will be part of the rock crushing machine operation and will not impact production rates. Thus, OSHA projects that there will be no productivity impacts for this job category.

Underground Tunneling

Underground tunneling operations currently use conventional dust control measures. Any increase in maintenance of systems generates negligible incremental work and is forecast to have no impact on crew productivity.

SBREFA Panel Comments on Productivity and Representative Job Costs

During the Small Business Regulatory Enforcement Fairness Act (SBREFA) Panel process, some stakeholders not a part of the process (i.e., not Small Entity Representatives (SERs)) commented on ERG's estimates of the impact of exposure control equipment on productivity during construction operations. A commenter noted that the ERG estimates of the productivity impact of using additional control measures were based on interviews with dealers, contractors, and researchers working on construction health topics and that it was not clear how ERG translated this "purely qualitative analysis into productivity [impact] rates . . . ." The commenter indicated that engineering control compliance costs would be sensitive to the ultimate choice of productivity impact measures.[15]

In response to this comment, OSHA refers readers to the discussion above on the basis for OSHA's productivity estimates. As described there, ERG's research revealed little substantive, quantitative evidence about the magnitude of the productivity impacts of the controls, and in some cases, the direction of the impacts (positive or negative) appears to depend on the specific nature of the job. OSHA's estimates in this preliminary analysis reflect ERG's best professional judgment about the likely magnitude of these impacts. Some of the estimates may be conservative because under some scenarios for certain tasks, the productivity impacts could be significantly smaller than those shown in Table V-23 or even positive. OSHA's estimated control costs are sensitive to these productivity impact estimates.

The commenter, representing the Reform OSHA Coalition (2003), also expressed a concern that even though silica is not now considered a hazardous waste, OSHA had not analyzed the impact of the proposed rule on disposal of silica-contaminated wastes. The commenter asserted that disposal issues are "acute on the construction site where a means to readily dispose of such material or water is not available."[16] In response, OSHA believes that since silica wastes are not classified as hazardous, the incremental disposal costs resulting from dust collected in vacuums and other sources are likely to be quite small. An analysis of wet methods for dust controls suggests that in most cases the amount of slurry discharges is not sufficient to cause a runoff to storm drains or surface water.[17]

Another SBREFA commenter raised questions about the availability of silica-free joint compound for drywall finishing.[18] ERG relied on NIOSH studies showing that silica-free joint

[15] OSHA Silica Docket, H006A: Exhibit 9-2-1. SBREFA Comments by the Reform OSHA Coalition on the Draft Standards for Crystalline Silica (hereafter: Reform OSHA Coalition (ROC, 2003)), p. 14. Unless otherwise specified, the term "SBREFA commenter" refers to a third-party stakeholder who was not a SER.

[16] Reform OSHA Coalition (2003), p.23.

[17] For a more detailed discussion of this issue, see Chapter IX of this PEA.

[18] OSHA Silica Docket, H006A: Exhibit 9-2-4. Memorandum for Tom McDonald, Jeff Oliver, and Jerry Painter, Small Entity Representatives, SBREFA Panel for Silica in Construction, Subject: OSHA's Crystalline Silica Standard for Construction Operations (hereafter, Mason Contractors Association of America), p. 38.

compounds have become readily available in recent years (see ERG, 2007a, Section 3.2). ERG's cost model, however, assumes that 20 percent of drywall finishing jobs would continue to use conventional joint compound.[19]

OSHA solicits comment on its responses to all these issues raised during the SBREFA Panel process.

Baseline and Incremental Unit Control Costs

Table V-24 summarizes the baseline costs and incremental compliance costs from Table V-22 for each representative job in OSHA's silica construction cost analysis. The incremental compliance costs are the sum of additional labor and equipment costs incurred as a result of the provision and use of silica controls. The negative productivity impacts of silica controls generate incremental labor costs and the silica control equipment generates incremental control costs.

The control costs (defined as incremental costs per day) are shown in Table V-24 as a percentage of the baseline daily job costs. These percentages are then used to calculate the weighted average incremental job costs for the jobs in each category (e.g., drywall finishing). These control costs range from 0 percent of the baseline for those jobs where baseline activities incorporate the relevant controls (such as use of non-silica drywall finishing compound) to over 6 percent where LEV systems are needed for grinding and tuck-pointing tasks. As is evident from Table V-24, the magnitude of the productivity impacts can substantially change the estimate of the overall cost increase associated with the controls.

Table V-25 presents the weighted average of control costs by task category. ERG defined weights for each job category based on the projected relative applicability of the controls and/or tasks within each category (as determined in the technological feasibility analysis in Chapter IV of this PEA). For example, based on the technological feasibility analysis for impact drillers, ERG estimated that impact drillers could use wet methods for 80 percent of jobs but that LEV would be required for 20 percent of the jobs. These percentages then defined the relative frequency of application for the controls assigned to each task category (from Table V-24).

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[19] See Table V-25 below.

Table V-24: Incremental Silica Control Costs as a Percentage of Activity Costs for OSHA's Economic Analysis of the Construction Industry

	Task Category/ Task Description	Total Daily Baseline Cost	Controls	Lost Production Time	Incremental Labor Cost/Day	Incremental Equipment Cost/Day	Total Incremental Cost/Day	Total Incremental Costs as % of Baseline Costs
Drywall finishing								
1	Drywall, gypsum plasterboard, nailed or screwed to studs, 5/8" thick, taped and finished	$991	Dust collection system	4.0%	$39.65	$8.62	$48.27	4.9%
2	Drywall, gypsum plasterboard, nailed or screwed to studs, 5/8" thick, taped and finished (Identical job w/different control)	$991	Use non-silica finishing compound	0.0%	$0.00	$0.00	$0.00	0.0%
Earth drilling								
3	Drilling only, 2" hole for rock bolts, average	$2,488	Dust collection system	0.0%	$0.00	$38.01	$38.01	1.5%
4	Pier holes, up to 1500 cubic yards	$2,527	Dust collection system	0.0%	$0.00	$38.01	$38.01	1.5%
5	Borings, casing borings in earth, no samples, 21/2" diameter	$2,035	Dust collection system	0.0%	$0.00	$38.01	$38.01	1.9%
Grinding and tuck pointing using hand-held tools								
6	Floors, 1/4" thick, patching concrete	$897	Dust collection system	5.0%	$44.84	$10.19	$55.03	6.1%

Table V-24: Incremental Silica Control Costs as a Percentage of Activity Costs for OSHA's Economic Analysis of the Construction Industry (continued)

	Task Category/ Task Description	Total Daily Baseline Cost	Controls	Lost Production Time	Incremental Labor Cost/Day	Incremental Equipment Cost/Day	Total Incremental Cost/Day	Total Incremental Costs as % of Baseline Costs
7	Crack repair, including chipping, sand blasting, and cleaning. Epoxy injection up to 1/4" wide.	$2,177	Dust collection system	5.0%	$99.24	$12.55	$111.79	5.1%
8	Cut and repoint brick, hard mortar, common bond.	$511	Dust collection system	5.0%	$24.58	$4.02	$28.60	5.6%
9	Hand-held milling, wall grinding	$427	Dust collection system	5.0%	$7.84	$3.23	$11.07	2.6%
Heavy construction equipment operating								
10	Backfill, structural, from existing stockpile, no compaction, 50' haul, sand and gravel	$1,664	Enclosed cab with ventilation	0.0%	$0.00	$12.81	$12.81	0.8%
Hole drilling using held-held drills								
11	Drilling for anchors, up to 4" in diameter including bit and layout in concrete or brick walls, no anchor. 3/4" diameter	$502	Dust Shroud Vacuum system	2.0%	$9.91	$4.97	$14.88	3.0%
Impact drilling								
12	Drilling bituminous material, with hand-held air equipment, up to 6 inches thick	$2,631	Wet method	3.0%	$73.63	$20.69	$94.32	3.6%
13	Cutout demolition, elevated slab, bar reinforced, under 6 c.f.	$2,162	Wet method	3.0%	$59.54	$20.69	$80.23	3.7%

Table V-24: Incremental Silica Control Costs as a Percentage of Activity Costs for OSHA's Economic Analysis of the Construction Industry (continued)

	Task Category/ Task Description	Total Daily Baseline Cost	Controls	Lost Production Time	Incremental Labor Cost/Day	Incremental Equipment Cost/Day	Total Incremental Cost/Day	Total Incremental Costs as % of Baseline Costs
14	Remove masonry walls, block, solid (presumed indoor environment)	$3,515	Dust collection system	5.0%	$148.96	$10.98	$159.94	4.5%
Masonry cutting using portable saws								
15	Demolition, concrete slabs, mesh reinforcing, up to 3" deep	$1,574	Baseline includes control measures	2.0%	$17.23	$0.00	$17.23	1.1%
16	Saw cutting, brick or masonry, with hand-held saw, per inch of depth	$454	Wet method	2.0%	$7.84	$1.01	$8.85	2.0%
17	Saw cutting, concrete walls, hydraulic saw, plain, per inch of depth	$1,578	Baseline includes control measures	2.0%	$17.02	$0.00	$17.02	1.1%
Masonry cutting using stationary saws								
18	Sawing brick or block, per inch in depth	$492	Wet method	2.0%	$9.83	$0.00	$9.83	2.0%
Milling using portable or mobile machines								
19	Asphalt cold planing & cleaning, 1" to 3" asphalt, over 25,000 square yards	$7,296	Baseline includes control measures	2.0%	$61.69	$0.00	$61.69	0.8%
20	Concrete surface repair	$880	Wet methods	2.0%	$16.18	$9.41	$25.58	2.9%
Rock crushing machine tending								
21	Rock crushing, excavation projects	$7,254	Setup and operate foam dust suppression system	0.0%	$0.00	$175.88	$175.88	2.4%

Table V-24: Incremental Silica Control Costs as a Percentage of Activity Costs for OSHA's Economic Analysis of the Construction Industry (continued)

	Task Category/ Task Description	Total Daily Baseline Cost	Controls	Lost Production Time	Incremental Labor Cost/Day	Incremental Equipment Cost/Day	Total Incremental Cost/Day	Total Incremental Costs as % of Baseline Costs
Underground (tunnel) construction work								
22	Tunnel construction, bored tunnels including mucking, 20' in diameter , rock excavation (average cost; assumes 400 feet/day)	$107,500	Additional maintenance	0.0%	$0.00	$15.60	$15.60	0.015%

Source: U.S. Dept. of Labor, OSHA, Directorate of Evaluation and Analysis, Office of Regulatory Analysis, based on ERG (2007a and 2011).

Table V-25: Weighted Average of Incremental Silica Control Costs as a Percentage of Activity Costs, by Job Category, for OSHA's Economic Analysis of the Construction Industry

	Job Category/Description	Controls	Relative Frequency Within Job Categories	Labor Costs as a Percentage of Project Costs	Incremental Costs as Percentage of Baseline Costs
Drywall finishers					
1	Drywall, gypsum plasterboard, nailed or screwed to studs, 5/8" thick, taped and finished	Dust collection system	20.0%	100.0%	4.9%
2	Drywall, gypsum plasterboard, nailed or screwed to studs, 5/8" thick, taped and finished (Identical job w/different control)	Use non-silica finishing compound	80.0%	100.0%	0.0%
	Job category total, averages		100.0%	100.0%	1.0%
Earth drillers					
3	Drilling only, 2" hole for rock bolts, average	Dust collection system	33.3%	51.4%	1.5%
4	Pier holes, 1500 cubic yards of media removed	Dust collection system	33.3%	50.6%	1.5%
5	Borings, casing borings in earth, no samples, 2.5" diameter	Dust collection system	33.3%	57.3%	1.9%
	Job category total, averages		100%	53.1%	1.6%
Grinders and tuck pointers using hand-held tools					
6	Floors, 1/4" thick, patching concrete	Dust collection system	25.0%	100.0%	6.1%
7	Crack repair, including chipping, sand blasting, and cleaning. Epoxy injection up to 1/4" wide.	Dust collection system	25.0%	91.2%	5.1%
8	Cut and repoint brick, hard mortar, common bond.	Dust collection system	25.0%	96.2%	5.6%
9	Hand-held milling, wall grinding	Dust control	25.0%	91.7%	2.6%
	Job category total, averages		100.0%	94.8%	4.9%

Table V-25: Weighted Average of Incremental Silica Control Costs as a Percentage of Activity Costs, by Job Category, for OSHA's Economic Analysis of the Construction Industry (continued)

Job Category/Description		Controls	Relative Frequency Within Job Categories	Labor Costs as a Percentage of Project Costs	Incremental Costs as Percentage of Baseline Costs
Heavy construction equipment operating					
10	Backfill, structural, from existing stockpile, no compaction, 50' haul, sand and gravel	Enclosed cab with ventilation	100.0%	41.7%	0.8%
Hole drillers using held-held drills					
11	Drilling for anchors, up to 4" in diameter including bit and layout in concrete or brick walls, no anchor. 3/4" diameter	Dust Shroud Vacuum system	100.0%	98.7%	3.0%
Impact drillers					
12	Drilling bituminous material, with hand-held air equipment, up to 6 inches thick	Wet methods	40.0%	93.3%	3.6%
13	Cutout demolition, elevated slab, bar reinforced, under 6 c.f.	Wet methods	40.0%	91.8%	3.7%
14	Remove masonry walls, block, solid (indoor environment)	Dust collection system	20.0%	84.8%	4.5%
	Job category total, averages		100%	91.0%	3.8%
Masonry cutters using portable saws					
15	Demolition, concrete slabs, mesh reinforcing, up to 3" deep	Baseline includes control measures	33.3%	54.8%	1.1%
16	Saw cutting, brick or masonry, with hand-held saw, per inch of depth	Wet method	33.3%	86.4%	2.0%
17	Saw cutting, concrete walls, hydraulic saw, plain, per inch of depth	Baseline includes control measures	33.3%	53.9%	1.1%
	Job category total, averages		100.0%	65.0%	1.4%
Masonry cutters using stationary saws					

Table V-25: Weighted Average of Incremental Silica Control Costs as a Percentage of Activity Costs, by Job Category, for OSHA's Economic Analysis of the Construction Industry (continued)

Job Category/Description		Controls	Relative Frequency Within Job Categories	Labor Costs as a Percentage of Project Costs	Incremental Costs as Percentage of Baseline Costs
18	Sawing brick or block, per inch in depth	Wet method	100.0%	100.0%	2.0%
Millers using portable or mobile machines					
19	Asphalt cold planing & cleaning, 1" to 3" asphalt, over 25,000 square yards	Baseline includes control measures	20.0%	42.3%	0.8%
20	Concrete surface repair	Wet methods	80.0%	92.0%	2.9%
	Job category total, averages		100.0%	82.0%	2.5%
Rock crushing machines and tenders					
21	Rock crushing, excavation projects	Wet methods	100.0%	42.5%	2.4%
Underground (tunnel) construction workers					
22	Tunnel construction, bored tunnels including mucking, 20' in diameter , rock excavation (average cost; assumes 100 feet/day)	Additional maintenance of dust suppression equipment	100.0%	15.0%	0.0%

Source: U.S. Dept. of Labor, OSHA, Directorate of Evaluation and Analysis, Office of Regulatory Analysis, based on ERG (2007a and 2011).

SBREFA Panel Comments on the Incremental Cost Methodology

A participant in the Silica SBREFA process noted that while ERG established the total incremental cost for each silica control method (summarized in Table V-24), the cost estimates are based on the application of a single method. The commenter argued that there may be cases where two or more control methods would have to be applied concurrently to meet the proposed exposure limits.[20] In response, OSHA notes, that for each task, specified control options correspond to the control methods described in the technological feasibility analysis in Chapter IV of this PEA. These methods reflect the choices laid out in Table 1 of the proposed rule;[21] they are also presented in Table V-25 along with OSHA's calculation of the weighted average proportion of project costs attributable to labor and the incremental control costs as a percentage of baseline project cost. OSHA solicits comment on its responses to this issue raised during the SBREFA Panel process.

Aggregate Labor Costs: Methodological Overview

Adopting ERG's methodology, OSHA used the weighted average control costs and labor share of projects shown in Table V-25 to aggregate task-specific crew costs into estimates of the total value of silica-related projects. OSHA first estimated, on an annual basis, the amount of time workers might spend on projects corresponding to each task category. Using wage and employment data from the BLS *Occupational Employment Statistics Survey* (OES),[22] OSHA then estimated the full-time-equivalent number of such employees and the associated value of their work.[23] Next, OSHA used the average labor share of value for each task category to estimate the total annual value of silica-related tasks.[24] The value of projects requiring additional controls was estimated by multiplying the total value by the percentage of workers who are exposed at levels higher than the proposed PEL (see Table III-5 in Chapter III of this PEA). OSHA then multiplied these values by the percentage changes in baseline costs due to required additional controls (shown in Table V-25) to generate estimates of total compliance costs.

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[20] Reform OSHA Coalition (2003), p. 14.

[21] Table 1 in the proposed rule shows the control options available to an employer in the construction industry, who need not go further to achieve compliance with the PEL than to adopt one of those control options.

[22] BLS (2005).

[23] To ensure consistency of employment estimates, ERG benchmarked the OES employment statistics to County Business Pattern industry totals for 2004 (Census, 2004).

[24] Dividing project labor value by the labor share of project value yields an estimate of the total value of the project.

Aggregate "Key" and "Secondary" Labor Costs for Representative Projects

To estimate aggregate labor costs or value for each task category, ERG first matched OES occupational classifications with the labor requirements for each task category. These matching occupations are shown in Table V-26. In order to estimate the percentage of time workers spend on the relevant tasks, ERG designated some occupations as "key" and others as "secondary." The distinction is needed in order to estimate the amount of time workers participate in silica-generating tasks. In this preliminary cost analysis, OSHA applied ERG's occupation designation, as explained in greater detail below.

"Key" occupations refer to the worker or workers on each crew who perform the principal silica-generating activity in each task. ERG judged, for example, that drillers represent the key occupation for the earth drilling tasks outlined in the analysis. Earth drillers spend an estimated 75 percent of their time performing relevant drilling tasks, such as those that generate silica exposures. In other cases, the activities of those in key occupations are less closely correlated with the task. For example, the key occupation for impact drilling was judged to be construction laborers. This group performs many diverse construction tasks, and ERG estimated that the time spent on impact drilling was approximately 3 percent.

Other, "secondary" crew members (e.g., the foreman) were estimated in terms of their ratio to the number of key workers. As noted above, ERG used these percentages and ratios to estimate (on an annual basis) the amount of time these employees are engaged in and around task-related work that causes silica exposures. The estimate of the percentage of time performing the silica-generating task can be viewed in terms of the full-time-equivalent employees engaged in each task category. These estimates and the corresponding ratios for secondary workers are shown in Table V-26.

For the key occupations, ERG had at least some data with which to estimate the proportion of time workers perform silica-generating tasks. For the secondary occupations, such estimates were generally not possible. Thus, their participation in silica-generating tasks was defined based on their relationship to the key occupations. This participation is defined by their presence in the job crews, as shown in Table V-19. To illustrate the need for this approach, consider the difficulty in predicting how often construction foremen of all types are present during silica-generating tasks. BLS data, for example, provide only a total number of foremen, but no information about how they might spend their time. It is reasonable to forecast, however, using the job crew definitions, that foremen will be present in some proportion to the particular impact drilling, earth drilling, and other silica-generating tasks performed by the key occupational groups.

Table V-26: Key and Secondary Occupations, by Task Category, for OSHA's Economic Analysis of the Construction Industry

Task Category/Occupations	Percentage in Key Occupations Working on Task (Full-Time Equivalent)	Ratio of Secondary to Key Workers
Drywall finishing		
Key Occupation(s):		
Drywall and Ceiling Tile Installers	25.0%	
Tapers	25.0%	
Secondary Occupation(s):		
None		N/A
Earthdrilling		
Key Occupation(s):		
Earth Drillers, Except Oil and Gas	75.0%	
Secondary Occupation(s):		
First-Line Supervisors/Managers of Construction Trades and Extraction Workers		0.50
Construction Laborers		1.00
Operating Engineers and Other Construction Equipment Operators		1.00
Explosives Workers, Ordnance Handling Experts, and Blasters		0.25
Helpers--Extraction Workers		0.25
Grinding and tuckpointing		
Key Occupation(s):		
Brickmasons and Blockmasons	2.5%	
Cement Masons and Concrete Finishers	2.5%	
Helpers--Brickmasons, Blockmasons, Stonemasons, and Tile and Marble Setters	2.5%	
Secondary Occupation(s):		
First-Line Supervisors/Managers of Construction Trades and Extraction Workers		1.0
Construction Laborers		3.0
Heavy construction equipment operation		
Key Occupation(s):		
Operating Engineers and Other Construction Equipment Operators	75.0%	
Excavating and Loading Machine and Dragline Operators	50.0%	
Highway Maintenance Workers [a]	5.0%	
Secondary Occupation(s):		
Construction Laborers		0.5

Table V-26: Key and Secondary Occupations, by Task Category, for OSHA's Economic Analysis of the Construction Industry (continued)

Task Category/Occupations	Percentage in Key Occupations Working on Task (Full-Time Equivalent)	Ratio of Secondary to Key Workers
Hole drillers using hand-held drills		
Key Occupation(s):		
Carpenters	1.0%	
Helpers--Carpenters	1.0%	
Secondary Occupation(s):		
Construction Laborers		1.0
Impact drilling		
Key Occupation(s):		
Construction Laborers	3.0%	
Highway Maintenance Workers [a]	2.5%	
Secondary Occupation(s):		
First-Line Supervisors/Managers of Construction Trades and Extraction Workers		0.25
Operating Engineers and Other Construction Equipment Operators		0.25
Masonry cutters using portable saws		
Key Occupation(s):		
Brickmasons and Blockmasons	10.0%	
Stonemasons	10.0%	
Helpers--Brickmasons, Blockmasons, Stonemasons, and Tile and Marble Setters	10.0%	
Secondary Occupation(s):		
Construction Laborers		1.0
Masonry cutters using stationary saws		
Key Occupation(s):		
Brickmasons and Blockmasons	10.0%	
Stonemasons	10.0%	
Helpers--Brickmasons, Blockmasons, Stonemasons, and Tile and Marble Setters	10.0%	
Secondary Occupation(s):		
None		N/A
Millers using portable or mobile machines		
Key Occupation(s):		

Table V-26: Key and Secondary Occupations, by Task Category, for OSHA's Economic Analysis of the Construction Industry (continued)

Task Category/Occupations	Percentage in Key Occupations Working on Task (Full-Time Equivalent)	Ratio of Secondary to Key Workers
Cement Masons and Concrete Finishers	5.0%	
Paving, Surfacing, and Tamping Equipment Operators	5.0%	
Secondary Occupation(s):		
First-Line Supervisors/Managers of Construction Trades and Extraction Workers		0.67
Construction Laborers		1.00
Rockcrushing		
Key Occupation(s):		
Crushing, Grinding, and Polishing Machine Setters, Operators, and Tenders	75.0%	
Secondary Occupation(s):		
First-Line Supervisors/Managers of Construction Trades and Extraction Workers		0.33
Construction Laborers		1.00
Underground construction (tunnel) work		
Key Occupation(s):		
Tunnel Workers [b]	50.0%	

Note: Occupations based on BLS, *Occupational Employment Survey* classification system (BLS, 2005).

[a] State and local government employees only.

[b] Tunnel workers not identified by specific occupational title.

Source: U.S. Dept. of Labor, OSHA, Directorate of Evaluation and Analysis, Office of Regulatory Analysis, based on ERG (2007a and 2011).

As illustration of the use of these estimates for specific tasks, in impact drilling the construction laborer is the key occupation, and first-line supervisors and equipment operators are the secondary occupations. Because the applicable standard work crew (as specified in RSMeans, 2008) consists of a supervisor, an equipment operator, and four construction laborers, ERG used a ratio of 1 to 4 (0.25, as shown in Table V-26) to estimate the participation level for each of these secondary occupations relative to the key occupation in impact drilling. In another example, in heavy construction equipment operation, ERG estimated that construction laborers are a secondary occupation and heavy equipment operators are the key occupation for standard work crews involving such equipment. The standard work crew in RSMeans (2008) calls for a heavy equipment operator and 0.5 construction laborers. Therefore, ERG's cost model uses a ratio of 1 to 2 (0.5, as shown in Table V-26) to estimate the participation level of construction laborers relative to key occupations in tasks involving heavy equipment operations.

For some activities, the crew size and composition vary among the jobs defined in the activity category. In those cases, ERG made a judgment as to the most representative crew composition and used that crew model to define the ratio of secondary to key occupations.

ERG's estimates of the number of full-time equivalent employees performing silica-generating tasks are one of many factors that influence the final cost estimates. There are little data, however, on the breakdown of time spent by construction workers in various activities. The following discussion presents ERG's basis for the time-on-task estimates for the key occupations.

Drywall Finishers

Workers who perform drywall finishing typically divide their time between drywall installation, finishing, and cleanup tasks. Of these, finishing was judged to require less than one-quarter of the job time.

Earth Drillers

A review of NIOSH reports covering earth drillers showed that over 75 percent of driller time was spent on actual drilling. (NIOSH 1992a, 1992b, 1995; NIOSH ECTB 233-122c, 1999). Therefore, ERG used 75 percent as the best indication of the time spent on the dust-generating task for this group.

Grinding and Tuckpointing

Grinding and tuckpointing are only two of the numerous jobs performed by brickmasons, cement masons, and their helpers. The tasks that are much more commonly performed by this trade are bricklaying, cement, and masonry construction. Where grinding and tuckpointing tasks are being performed, ERG's review of the OSHA Special Emphasis Program reports revealed that the time spent on these tasks varied widely (see the technological feasibility analysis for this activity in Chapter IV of this PEA). ERG estimated that 2.5 percent of the time for each of the applicable operations would be spent on these tasks.

Heavy Construction Equipment Operation

Heavy equipment operators often spend the bulk of their work shift on the equipment itself, engaged in construction work. OSHA Inspection Reports and other documentation consistently show that heavy equipment operators perform their tasks for more than 7 hours per shift (OSHA SEP Inspection Reports 122212079, 116179359; Greenspan, et al., 1995; NIOSH HETA 93-0696-2395, 1999; NIOSH ECTB 233-122c, 1999; NIOSH ECTB 233-120, 1999c.). Nevertheless, this occupational category also includes operators of such equipment as pile drivers, cranes, and air compressors that are not generally associated with silica dust generation. ERG used an estimate of 75 percent for operating engineers and 50 percent for excavating and loading machine and dragline operators in this category to reflect the extent of silica-related heavy equipment operations.

Hole Drilling

While many workers might occasionally be assigned to drill holes in concrete, this activity represents a very small part of the activities of the large occupational groups performing this work. ERG judged that one percent of the time for carpenters and carpenter assistants in the affected industries is spent in hole drilling.

Impact Drilling

ERG judged that among the key occupation, construction laborers, relatively few are engaged in impact drilling. ERG examined a snapshot of construction activities from the BLS publication, *Injuries to Construction Laborers* (BLS, 1986). That source presents a survey of injured construction workers and includes questions about their activities at the time they were injured. The survey indicated that 3 percent of construction workers were using jackhammers at the time they were injured. ERG judged that, while the survey was not intended to characterize typical construction activities, and a survey of injured workers introduces considerable potential bias into the observations, this estimate was useful as an observation of representative construction activities. ERG also judged that, because jackhammers are heavier, more cumbersome, and more powerful than much construction equipment, workers are probably injured more frequently while using jackhammers, on average, than when using all other construction equipment. Thus, the 3 percent figure is likely to be an upper bound of the amount of time spent on impact drilling. In lieu of other data, ERG estimated that 3 percent of laborers are performing this task.

Masonry Cutting Using Portable Saws

The key occupations for masonry cutting, namely brickmasons, blockmasons, stonemasons, and their helpers, spend, on average, a small share of their time cutting masonry with portable saws. According to OSHA and NIOSH reports, saw operators perform multiple masonry activities and might engage in cutting for only a small portion of their shift (OSHA SEP Inspection Report 300646510; NIOSH ECTB 233-118c, 1999). Another glimpse of this activity can be gleaned from the BLS injury report for construction laborers, where 3 percent of workers were injured while breaking up or cutting concrete, asphalt, brick, rocks, etc.[25] For each of the applicable occupations, ERG estimated that 10 percent of the time would be spent on these tasks.

Masonry Cutting Using Stationary Saws

As noted above, OSHA and NIOSH surveillance publications report that saw operators perform multiple masonry activities and might engage in cutting for only a small portion of their shift (OSHA SEP Inspection Report 300646510; NIOSH ECTB 233-118c, 1999). ERG estimated that mason occupations spend 10 percent of their time on cutting tasks.

Milling Using Portable or Mobile Machines

Milling represents a small share of the overall job duties of the two applicable key occupations: (1) cement masons and (2) paving, surfacing, and tamping equipment operators. ERG judged that 5 percent of all work for these occupations is spent in milling tasks.

Rockcrushers

According to information collected from ERG communication and OSHA SEP inspection reports, rock crushing machine operators spend most, if not all, of their shift at and around the rock crushing process (Polhemus, 2000; Haney, 2001; OSHA SEP Inspection Report 2116507; OSHA SEP Inspection Report 300441862.) ERG estimated that this occupational group spends 75 percent of its time on the rock crushing task.

Underground (Tunnel) Construction Workers

Underground workers perform both tunnel work and other types of construction work. ERG estimated that underground workers participate in underground work approximately 50 percent of the time. (As described further below, this level of work also generates estimates of the labor value of tunneling work that are approximately consistent with the level of work measured in Census estimates.)

SBREFA Panel Comments on Key and Secondary Occupations

As stated in the comments during the Silica SBREFA process, one participant was "unable to reconcile ERG's statement that 'the amount of time . . . grinders and tuck-pointers perform grinding ranges widely, from about 1 hour per shift up to a full 8-hour shift (or longer)' [see the discussion on technological feasibility in Chapter IV of this PEA] with the 2.5% estimate in Table 4-8 [in the ERG report (2007a); Table V-26 in this PEA]." The commenter also asserted that masonry cutters use stationary saws approximately 20 to 30 percent of their working time (rather than 10 percent), and that masonry cutters use portable saws approximately 5 percent of their working time (rather than 10 percent).[26]

[25] OSHA notes that these data are of uncertain value since they probably exclude most craft workers (i.e., masons) and may contain various other potential biases in injury data.

[26] Mason Contractors Association of America, p. 34.

In response, OSHA reiterates that Table V-26 shows the estimates of the full-time-equivalent number of workers in key and secondary occupations working on silica-generating tasks. These occupations are taken from the BLS *Occupational Employment Survey* classification system and are much broader than the "masonry cutter" category referred to by the commenter, implying a lower percentage of time devoted to tasks involving masonry cutting. To summarize, for each occupation, the estimates in Table V-26 are meant to reflect the typical or average amount of a worker's time (over a year) devoted to the listed tasks. OSHA solicits comment on its response to this issue raised during the SBREFA Panel process.

FTE At-Risk Employment by Task Category

Tables V-27a and V-27b provide estimates, by occupation, of the full-time-equivalent (FTE) number of key and secondary workers, respectively, for each task category, using the percentages and ratios from Table V-26.

Table V-28 shows the corresponding estimates by NAICS code for the construction industry.[27] OSHA distributed FTE at-risk workers across NAICS codes according to the combination of task categories and occupational (key and secondary) categories (from BLS, 2005) derived by ERG for each industry group (ERG, 2007a).[28] Overall, a full-time equivalent of 652,029 workers is estimated to work on silica-related tasks in construction, ranging from 1,331 for underground construction to 369,655 for heavy construction equipment operations.

[27] OSHA notes that some industries appear unlikely to generate silica exposures even when the affected occupational categories are included within their employment totals. Despite this, OSHA has not eliminated these industries from consideration on the grounds that some establishments might participate substantially in more than one type of construction activity, a fact which might not be fully represented by the NAICS classification. Further, eliminating these industries would create accounting and estimation difficulties for the analysis.

[28] For example, OSHA estimated that the full-time-equivalent of 29,872, or 25% of the total employment of 119,489, drywall and ceiling tile installers work on drywall finishing tasks where silica exposures occur. OSHA then distributed these FTE at-risk workers by industry, assuming the same share of drywall and ceiling tile installers are affected in each industry. Thus, NAICS 236100, Residential Building Construction, which employs an estimated 5,360 drywall and ceiling tile installers, was estimated to have 1,340 FTE affected workers in this occupation (0.25 x 5,360). Similarly, NAICS 238300, Building Finishing Contractors, which employs at estimated 113,829 drywall and ceiling tile installers, was estimated to have 28,457 FTE affected workers in this occupation (0.25 x 113,829).

Table V-27a: Estimated Full-Time-Equivalent Employment, by Occupation and Task, At Risk of Silica Exposure, for OSHA's Economic Analysis of the Construction Industry (Excludes Abrasive Blasters)

OES Code	Key Occupation	Total Employment	Total Full-Time Equivalent Working on At-Risk Tasks		Drywall finishers	Earth drillers	Operators of tractors and other heavy construction vehicles and equipment	Grinders and tuckpointers using hand-held tools	Hole drillers using hand-held drills
			Number of Workers	Percentage of Total Employment					
47-1011	First-Line Supervisors/Managers of Construction Trades and Extraction Workers	**489,790**	0	0.0%	0	0	0	0	0
47-2021	Brickmasons and Blockmasons	**111,585**	25,107	22.5%	0	0	0	2,790	0
47-2022	Stonemasons	**17,414**	3,483	20.0%	0	0	0	0	0
47-2031	Carpenters	**783,255**	7,833	1.0%	0	0	0	0	7,833
47-2051	Cement Masons and Concrete Finishers	**192,037**	14,403	7.5%	0	0	0	4,801	0
47-2061	Construction Laborers	**823,733**	24,712	3.0%	0	0	0	0	0
47-2071	Paving, Surfacing, and Tamping Equipment Operators	**51,857**	2,593	5.0%	0	0	0	0	0
47-2073	Operating Engineers and Other Construction Equipment Operators	**295,758**	221,818	75.0%	0	0	221,818	0	0
47-2081	Drywall and Ceiling Tile Installers	**119,489**	29,872	25.0%	29,872	0	0	0	0
47-2082	Tapers	**32,185**	8,046	25.0%	8,046	0	0	0	0
47-3011	Helpers--Brickmasons, Blockmasons, Stonemasons, and Tile and Marble Setters	**56,602**	12,735	22.5%	0	0	0	1,415	0
47-3012	Helpers--Carpenters	**77,858**	779	1.0%	0	0	0	0	779
47-4051	Highway Maintenance Worker	**131,180**	9,839	7.5%	0	0	6,559	0	0
47-5021	Earth Drillers, Except Oil and Gas	**11,694**	8,770	75.0%	0	8,770	0	0	0
47-5031	Explosives Workers, Ordnance Handling Experts, and Blasters	**543**	0	0.0%	0	0	0	0	0

Table V-27a: Estimated Full-Time-Equivalent Employment, by Occupation and Task, At Risk of Silica Exposure, for OSHA's Economic Analysis of the Construction Industry (Excludes Abrasive Blasters) (continued)

OES Code	Key Occupation	Total Employment	Total Full-Time Equivalent Working on At-Risk Tasks		Impact drillers	Millers using portable or mobile machines	Masonry cutters using portable saws	Masonry cutting using stationary saws	Rock-crushing machine operators and tenders	Underground construction workers
			Number of Workers	Percentage of Total Employment						
47-1011	First-Line Supervisors/Managers of Construction Trades and Extraction Workers	**489,790**	0	0.0%	0	0	0	0	0	0
47-2021	Brickmasons and Blockmasons	**111,585**	25,107	22.5%	0	0	11,158	11,158	0	0
47-2022	Stonemasons	**17,414**	3,483	20.0%	0	0	1,741	1,741	0	0
47-2031	Carpenters	**783,255**	7,833	1.0%	0	0	0	0	0	0
47-2051	Cement Masons and Concrete Finishers	**192,037**	14,403	7.5%	0	9,602	0	0	0	0
47-2061	Construction Laborers	**823,733**	24,712	3.0%	24,712	0	0	0	0	0
47-2071	Paving, Surfacing, and Tamping Equipment Operators	**51,857**	2,593	5.0%	0	2,593	0	0	0	0
47-2073	Operating Engineers and Other Construction Equipment Operators	**295,758**	221,818	75.0%	0	0	0	0	0	0
47-2081	Drywall and Ceiling Tile Installers	**119,489**	29,872	25.0%	0	0	0	0	0	0
47-2082	Tapers	**32,185**	8,046	25.0%	0	0	0	0	0	0
47-3011	Helpers--Brickmasons, Blockmasons, Stonemasons, and Tile and Marble Setters	**56,602**	12,735	22.5%	0	0	5,660	5,660	0	0
47-3012	Helpers--Carpenters	**77,858**	779	1.0%	0	0	0	0	0	0
47-4051	Highway Maintenance Worker	**131,180**	9,839	7.5%	3,280	0	0	0	0	0
47-5021	Earth Drillers, Except Oil and Gas	**11,694**	8,770	75.0%	0	0	0	0	0	0
47-5031	Explosives Workers, Ordnance Handling Experts, and Blasters	**543**	0	0.0%	0	0	0	0	0	0

Table V-27a: Estimated Full-Time-Equivalent Employment, by Occupation and Task, At Risk of Silica Exposure, for OSHA's Economic Analysis of the Construction Industry (Excludes Abrasive Blasters) (continued)

OES Code	Key Occupation	Total Employment	Total Full-Time Equivalent Working on At-Risk Tasks		Drywall finishers	Earth drillers	Operators of tractors and other heavy construction vehicles and equipment	Grinders and tuckpointers using hand-held tools	Hole drillers using hand-held drills
			Number of Workers	Percentage of Total Employment					
47-5081	Helpers--Extraction Workers	**5,060**	0	0.0%	0	0	0	0	0
51-9021	Crushing, Grinding, and Polishing Machine Setters, Operators, and Tenders	**1,249**	937	75.0%	0	0	0	0	0
53-7032	Excavating and Loading Machine and Dragline Operators	**36,118**	18,059	50.0%	0	0	18,059	0	0
99999	Tunnel workers [a]	**2,662**	1,331	50.0%	0	0	0	0	0
	Total	**3,237,406**	**390,316**	**12.1%**	**37,919**	**8,770**	**246,436**	**9,006**	**8,611**

Table V-27a: Estimated Full-Time-Equivalent Employment, by Occupation and Task, At Risk of Silica Exposure, for OSHA's Economic Analysis of the Construction Industry (Excludes Abrasive Blasters) (continued)

OES Code	Key Occupation	Total Employment	Total Full-Time Equivalent Working on At-Risk Tasks		Impact drillers	Millers using portable or mobile machines	Masonry cutters using portable saws	Masonry cutting using stationary saws	Rock-crushing machine operators and tenders	Underground construction workers
			Number of Workers	Percentage of Total Employment						
47-5081	Helpers--Extraction Workers	**5,060**	0	0.0%	0	0	0	0	0	0
51-9021	Crushing, Grinding, and Polishing Machine Setters, Operators, and Tenders	**1,249**	937	75.0%	0	0	0	0	937	0
53-7032	Excavating and Loading Machine and Dragline Operators	**36,118**	18,059	50.0%	0	0	0	0	0	0
99999	Tunnel workers [a]	**2,662**	1,331	50.0%	0	0	0	0	0	1,331
	Total	**3,237,406**	**390,316**	**12.1%**	**27,991**	**12,195**	**18,560**	**18,560**	**937**	**1,331**

Table V-27b: Estimated Full-Time-Equivalent Employment, by Occupation and Task, At Risk of Silica Exposure, for OSHA's Economic Analysis of the Construction Industry (Excludes Abrasive Blasters)

OES Code	Secondary Occupation (b)	Total Employment	Total Full-Time Equivalent Working on At-Risk Tasks		Drywall finishers	Earth drillers	Operators of tractors and other heavy construction vehicles and equipment	Grinders and tuckpointers using hand-held tools	Hole drillers using hand-held drills
			Number of Workers	Percentage of Total Employment					
47-1011	First-Line Supervisors/Managers of Construction Trades and Extraction Workers	**489,790**	28,746	5.9%	0	4,385	0	9,006	0
47-2021	Brickmasons and Blockmasons	**111,585**	0	0.0%	0	0	0	0	0
47-2022	Stonemasons	**17,414**	0	0.0%	0	0	0	0	0
47-2031	Carpenters	**783,255**	0	0.0%	0	0	0	0	0
47-2051	Cement Masons and Concrete Finishers	**192,037**	0	0.0%	0	0	0	0	0
47-2061	Construction Laborers	**823,733**	199,308	24.2%	0	8,770	123,218	27,017	8,611
47-2073	Operating Engineers and Other Construction Equipment Operators	**295,758**	15,528	5.3%	0	8,770	0	0	0
47-2081	Drywall and Ceiling Tile Installers	**119,489**	0	0.0%	0	0	0	0	0
47-2082	Tapers	**32,185**	0	0.0%	0	0	0	0	0
47-3011	Helpers--Brickmasons, Blockmasons, Stonemasons, and Tile and Marble Setters	**56,602**	0	0.0%	0	0	0	0	0
47-3012	Helpers--Carpenters	**77,858**	0	0.0%	0	0	0	0	779
47-4051	Highway Maintenance Worker	**131,180**	0	0.0%	0	0	0	0	0
47-5021	Earth Drillers, Except Oil and Gas	**11,694**	0	0.0%	0	0	0	0	0
47-5031	Explosives Workers, Ordnance Handling Experts, and Blasters	**543**	497	91.6%	0	497	0	0	0

Table V-27b: Estimated Full-Time-Equivalent Employment, by Occupation and Task, At Risk of Silica Exposure, for OSHA's Economic Analysis of the Construction Industry (Excludes Abrasive Blasters) (continued)

OES Code	Secondary Occupation (b)	Total Employment	Total Full-Time Equivalent Working on At-Risk Tasks		Impact drillers	Millers using portable or mobile machines	Masonry cutters using portable saws	Masonry cutting using stationary saws	Rock-crushing machine operators and tenders	Underground construction workers
			Number of Workers	Percentage of Total Employment						
47-1011	First-Line Supervisors/Managers of Construction Trades and Extraction Workers	**489,790**	0	0.0%	0	0	0	0	0	0
47-2021	Brickmasons and Blockmasons	**111,585**	25,107	22.5%	6,757	0	0	0	0	0
47-2022	Stonemasons	**17,414**	3,483	20.0%	0	0	0	0	0	0
47-2031	Carpenters	**783,255**	7,833	1.0%	0	0	0	0	0	0
47-2051	Cement Masons and Concrete Finishers	**192,037**	14,403	7.5%	0	0	0	0	0	0
47-2061	Construction Laborers	**823,733**	24,712	3.0%	0	0	0	0	0	0
47-2071	Paving, Surfacing, and Tamping Equipment Operators	**51,857**	2,593	5.0%	0	0	0	0	0	0
47-2073	Operating Engineers and Other Construction Equipment Operators	**295,758**	221,818	75.0%	0	0	0	0	0	0
47-2081	Drywall and Ceiling Tile Installers	**119,489**	29,872	25.0%	0	0	0	0	0	0
47-2082	Tapers	**32,185**	8,046	25.0%	0	0	0	0	0	0
47-3011	Helpers--Brickmasons, Blockmasons, Stonemasons, and Tile and Marble Setters	**56,602**	12,735	22.5%	0	0	5,660	5,660	0	0
47-3012	Helpers--Carpenters	**77,858**	779	1.0%	0	0	0	0	0	0
47-4051	Highway Maintenance Worker	**131,180**	9,839	7.5%	3,280	0	0	0	0	0
47-5021	Earth Drillers, Except Oil and Gas	**11,694**	8,770	75.0%	0	0	0	0	0	0
47-5031	Explosives Workers, Ordnance Handling Experts, and Blasters	**543**	0	0.0%	0	0	0	0	0	0

Table V-27b: Estimated Full-Time-Equivalent Employment, by Occupation and Task, At Risk of Silica Exposure, for OSHA's Economic Analysis of the Construction Industry (Excludes Abrasive Blasters) (continued)

OES Code	Secondary Occupation (b)	Total Employment	Total Full-Time Equivalent Working on At-Risk Tasks		Drywall finishers	Earth drillers	Operators of tractors and other heavy construction vehicles and equipment	Grinders and tuckpointers using hand-held tools	Hole drillers using hand-held drills
			Number of Workers	Percentage of Total Employment					
47-5081	Helpers--Extraction Workers	**5,060**	2,187	43.2%	0	2,187	0	0	0
51-9021	Crushing, Grinding, and Polishing Machine Setters, Operators, and Tenders	**1,249**	0	0.0%	0	0	0	0	0
53-7032	Excavating and Loading Machine and Dragline Operators	**36,118**	0	0.0%	0	0	0	0	0
	Total	**3,237,406**	**246,267**	**7.6%**	**0**	**24,611**	**123,218**	**36,022**	**8,611**
	Total for key and secondary occupations		**636,583**	**19.7%**	**37,919**	**33,381**	**369,655**	**45,028**	**17,222**

Table V-27b: Estimated Full-Time-Equivalent Employment, by Occupation and Task, At Risk of Silica Exposure, for OSHA's Economic Analysis of the Construction Industry (Excludes Abrasive Blasters) (continued)

OES Code	Secondary Occupation (b)	Total Employment	Total Full-Time Equivalent Working on At-Risk Tasks		Impact drillers	Millers using portable or mobile machines	Masonry cutters using portable saws	Masonry cutting using stationary saws	Rock-crushing machine operators and tenders	Underground construction workers
			Number of Workers	Percentage of Total Employment						
47-5081	Helpers--Extraction Workers	**5,060**	0	0.0%	0	0	0	0	0	0
51-9021	Crushing, Grinding, and Polishing Machine Setters, Operators, and Tenders	**1,249**	937	75.0%	0	0	0	0	937	0
53-7032	Excavating and Loading Machine and Dragline Operators	**36,118**	18,059	50.0%	0	0	0	0	0	0
	Total	**3,237,406**	**390,316**	**12.1%**	**27,991**	**12,195**	**18,560**	**18,560**	**937**	**1,331**
	Total for key and secondary occupations		**636,583**	**19.7%**	**41,747**	**32,438**	**37,120**	**18,560**	**2,183**	**1,331**

[a] Tunnel workers not identified by specific occupational title. Tunnel worker employment included in the totals for other listed occupations.
[b] Total number of full-time equivalent workers constrained by occupational employment totals for each industry.
Source: U.S. Dept. of Labor, OSHA, Office of Regulatory Analysis, based on task percentages shown in Table V-26.

Table V-28: Estimated Full-Time-Equivalent Employment, by NAICS Code and Task, At Risk of Silica Exposure, for OSHA's Economic Analysis of the Construction Industry (Includes Abrasive Blasters)

NAICS	Industry	Total Employment	Total Full-Time Equivalent Working on At-Risk Tasks		Drywall finishers	Earth drillers	Operators of tractors and other heavy construction vehicles and equipment	Grinders and tuckpointers using hand-held tools	Hole drillers using hand-held drills
			Number of Workers	Percentage of Total Employment					
236100	Residential Building Construction	**966,198**	27,669	2.9%	1,431	0	8,663	2,011	6,606
236200	Nonresidential Building Construction	**741,978**	34,788	4.7%	482	0	17,938	3,135	3,112
237100	Utility System Construction	**496,628**	96,181	19.4%	13	24,188	65,917	578	164
237200	Land Subdivision	**77,406**	3,255	4.2%	0	0	2,912	43	43
237300	Highway, Street, and Bridge Construction	**325,182**	66,916	20.6%	0	419	55,367	1,583	279
237900	Other Heavy and Civil Engineering Construction	**90,167**	18,835	20.9%	13	1,015	16,370	171	111
238100	Foundation, Structure, and Building Exterior Contractors	**1,167,986**	111,946	9.6%	148	0	11,929	30,747	3,343
238200	Building Equipment Contractors	**1,940,281**	10,179	0.5%	13	141	8,061	59	158
238300	Building Finishing Contractors	**975,335**	60,006	6.2%	35,807	0	94	2,079	2,943
238900	Other Specialty Trade Contractors	**557,638**	137,219	24.6%	13	7,541	107,169	4,437	252
999000	State and Local Governments	**5,762,939**	85,034	1.5%	0	79	75,235	186	212
	Total	**13,101,738**	**652,029**	**5.0%**	**37,919**	**33,381**	**369,655**	**45,028**	**17,222**

Source: U.S. Dept. of Labor, OSHA, Office of Regulatory Analysis, based on task percentages shown in Table V-26.

Table V-28: Estimated Full-Time-Equivalent Employment, by NAICS Code and Task, At Risk of Silica Exposure, for OSHA's Economic Analysis of the Construction Industry (Includes Abrasive Blasters) (continued)

NAICS	Industry	Total Employment	Total Full-Time Equivalent Working on At-Risk Tasks		Impact drillers	Millers using portable or mobile machines	Masonry cutters using portable saws	Masonry cutting using stationary saws	Rock-crushing machine operators and tenders	Under-ground construc-tion workers	Abrasive blasters
			Number of Workers	Percentage of Total Employment							
236100	Residential Building Construction	**966,198**	27,669	2.9%	5,784	1,602	1,048	524	0	0	0
236200	Nonresidential Building Construction	**741,978**	34,788	4.7%	5,212	2,301	1,739	869	0	0	0
237100	Utility System Construction	**496,628**	96,181	19.4%	4,316	765	102	51	87	0	0
237200	Land Subdivision	**77,406**	3,255	4.2%	202	55	0	0	0	0	0
237300	Highway, Street, and Bridge Construction	**325,182**	66,916	20.6%	3,695	4,016	10	5	211	1,331	0
237900	Other Heavy and Civil Engineering Construction	**90,167**	18,835	20.9%	808	215	30	15	87	0	0
238100	Foundation, Structure, and Building Exterior Contractors	**1,167,986**	111,946	9.6%	6,235	14,654	29,869	14,934	87	0	0
238200	Building Equipment Contractors	**1,940,281**	10,179	0.5%	1,609	13	84	42	0	0	0
238300	Building Finishing Contractors	**975,335**	60,006	5.0%	1,503	530	3,005	1,503	1,500	0	11,043
238900	Other Specialty Trade Contractors	**557,638**	137,219	23.8%	5,500	6,124	1,130	565	87	0	4,403
999000	State and Local Governments	**5,762,939**	85,034	1.5%	6,883	2,161	104	52	122	0	0
	Total	**13,101,738**	**652,029**	**5.0%**	**41,747**	**32,438**	**37,120**	**18,560**	**2,183**	**1,331**	**15,446**

Source: U.S. Dept. of Labor, OSHA, Directorate of Evaluation and Analysis, Office of Regulatory Analysis, based on task percentages shown in Table V-26.

Labor Cost and Total Value of Silica Exposure-Generating Tasks

To derive labor costs and project value for the construction tasks where occupational exposure to silica is found, ERG multiplied the mean hourly wage, as reported by OES (BLS, 2009) for each affected job category within each affected industry, by 2,000 hours and by the number of affected full-time-equivalent employees to derive the total value of annual wages expended for each silica exposure-generating task. These estimates were then inflated to adjust for fringe benefits.[29] These loaded-wage costs, totaled by industry and task category, are summarized in Table V-29 as the annual labor value (or labor cost) of silica-generating projects. Thus for earth drilling, for example, ERG estimated the labor share of the project value, or cost, was $1,929.3 million annually. Overall, ERG estimated the labor value of all silica-generating construction tasks at $34.0 billion annually.

ERG then extrapolated the labor values for each industry and task category to the total project value by dividing by the labor share of project costs. Because the labor share for each task category equals the labor value divided by project value, dividing the labor value by the labor share generates an estimate of project value. Table V-30 shows the estimated labor share for each task category as derived in Table V-25 and the associated estimates of total project value for each industry and task category. For example, for earth drilling, the labor share of costs was estimated at 53.1 percent (from Table V-25). The total project value for these earth drilling tasks was estimated, therefore, at 1.88 (1 divided by 0.531) times the labor value of $1,929.3 million—or $3,634.6 million annually. Overall, ERG estimated the value of silica-generating construction tasks at $65.2 billion. The values for specific task categories ranged from $251.3 million for rock crushing to $46.8 billion for heavy construction equipment operations.

The value of at-risk tasks were then summed within NAICS industry codes to derive the total value of at-risk projects, a base from which OSHA calculated control costs associated with the proposed PEL. Aggregate control costs are presented below, following the discussion of the costs of abrasive blasting in construction.

[29] Bureau of Labor Statistics, *Employer Costs for Employee Compensation*, 2008 (BLS, 2009). For private-sector, construction-industry employees, wages and salaries comprised 69.2 percent of total compensation in the fourth quarter of 2004.

Table V-29: Estimated Labor Value of Construction Tasks with Risk of Silica Exposure, for OSHA's Cost Analysis of the Construction Industry (millions of 2009 dollars)

NAICS	Industry	Total	Drywall finishers	Earth drillers	Operators of tractors and other heavy construction vehicles and equipment	Grinders and tuckpointers using hand-held tools	Hole drillers using hand-held drills	Impact drillers	Millers using portable or mobile machines	Masonry cutters using portable saws	Masonry cutting using stationary saws	Rock-crushing machine operators and tenders	Under-ground construc-tion workers
236100	Residential Building Construction	**$1,459.7**	$79.7	$0.0	$471.6	$107.1	$323.2	$303.8	$90.6	$53.1	$30.5	$0.0	$0.0
236200	Nonresidential Building Construction	**$2,105.2**	$33.1	$0.0	$1,100.6	$187.1	$176.9	$309.6	$143.8	$98.6	$55.5	$0.0	$0.0
237100	Utility System Construction	**$5,537.3**	$0.7	$1,398.7	$3,800.8	$31.9	$8.8	$238.9	$44.6	$5.3	$3.0	$4.6	$0.0
237200	Land Subdivision	**$164.1**	$0.0	$0.0	$145.2	$2.4	$2.2	$11.0	$3.3	$0.0	$0.0	$0.0	$0.0
237300	Highway, Street, and Bridge Construction	**$4,030.7**	$0.0	$25.3	$3,359.9	$93.2	$16.1	$217.9	$243.8	$0.5	$0.3	$11.5	$62.1
237900	Other Heavy and Civil Engineering Construction	**$1,042.1**	$0.7	$57.8	$903.9	$9.7	$5.6	$44.4	$13.2	$1.5	$0.8	$4.6	$0.0
238100	Foundation, Structure, and Building Exterior Contractors	**$6,105.7**	$9.9	$0.0	$728.0	$1,648.0	$164.9	$339.1	$828.0	$1,518.8	$865.0	$4.0	$0.0
238200	Building Equipment Contractors	**$596.1**	$0.6	$8.2	$477.6	$3.3	$8.6	$90.5	$0.8	$4.2	$2.4	$0.0	$0.0
238300	Building Finishing Contractors	**$2,738.6**	$2,084.9	$0.0	$5.2	$106.8	$152.3	$76.5	$30.5	$135.9	$71.4	$75.1	$0.0
238900	Other Specialty Trade Contractors	**$7,293.6**	$0.6	$437.9	$5,872.6	$236.4	$12.9	$289.9	$343.1	$60.4	$35.5	$4.4	$0.0
999000	State and Local Governments	**$2,901.0**	$0.0	$1.4	$2,617.1	$2.5	$6.8	$222.6	$40.1	$3.9	$3.9	$2.6	$0.0
	Totals	**$33,974.2**	**$2,210.2**	**$1,929.3**	**$19,482.6**	**$2,428.4**	**$878.2**	**$2,144.2**	**$1,781.9**	**$1,882.4**	**$1,068.2**	**$106.8**	**$62.1**

Source: U.S. Dept. of Labor, OSHA, Directorate of Evaluation and Analysis, Office of Regulatory Analysis, based on ERG (2007a and 2011).

Table V-30: Estimated Total Value of Construction Tasks with Risk of Silica Exposure, for OSHA's Cost Analysis of the Construction Industry (millions of 2009 dollars)

NAICS	Industry	Total	Drywall finishers	Earth drillers	Operators of tractors and other heavy construction vehicles and equipment	Grinders and tuckpointers using hand-held tools	Hole drillers using hand-held drills	Impact drillers	Millers using portable or mobile machines	Masonry cutters using portable saws	Masonry cutting using stationary saws	Rock-crushing machine operators and tenders	Under-ground construc-tion workers
Average Labor Share of Project Value			100.0%	53.1%	41.7%	94.8%	98.7%	91.0%	82.0%	65.0%	100.0%	42.5%	15.0%
236100	Residential Building Construction	**$2,208.6**	$79.7	$0.0	$1,132.1	$113.0	$327.3	$334.0	$110.5	$81.7	$30.5	$0.0	$0.0
236200	Nonresidential Building Construction	**$3,774.2**	$33.1	$0.0	$2,641.7	$197.4	$179.2	$340.3	$175.3	$151.6	$55.5	$0.0	$0.0
237100	Utility System Construction	**$12,140.3**	$0.7	$2,635.1	$9,123.1	$33.6	$8.9	$262.6	$54.3	$8.2	$3.0	$10.8	$0.0
237200	Land Subdivision	**$369.4**	$0.0	$0.0	$348.6	$2.5	$2.3	$12.0	$4.0	$0.0	$0.0	$0.0	$0.0
237300	Highway, Street, and Bridge Construction	**$9,205.8**	$0.0	$47.6	$8,064.6	$98.3	$16.3	$239.5	$297.3	$0.8	$0.3	$27.1	$413.8
237900	Other Heavy and Civil Engineering Construction	**$2,373.9**	$0.7	$108.8	$2,169.7	$10.3	$5.7	$48.7	$16.1	$2.2	$0.8	$10.8	$0.0
238100	Foundation, Structure, and Building Exterior Contractors	**$8,255.1**	$9.9	$0.0	$1,747.5	$1,738.8	$167.0	$372.8	$1,009.6	$2,335.3	$865.0	$9.4	$0.0
238200	Building Equipment Contractors	**$1,283.8**	$0.6	$15.5	$1,146.3	$3.5	$8.7	$99.4	$1.0	$6.5	$2.4	$0.0	$0.0
238300	Building Finishing Contractors	**$2,942.6**	$2,084.9	$0.0	$12.5	$112.7	$154.2	$84.1	$37.2	$208.9	$71.4	$176.7	$0.0
238900	Other Specialty Trade Contractors	**$16,059.5**	$0.6	$824.9	$14,096.0	$249.4	$13.0	$318.6	$418.3	$92.9	$35.5	$10.2	$0.0
999000	State and Local Governments	**$6,603.6**	$0.0	$2.6	$6,281.8	$2.7	$6.8	$244.6	$48.9	$6.1	$3.9	$6.2	$0.0
	Totals	**$65,216.9**	**$2,210.2**	**$3,634.6**	**$46,763.8**	**$2,562.2**	**$889.3**	**$2,356.7**	**$2,172.5**	**$2,894.3**	**$1,068.2**	**$251.3**	**$413.8**

Source: U.S. Dept. of Labor, OSHA, Directorate of Evaluation and Analysis, Office of Regulatory Analysis, based on ERG (2007a and 2011).

Abrasive Blasting

Based on ERG (2011), OSHA estimated program compliance costs for construction industry abrasive blasters. Table V-31 presents the unit costs and analytical assumptions applied in OSHA's cost analysis of controlling silica exposures during abrasive blasting operations. As shown in the table, after accounting for the number of affected workers, crew size, daily output, blasting cost per square foot, number of blasting days per year, and the percentage of crews using sand, OSHA estimates that baseline annual costs for sand blasting total $231.7 million. According to ERG (2011), the incremental cost for wet blasting is 30 percent of baseline costs; ERG estimates that 50 percent of crews currently use wet methods. Therefore, the annual costs to comply with the proposed standard by using wet methods during sand blasting are expected to total $34.8 million, or $2,250 per worker for the approximately 15,450 workers exposed to silica dust.

Distributing these annualized costs by industry, OSHA estimates that employers in NAICS 238200, Building Finishing Contractors, will incur compliance costs of $24.9 million annually, while firms in NAICS 238900, Other Specialty Trade Contractors, will incur compliance costs of $9.9 million annually.

Table V-31: Unit and Total Engineering Costs for Controlling Silica Exposure during Abrasive Blasting Construction Operations

Cost Variable		Cost or Parameter	Comment
Numbers of workers in blasting operations			
238300	Building Finishing Contractors	11,043	ERG estimate; projected to 2006 levels
238900	Other Specialty Trade Contractors	4,403	
	Total	15,446	
Blasting crew size		4	ERG estimate based on RSMeans (2008)
Output per day (square ft.)		1,500	ERG estimate based on RSMeans (2008)
Blasting cost per square foot (dry blasting)		$2.00	ERG estimate based on RSMeans (2008)
Blasting days per year		100	ERG estimate
Percent of blasting crews using sand		20.0%	ERG estimate
Annual costs of sand blasting		$231,690,000	
Incremental cost for wet blasting		30.0%	ERG estimate based on RSMeans (2008)
Share of blasting currently with wet methods		50.0%	ERG estimate
Cost of requiring all sand blasting to use wet methods		$34,753,500	
Cost per blasting worker		$2,250	
Costs by Industry			
238300	Building Finishing Contractors	$24,846,750	
238900	Other Specialty Trade Contractors	$9,906,750	

Source: U.S. Dept. of Labor, OSHA, Directorate of Evaluation and Analysis, Office of Regulatory Analysis, based on ERG, 2011.

Aggregate Control Costs in Construction to Comply with the Proposed PEL

The percentage of workers, by construction industry, requiring controls for the proposed 50 $\mu g/m^3$ PEL can be derived from Table III-6 in Chapter III of this PEA. These figures are a weighted average of the percentage of workers for each task category within a particular construction industry estimated to be exposed at levels above the PEL. ERG multiplied these percentages by the total project values for each task category, shown in Table V-30, to derive the value of silica-generating projects for which additional engineering controls are required to meet the proposed PEL of 50 $\mu g/m^3$. These values are shown in Table V-32 by task category and by NAICS construction industry. For the proposed PEL of 50 $\mu g/m^3$, 11.9 billion dollars' worth of silica-generating construction projects will require controls. Operation of tractors and other heavy construction vehicles and equipment constitute approximately 49 percent of the value of silica-generated construction projects affected by OSHA's proposed standard.

Table V-32: Estimated Value of At-Risk Construction Tasks Requiring Controls under OSHA's Proposed Silica Standard (millions of 2009 dollars)

NAICS	Industry	Total	Drywall finishers	Earth drillers	Operators of tractors and other heavy construction vehicles and equipment	Grinders and tuckpointers using hand-held tools	Hole drillers using hand-held drills	Impact drillers	Millers using portable or mobile machines	Masonry cutters using portable saws	Masonry cutting using stationary saws	Rock-crushing machine operators and tenders	Under-ground construc-tion workers
Average Labor Share of Project Value			100.0%	53.1%	41.7%	94.8%	98.7%	91.0%	82.0%	65.0%	100.0%	42.5%	15.0%
236100	Residential Building Construction	$554.8	$5.3	$0.0	$141.5	$34.3	$163.6	$134.8	$25.2	$41.3	$8.7	$0.0	$0.0
236200	Nonresidential Building Construction	$751.9	$2.2	$0.0	$330.2	$59.9	$89.6	$137.4	$40.1	$76.7	$15.9	$0.0	$0.0
237100	Utility System Construction	$2,226.6	$0.0	$945.9	$1,140.4	$10.2	$4.4	$106.0	$12.4	$4.2	$0.9	$2.2	$0.0
237200	Land Subdivision	$51.2	$0.0	$0.0	$43.6	$0.8	$1.1	$4.9	$0.9	$0.0	$0.0	$0.0	$0.0
237300	Highway, Street, and Bridge Construction	$1,310.4	$0.0	$17.1	$1,008.1	$29.8	$8.2	$96.7	$68.0	$0.4	$0.1	$5.4	$76.6
237900	Other Heavy and Civil Engineering Construction	$343.2	$0.0	$39.1	$271.2	$3.1	$2.8	$19.7	$3.7	$1.1	$0.2	$2.2	$0.0
238100	Foundation, Structure, and Building Exterior Contractors	$2,641.0	$0.7	$0.0	$218.4	$527.7	$83.5	$150.5	$230.8	$1,180.5	$247.1	$1.9	$0.0
238200	Building Equipment Contractors	$198.6	$0.0	$5.6	$143.3	$1.1	$4.3	$40.1	$0.2	$3.3	$0.7	$0.0	$0.0
238300	Building Finishing Contractors	$455.6	$139.0	$0.0	$1.6	$34.2	$77.1	$34.0	$8.5	$105.6	$20.4	$35.3	$0.0
238900	Other Specialty Trade Contractors	$2,423.7	$0.0	$296.1	$1,762.0	$75.7	$6.5	$128.6	$95.6	$47.0	$10.1	$2.0	$0.0
999000	State and Local Governments	$905.7	$0.0	$0.9	$785.2	$0.8	$3.4	$98.7	$11.2	$3.1	$1.1	$1.2	$0.0
	Totals	**$11,862.8**	**$147.3**	**$1,304.7**	**$5,845.5**	**$777.6**	**$444.7**	**$951.3**	**$496.6**	**$1,463.1**	**$305.2**	**$50.3**	**$76.6**

Source: U.S. Dept. of Labor, OSHA, Directorate of Evaluation and Analysis, Office of Regulatory Analysis, based on ERG, 2007a and 2011.

ERG next multiplied the value of construction tasks for which additional engineering controls are required when silica exposures exceed 50 $\mu g/m^3$ (from Table V-32) by the incremental cost percentage for each task (from Table V-25) to derive estimates in Table V-33 of aggregate incremental compliance costs to meet the proposed PEL. Using the drywall task as an example, projects requiring additional engineering controls are estimated in Table V-25 to incur a 0.97 percent increase (or 1.0 percent after rounding) in total cost. For a PEL of 50 $\mu g/m^3$, the total value of drywall finishing tasks requiring controls is estimated in Table V-32 at $5.3 million per year in the residential building construction industry (NAICS 2361). The incremental cost of silica controls in this industry per year is thus estimated in Table V-33 to be $5.3 million times 1.0 percent, or approximately $52,000 per year (shown rounded in Table V-33 as $0.1 million). OSHA performed this type of calculation for each construction task and NAICS industry code. As indicated in Table V-33, OSHA estimates that the incremental compliance costs for engineering controls (excluding abrasive blasting) will total $207.8 million for construction tasks affected by the proposed standard.

Table V-33 shows that the largest share of compliance costs, roughly 25 percent, is forecast for operators of tractors and other heavy equipment ($52.5 million), largely due to the significant share of total affected workers represented by this task category (as shown in Table V-27b, 369,655 of 636,583 affected full-time-equivalent (FTE) workers, or 58 percent of affected FTEs). Grinding and tuckpointing tasks and impact drilling tasks are expected to generate the next highest levels of compliance costs ($43.2 million and $36.4 million, respectively).

Examining incremental control costs by NAICS industry, for the proposed PEL of 50 $\mu g/m^3$, foundation, structure, and building exterior contractors (NAICS 2381) will incur the highest costs at $66.5 million per year. Other specialty trade contractors (NAICS 2389) and utility system construction (NAICS 2371) are also expected to incur significant control costs to comply with the proposed PEL. Foundation, structure, and building exterior contractors would incur almost half of their costs to control grinding and tuckpointing operations, whereas for utility system contractors and other specialty trade contractors, earth drilling and operation of heavy construction vehicles and equipment were activities that accounted for a large share of engineering control costs.

Table V-33: Incremental Control Costs for Construction Tasks Affected by OSHA's Proposed Silica Standard (millions of 2009 dollars)

NAICS	Industry	Total	Drywall finishers	Earth drillers	Operators of tractors and other heavy construction vehicles and equipment	Grinders and tuckpointers using hand-held tools	Hole drillers using hand-held drills	Impact drillers	Millers using portable or mobile machines	Masonry cutters using portable saws	Masonry cutting using stationary saws	Rock-crushing machine operators and tenders	Under-ground construc-tion workers
236100	Residential Building Construction	**$14.6**	$0.1	$0.0	$1.3	$1.9	$4.9	$5.2	$0.6	$0.6	$0.2	$0.0	$0.0
236200	Nonresidential Building Construction	**$16.6**	$0.0	$0.0	$3.0	$3.3	$2.7	$5.3	$1.0	$1.1	$0.3	$0.0	$0.0
237100	Utility System Construction	**$30.9**	$0.0	$15.5	$10.2	$0.6	$0.1	$4.1	$0.3	$0.1	$0.0	$0.1	$0.0
237200	Land Subdivision	**$0.7**	$0.0	$0.0	$0.4	$0.0	$0.0	$0.2	$0.0	$0.0	$0.0	$0.0	$0.0
237300	Highway, Street, and Bridge Construction	**$16.8**	$0.0	$0.3	$9.0	$1.7	$0.2	$3.7	$1.7	$0.0	$0.0	$0.1	$0.0
237900	Other Heavy and Civil Engineering Construction	**$4.2**	$0.0	$0.6	$2.4	$0.2	$0.1	$0.8	$0.1	$0.0	$0.0	$0.1	$0.0
238100	Foundation, Structure, and Building Exterior Contractors	**$66.5**	$0.0	$0.0	$2.0	$29.3	$2.5	$5.8	$5.8	$16.2	$4.9	$0.0	$0.0
238200	Building Equipment Contractors	**$3.2**	$0.0	$0.1	$1.3	$0.1	$0.1	$1.5	$0.0	$0.0	$0.0	$0.0	$0.0
238300	Building Finishing Contractors	**$9.8**	$1.4	$0.0	$0.0	$1.9	$2.3	$1.3	$0.2	$1.5	$0.4	$0.9	$0.0
238900	Other Specialty Trade Contractors	**$33.3**	$0.0	$4.8	$15.8	$4.2	$0.2	$4.9	$2.4	$0.6	$0.2	$0.0	$0.0
999000	State and Local Governments	**$11.4**	$0.0	$0.0	$7.0	$0.0	$0.1	$3.8	$0.3	$0.0	$0.0	$0.0	$0.0
	Totals	**$207.8**	**$1.4**	**$21.3**	**$52.5**	**$43.2**	**$13.2**	**$36.4**	**$12.4**	**$20.1**	**$6.1**	**$1.2**	**$0.0**

Source: U.S. Dept. of Labor, OSHA, Directorate of Evaluation and Analysis, Office of Regulatory Analysis, based on ERG, 2007.

SBREFA Panel Comments on Cost Methodology for Construction

One SBREFA commenter criticized the methodology discussed above for estimating engineering control costs on the grounds that while RSMeans data were used to establish the marginal costs of new controls (as a percentage of baseline costs), ERG used average wage rates (including fringe benefits) from the BLS *Occupational Employment Statistics Survey*, 2000, to calculate the value of at-risk tasks without providing a justification for not using RSMeans wage data. Since BLS wage rates are significantly lower than the RSMeans rates used by ERG in earlier parts of the analysis, the commenter argued that this would significantly lower the base to which the marginal cost factors are applied to estimate compliance costs.[30]

As described above, ERG used the RSMeans data only to develop costs for the representative jobs and then to determine the incremental compliance costs as a percentage of the total and the share (percentage) of project value accounted for by labor. Dividing project labor value by the labor share of project value yields an estimate of total project value. The absolute level of the RSMeans wage and equipment cost levels do not directly affect the resultant aggregate compliance costs. While lower wage rates would lower the baseline costs of the representative jobs, it does not follow that control costs as a percent of baseline costs would also be lower. In fact, if lower wage rates are combined with the same equipment costs, the equipment part of incremental control costs would be a *higher* percentage of total baseline costs. Only the labor share (percentage) of baseline costs and the incremental compliance costs as a percent of baseline costs are taken from the analysis of representative costs and used in the subsequent estimation of aggregate costs. The absolute levels of the wage rates and equipment costs taken from RSMeans do not directly enter the aggregate cost analysis.

This SBREFA commenter further argued that the RSMeans data are likely to be on the high end of estimated wages because they only cover unionized labor and are therefore likely to lead to high estimates of impacts. The commenter then recommended that more appropriate indexed labor wage costs be computed and used consistently throughout the analysis.[31] In response, OSHA notes, to restate a point made above, that ERG used the RSMeans data only to estimate the percentage of the value of projects covered by the standard attributable to labor ("the labor share") and compliance costs as a percentage of total baseline costs. The BLS wage data, on which the aggregate compliance costs are based, are obtained from a statistically valid, national survey of employment and compensation levels and are the best available data characterizing national averages of wages by detailed occupation.

Another SBREFA commenter criticized ERG's cost estimation methodology, arguing that fundamental errors resulted in serious underestimates of the costs of engineering controls. The commenter asserted that ERG's task-by-task incremental cost estimates shown in Table V-23 should be multiplied by two factors: "the ratio of the RSMeans labor rate to the BLS wage and benefits rate" and the inverse of the "percentage in key occupations working on task" from Table V-26. Under this approach, the commenter argued that "the cost of PEL controls for brickmasons, blockmasons, cement masons and concrete finishers performing grinding and

[30] Reform OSHA Coalition (ROC, 2003), p. 13.

[31] Reform OSHA Coalition (ROC, 2003), p. 14.

tuckpointing would be approximately seventy-two (72.0) times the ERG estimate, and . . . the cost of PEL controls for drywall finishing (at the 50 µg/m3 PEL) would be approximately 7.2 times the ERG estimate."[32]

The rationalization for these calculations was not provided, and OSHA finds no merit in these conclusions. The incremental control costs shown in Table V-23 are based on RSMeans data for labor and equipment costs. As shown in Table V-23, these cost estimates, after adjustments for productivity impacts, are used to calculate the percentage increase in baseline costs associated with each control. The RSMeans-based cost estimates shown in Table V-23 are also used to estimate the share of total baseline task/project costs accounted for by labor requirements. The averages of the percentage increase due to incremental control costs and the labor share (percentage) of total baseline costs are shown in Table V-26. ERG used these two percentages to extrapolate the aggregate control costs associated with each task. This extrapolation was based on (1) the full-time-equivalent employment in key and secondary occupations associated with each task, and (2) the value of the labor time as measured by the BLS occupational wage statistics, adjusted for fringe benefits.

This commenter further argued that ERG's analysis contained five more "fundamental errors."[33] First, the commenter asserted that the ERG calculations understate the actual cost because they are based on 1999 or 2000 data from RSMeans rather than RSMeans 2003 data. In response, OSHA notes that the RSMeans data do not directly determine the absolute level of aggregate compliance costs, but rather the labor share (percentage) of project costs and incremental compliance costs as a percentage of baseline costs. Therefore, OSHA would expect that compliance costs would only be minimally affected by the year from which the RSMeans data were drawn. Furthermore, ERG has since updated its analysis (ERG, 2011) to incorporate 2009 RSMeans data (RSMeans, 2008).

Second, the commenter asserted that there is no information to "suggest much less substantiate the premise that the exposure monitoring data in Tables 3-1 and 3-2 [in the ERG (2007a) report] (even if they were properly collected and analyzed) are in any way representative of current workplace exposures across the country." In response, OSHA points out that the profiles used to estimate the numbers of workers exposed in excess of each PEL option are, in fact, based on the extensively documented technological feasibility analysis presented in Chapter IV of this PEA (and based on ERG, 2007a). Also, because many of the data points in the profiles are taken from the findings of OSHA inspections (which tend to over-represent cases of overexposure), OSHA believes that its exposure profiles in the technological feasibility analysis are likely to be conservative (i.e., they probably overestimate the number of workers exposed at higher levels).

Third, the commenter claimed that there is "is no information to suggest much less substantiate the premise that the exposure monitoring data in Tables 3-1 and 3-2 (even if they were representative of current workplace exposures) are in any way representative of the non-existent, theoretical jobs artificially created by the FTE [full-time equivalent] analysis so as to justify their use as the foundation for Table 4-12." However, OSHA notes that ERG designed the

[32] Mason Contractors Association of America, p. 34.

[33] Mason Contractors Association of America, p. 34.

representative jobs on which the cost analysis is based to correspond directly to the tasks assessed in the technological feasibility analysis. Furthermore, Table 4-12 in ERG (2007a) is derived directly from Table 3-2 and is independent of the "FTE analysis."

Fourth, the commenter argued that a more logical and appropriate methodology would assume that all FTEs were exposed above the PEL in the absence of controls and that they (the commenter) could find "no justification, and substantial support to the contrary, for an approach that artificially condenses actual exposures into far more highly concentrated exposures (by condensing all at-risk task hours into FTEs) and then [assumes] that, despite the impact of this change, the grab bag of exposure monitoring described in ERG Tables 3-1, 3-2 and 4-12 represents these FTEs." The commenter asserted that the effect in ERG (2007a) of "first multiplying total project costs by the FTE percentage (from Table 4-8) and then by the 'Percentage of Workers Requiring Controls' from Table 4-12 (and then by the average 'Total Incremental Costs as % of Baseline Costs' by job category from Table 4-7) results in an unjustified double discounting of exposed workers in the incremental cost calculation."

However, OSHA notes that ERG (2007a) used the exposure profiles from Section 3 to estimate the number of full-time equivalent workers that are exposed above the PEL. In other words, this exposure profile is applicable if all exposed workers worked full time only at the specified silica-generating tasks. In ERG's analysis, the *actual* number exposed above the PEL is represented by the *adjusted* FTE numbers (see Table 4-22 in ERG, 2007a). The adjusted FTE estimate takes into account that most workers, irrespective of occupation, spend some time working on jobs where no silica contamination is present. For the control cost analysis, however, it matters only how many worker-days there are in which exposures are above the PEL; for these worker-days, controls are required. The control costs (as opposed to some program costs) are independent of the number of workers associated with these worker-days. The thrust of the comment about "double discounting" is unclear. Nothing is "discounted" in ERG's estimation of aggregate control costs.

Finally, the SBREFA commenter argued that the "application of the FTE analysis to the additional equipment costs is based on the wholly unfounded assumption, contrary to actual experience, that this additional equipment could be used with perfect efficiency (i.e., never idle) so that it is only at a particular site during the time the at-risk tasks are being performed." In response, OSHA notes that ERG's analysis does in fact assume some efficiency with respect to the use of additional equipment required for controls. However, many of the equipment costs are based on monthly equipment rental rates provided by RSMeans which already embody some degree of idleness over the course of a year (see ERG, 2007a, Table 4-3). In other cases, ERG directly estimated daily equipment costs based on equipment purchase costs, annualization factors, and assumed operating and maintenance costs (see, for example, Table 4-3, "cab enclosures"). ERG originally translated these to daily costs on the assumption of full-time usage (240 days per year). However, in response to this comment, ERG adjusted this rate downward, assuming instead that equipment would be used 150 days per year (30 weeks), on average; OSHA applied this downward adjustment to equipment usage in this PEA and the effect of this change in equipment usage was to increase the daily cost of some control equipment.

OSHA solicits comment on its responses to all these issues raised during the SBREFA Panel process.

Respirator Costs

For costing purposes, employers in the construction sector whose workers receive exposures above the PEL are assumed to adopt the appropriate task-specific engineering controls and, where required, respirators prescribed in Table 1 and paragraph (g)(1) in the proposed standard. Thus, with Table 1 and paragraph (g)(1) as a backdrop, ERG first identified the respirators for each of the tasks evaluated in the engineering cost analysis. Where respirators varied among control methods for a given task, ERG used the respirator type associated with the most commonly used control method. The respirator specifications are shown in Table V-34. Respirator costs by task are weighted by usage of 4 hours or less for 50 percent of workers and more than 4 hours for 50 percent of workers.[34] The table also shows, for each respirator type, annualized unit costs as derived in an earlier respirator study for OSHA (ERG, 2003). The annualized cost per worker is estimated at $570 per year (in 2009 dollars) to use a half-mask nonpowered air-purifying respirator and at $638 per year (in 2009 dollars) to use a full-face nonpowered air-purifying respirator. These unit costs reflect the annualized cost of respirator use, including accessories (e.g., filters), training, fit testing, and cleaning. OSHA notes that respirator costs—and, in particular, filter costs—may have declined appreciably since they were originally estimated for use in this PEA. The Agency has therefore, in its sensitivity analysis presented in Chapter VII of this PEA, included an analysis of the effects on annualized costs and net benefits of a 40 percent reduction in the cost of respirator filters.[35] OSHA also invites comments on the costs of filters and the annualized cost of respirators suitable for regular use in a construction environment where respirable crystalline silica is present at levels above the proposed PEL of 50 μg/m^3.

Using these annualized unit respirator costs, Table V-35 shows that the estimated costs of

[34] Note that for tasks in Table 1 involving more than 4 hours of silica exposure, respirators are required to be worn during the entire task, not just after 4 hours.

[35] OSHA's respirator costs are based on estimates of the annual costs of respirator use derived in an earlier study (OSHA, 2003). These costs include not only the purchase cost of the respirator itself, but the ancillary costs of accessories (e.g., filters) and other costs associated with respirator cleaning and required training and fit testing. The 2003 estimates were based a unit cost of $3.57 for a replacement pair of filters for half-mask and full-face negative-pressure air-purifying respirators. These were extrapolated to an annual cost of $285.52 per year, assuming that the filters would be changed 80 times a year, or roughly every 3 days. These filter costs accounted for 61% and 51% of the total annualized respirator costs estimates for half-mask and full-face respirators, respectively.

In the silica cost analysis, respirator costs from the 2003 study were used, but inflated from 2003 to 2009 dollars using the implicit price deflator for this period, or 16.7%. This resulted in an annual filter cost estimate of $333.07. Current research, however, shows that filter prices have not, in fact, increased over this period, and might well have declined, at least for the N95 particulate filters used for silica protection. A sample of 21 filter prices obtained from various Internet vendors shows a median value slightly less than comparable price used in the 2003 estimates. This sample also showed significant variation in price for comparable N95 particulate filters, depending on the manufacturer and vendor. While the performance characteristics of different filters are not known, it is clear that filters meeting the N95 standard are available at a cost significantly less than the median price found in this sample. When ranked by price, the 25th percentile price was calculated at $2.50 per pair. If filters at this price were changed out 80 times a year, the resultant cost would be $200.05, or 60.1% of the inflated filter price used in the silica cost analysis. It is on this basis that a 40 percent reduction in filter prices was used to conduct the sensitivity analysis in Chapter VII.

respirator use in construction are $80.8 million annually.[36] These costs have been adjusted to take into account OSHA's estimate—consistent with the findings from the NIOSH Respiratory Survey (NIOSH, 2003)—that 56 percent of employees in the construction industry whose exposures are high enough that they would need respirators under the proposed silica rule are already using respirators that would bring them into compliance.[37] OSHA's derivation of the 56 percent current compliance rate in construction, in the context of the proposed silica rule, is a bit complicated, and the eight-step process is described in the footnote below.[38] OSHA requests comment on its estimate of 56 percent current respirator compliance with the proposed silica rule by affected employees in construction and on the methodology the Agency used to derive this estimate. In particular, OSHA invites comment on whether an alternative methodology to estimate current compliance—i.e., a methodology that does not depend on the number of respirators required by the proposed rule—might be preferred.[39]

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[36] Note that these respirator costs do not include the costs of disposable respirators used in regulated areas or as part of an access control plan. The costs for these disposable respirators are separately estimated in Table V-45 in this chapter as part of the costs of a regulated area or an access control plan.

[37] OSHA notes that the NIOSH Respirator Survey (NIOSH, 2003) reported required use of respirators during the prior 12 months, but did not specify how frequently they were used. Therefore, OSHA's estimate of 56 percent current compliance may overstate the regular use of respirators that would be needed under the proposed rule.

[38] The eight steps, which relate to the 2001 NIOSH Respirator Survey published in 2003 (NIOSH, 2003), are as follows:

1. According to the 2001 NIOSH Respirator Survey, 64,200 construction establishments, or 9.6%, required the use of respirators in the previous 12 months (Text Table 3, page 4). This implies a total of 668,750 (64,200/.096) construction establishments in 2001.

2. In 2006 (the base year for the silica estimates in OSHA's silica proposal), there were 802,349 construction establishments (Silica Draft PEA, Chapter III: Industry Profile, page III-9, Table III-2; from Bureau of the Census, 2006 construction establishments), or 1.2 times as many as when the NIOSH Respirator Survey was performed (802,349/668,750).

3. A total of 60,012 construction establishments and 566,909 construction employees use air-purifying respirators (NIOSH Respirator Survey, Table 8, page 28).

4. A total of 15,263 construction establishments (NIOSH Respirator Survey, Table 65, page 151) use air purifying respirators for silica (25.4% of the total 60,012 construction establishments using air-purifying respirators).

5. Accordingly, OSHA concludes that 144,183 employees use these respirators for silica (25.4% x 566,909).

6. If inflated by the growth in the construction industry, this implies that 172,988 employees would have been using respirators for silica protection in 2006 (144,183 x 1.20).

7. The proposed silica rule requires an estimated 308,513 private sector employees (314,777 Total – 6,264 for State and Local Governments) to use respirators.

8. Thus, the current percentage of private sector employees in construction using air-purifying respirators is estimated to be approximately 56% (172,988/308,513= 56.07%).

[39] For example, for the alternative PEL of 100 $\mu g/m^3$, using the same methodology, OSHA estimated that,

Table V-35 also shows, by task and NAICS industry, the aggregate respirator costs for those workers requiring respirators, as prescribed in Table 1, to comply with the proposed 50 μg/m^3 PEL. These costs are most highly concentrated in grinding and tuckpointing due to two factors: (1) many workers in that task group are believed to be exposed above the proposed PEL and (2) Table 1 specifies that tuckpointers must wear full-face respirators. Table 1 does not specify respirators for some workers, such as drywall finishers, heavy equipment operators, hole drillers, tunnel workers, and, depending upon the PEL, some other categories of workers. For these workers, Table V-35 shows zero costs.

In addition to bearing the costs associated with the provision of respirators, employers will incur a cost burden to establish a respirator program. OSHA projects that this expense will involve an initial 8 hours of a supervisor's time for establishments with 500 or more employees and 4 hours for all other firms. After the first year, OSHA estimates that 20 percent would revise the program every year, with the largest establishments (500 or more employees) expending 4 hours for program revision, and all other employers expending two hours for program revision. OSHA estimates that 56 percent of construction firms currently have a respirator program.[40] Table V-36 presents, by NAICS industry, total annual costs for the respirator program and, combined with annual costs for respirator use, total annual costs—of $84.0 million—for respiratory protection in construction.

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based on current respirator use by affected employees in construction relative to the number of respirators required to meet the PEL of 100 μg/m^3, approximately a 97 percent current compliance rate.

[40] Even though NIOSH (2003) estimated from its survey that 9.6 percent of all construction establishments require use of respirators, OSHA has judged that 56 percent is a more plausible estimate for those establishments with elevated silica exposures that would be affected by this proposed rule. OSHA welcomes comment and data on this estimate.

Table V-34: Parameters and Unit Costs Applied in OSHA's Preliminary Analysis of Costs for Respirators in Construction (PEL=50; 2009 dollars)

Respirator Selection by Task	Control/ Use Shares	Respirators Requirement (from Table 1 in the Proposed Standard) ≤ 4 hrs	>4 hrs	Type of Control	Weighted Respirator Cost ≤ 4 hrs	>4 hrs	Average Cost by Task ≤ 4 hrs	>4 hrs	Overall Weighted Average Cost
Drywall finishers	100.0%	None	None		$0.00	$0.00	$0.00	$0.00	$0.00
Earth drillers	90.0%	None	Half-mask		$0.00	$513.11	$0.00	$513.11	$384.84
	10.0%	None	None	Operator only in cab	$0.00	$0.00			
Grinders and tuckpointers using hand-held tools							$419.43	$590.47	$547.71
Hand-held grinders	30.0%	None	Half-mask	Wet methods	$0.00	$171.04			
	30.0%	Half-mask	Half-mask	Dust collection	$171.04	$171.04			
Hand-held milling machines	5.0%	Half-mask	Half-mask	Wet methods	$28.51	$28.51			
	5.0%	Half-mask	Half-mask	Dust collection	$28.51	$28.51			
Tuckpointing	30.0%	Full face NAP [a]	Full face NAP [a]	Dust collection	$191.38	$191.38			
Operators of tractors and other heavy construction vehicles and equipment	100.0%	None	None		$0.00	$0.00	$0.00	$0.00	$0.00
Hole drillers using hand-held drills	100.0%	None	None		$0.00	$0.00	$0.00	$0.00	$0.00
Impact drillers	90.0%	None	Half-mask	Wet methods	$0.00	$513.11	$57.01	$570.13	$441.85
	10.0%	Half-mask	Half-mask	Dust collection	$57.01	$57.01			
Masonry cutters using portable saws							$171.04	$342.08	$299.32
Hand held	30.0%	None	Half-mask	Wet methods	$0.00	$171.04			
	30.0%	Half-mask	Half-mask	Dust collection	$171.04	$171.04			
Walk-behind	40.0%	None	None	Wet methods	$0.00	$0.00			
Masonry cutting using stationary saws	75.0%	None	Half-mask	Wet methods	$0.00	$427.60	$0.00	$570.13	$427.60
	25.0%	None	Half-mask	Ventilated enclosure	$0.00	$142.53			
Millers using portable or mobile machines	25.0%	None	None	Wet methods - asphalt	$0.00	$0.00	$0.00	$427.60	$320.70
	75.0%	None	Half-mask	Wet methods - concrete	$0.00	$427.60			
Rock-crushing machine operators and tenders	75.0%	Half-mask	Full facepiece	Wet methods or dust suppressants	$427.60	$478.45	$570.13	$620.98	$608.27
	25.0%	Half-mask	Half-mask	LEV	$142.53	$142.53			
Underground construction workers	100.0%	None	None		$0.00	$0.00	$0.00	$0.00	$0.00

Table V-34: Parameters and Unit Costs Applied in OSHA's Preliminary Analysis of Costs for Respirators in Construction (PEL=50; 2009 dollars) (continued)

Parameters	
Half-mask - annual cost [b]	$570.13
Full-face - annual cost [b]	$637.94
No respirator	$0.00
Percentage of workers 4 hours or less at task	50.00%
Compliance Rate [c]	56%

[a] "Full face NAP" stands for "full-faced nonpowered air-purifying respirator."
[b] Based on annualized costs for a half-mask or full-faced nonpowered air-purifying respirator, including accessories, training, fit testing, and cleaning. See ERG (2003). Costs inflated based on the 2003-2009 GDP implicit price deflator as reported by the Bureau of Economic Analysis.
[c] Based on findings from NIOSH Respirator Survey (2003).
Source: U.S. Dept. of Labor, OSHA, Directorate of Evaluation and Analysis, Office of Regulatory Analysis, based on ERG (2007a).

Table V-35: Total Costs for Respirator Use in Construction Industries under the Proposed Silica Standard (2009 dollars)

NAICS/ Industry	Total	Drywall finishers	Earth drillers	Operators of tractors and other heavy construc-tion vehicles and equipment	Grinders and tuck-pointers using hand-held tools	Hole drillers using hand-held drills	Impact drillers	Millers using portable or mobile machines	Masonry cutters using portable saws	Masonry cutting using stationary saws	Rock-crushing machine operators and tenders	Under-ground construc-tion workers
236100 - Residential Building Construction	**$2,252,523**	$0	$0	$0	$770,401	$0	$1,064,955	$103,369	$243,406	$70,393	$0	$0
236200 - Nonresidential Building Construction	**$7,074,102**	$0	$0	$0	$3,002,232	$0	$2,398,907	$371,011	$1,009,891	$292,061	$0	$0
237100 - Utility System Construction	**$2,708,363**	$0	$1,422,075	$0	$249,893	$0	$896,768	$55,681	$26,745	$7,735	$0	$0
237200 - Land Subdivision	**$57,109**	$0	$0	$0	$16,359	$0	$37,185	$3,565	$0	$0	$0	$0
237300 - Highway, Street, and Bridge Construction	**$2,566,514**	$0	$33,384	$0	$928,119	$0	$1,041,473	$396,660	$3,557	$1,029	$0	$0
237900 - Other Heavy and Civil Engineering Construction	**$414,898**	$0	$65,694	$0	$81,316	$0	$184,978	$17,266	$8,662	$2,505	$0	$0
238100 - Foundation, Structure, and Building Exterior Contractors	**$57,151,594**	$0	$0	$0	$29,442,036	$0	$2,869,751	$2,363,201	$17,349,522	$5,017,491	$0	$0
238200 - Building Equipment Contractors	**$352,058**	$0	$7,327	$0	$22,517	$0	$296,177	$858	$19,531	$5,648	$0	$0

Table V-35: Total Costs for Respirator Use in Construction Industries under the Proposed Silica Standard (2009 dollars) (continued)

NAICS/ Industry	Total	Drywall finishers	Earth drillers	Operators of tractors and other heavy construction vehicles and equipment	Grinders and tuck-pointers using hand-held tools	Hole drillers using hand-held drills	Impact drillers	Millers using portable or mobile machines	Masonry cutters using portable saws	Masonry cutting using stationary saws	Rock-crushing machine operators and tenders	Underground construction workers
238300 - Building Finishing Contractors	**$2,759,662**	$0	$0	$0	$796,243	$0	$276,724	$34,170	$698,268	$201,939	$752,318	$0
238900 - Other Specialty Trade Contractors	**$3,882,009**	$0	$392,877	$0	$1,699,313	$0	$1,012,597	$395,055	$262,434	$75,896	$43,837	$0
999000 - State and Local Governments	**$1,574,648**	$0	$4,103	$0	$71,339	$0	$1,267,270	$139,413	$24,164	$6,988	$61,372	$0
Total	$80,793,481	$0	$1,925,460	$0	$37,079,767	$0	$11,346,783	$3,880,249	$19,646,180	$5,681,686	$1,233,357	$0

Source: U.S. Dept. of Labor, OSHA, Directorate of Evaluation and Analysis, Office of Regulatory Analysis, based on ERG (2007a and 2011).

Table V-36: Total Costs for the Provision of Respiratory Protection in Construction, as Required under the Proposed Silica Standard (2009 dollars)

NAICS	Industry	Respirator Costs	Respirator Program Costs	Total Costs
236100	Residential Building Construction	$2,252,523	$103,983	$2,356,507
236200	Nonresidential Building Construction	$7,074,102	$265,292	$7,339,394
237100	Utility System Construction	$2,708,363	$100,206	$2,808,570
237200	Land Subdivision	$57,109	$2,497	$59,606
237300	Highway, Street, and Bridge Construction	$2,566,514	$88,301	$2,654,815
237900	Other Heavy and Civil Engineering Construction	$414,898	$15,229	$430,127
238100	Foundation, Structure, and Building Exterior Contractors	$57,151,594	$2,276,284	$59,427,878
238200	Building Equipment Contractors	$352,058	$14,252	$366,310
238300	Building Finishing Contractors	$2,759,662	$115,257	$2,874,918
238900	Other Specialty Trade Contractors	$3,882,009	$162,670	$4,044,680
999000	State and Local Governments	$1,574,648	$67,064	$1,641,712
	Totals	**$80,793,481**	**$3,211,036**	**$84,004,516**

Source: U.S. Dept. of Labor, OSHA, Directorate of Evaluation and Analysis, Office of Regulatory Analysis, based on ERG (2007a and 2011).

SBREFA Panel Comments on Respirator Costs

A SBREFA commenter questioned how ERG was able to determine the full-time-equivalent number of at-risk construction workers who are exposed above the PEL.[41] To restate ERG's methodology for calculating the number of at-risk workers, OSHA notes that ERG estimated aggregate respirator costs for *all* workers at risk above the proposed PEL, by task and industry (and also by the PEL option, to provide alternatives for analytical purposes[42]). The total number of at-risk workers is derived from estimates in Table 4-9 (full-time equivalent workers by occupation and task) and Table 4-22 in ERG (2007a).[43]

Another commenter asserted that ERG's respirator analysis was based on two incorrect assumptions: (1) a condensed group of FTEs wear a respirator full-time (rather than a larger pool of workers wearing respirators on an intermittent basis, a more realistic assumption in the mind of the commenter) and (2) the respirators are shared optimally from a cost-efficiency standpoint.[44] In response to these criticisms, OSHA emphasizes that, in fact, ERG based its estimates of compliance costs on respirators for *all* workers at risk above the proposed PEL, thereby not requiring respirator-sharing by workers who might not be engaged in the Table 1 tasks full-time.[45]

OSHA solicits comment on its responses to these issues raised during the SBREFA Panel process.

<u>Program Costs</u>

This section presents OSHA's estimated costs for ancillary silica control programs for the construction industry as required under the proposed rule. Based on the program requirements contained in the proposed standard, OSHA considered four potential cost elements: exposure assessments (air monitoring), medical surveillance, provision of information and training, and regulated areas.

For costing purposes, ERG judged that employers will comply with these program requirements by including all workers who are either currently exposed or are at all likely to be exposed to silica hazards during their work. Accordingly, ERG concluded that employers will include program elements for employees who perform dusty tasks, even if only sporadically. This broad inclusion of program elements for workers is projected to be less costly for employers than manipulating worker assignments so that only those with silica-related training and health screening would be allowed to perform certain dusty tasks. Instead, employers are expected to

[41] Reform OSHA Coalition, p. 18.

[42] See Table 4-28 in ERG (2007a).

[43] Total workers at risk above the PEL were referred to as "adjusted full-time-equivalent workers" or "adjusted workers at risk" in ERG (2007a). The following section in this chapter of the PEA provides further explanation of the derivation of the total number of workers at risk, as well as estimates in Table V-37 below.

[44] Mason Contractors Association of America, p. 29.

[45] This is explained in the note to Table 4-28 in ERG (2007a).

develop inclusive programs and retain the latitude to assign workers according to normal scheduling demands.

As shown in Table V-37, ERG identified the number of at-risk full-time-equivalent workers in construction by industry and then increased those estimates to include the share of workers who are likely to be exposed to respirable silica periodically, regardless of their degree of contact with dusty operations. As can be seen in Table V-37, there is some breadth to the distribution of silica-generating tasks among workers in all construction industries. The construction industries include a sufficiently diverse mix of occupations that many workers are likely to perform silica-generating tasks with some regularity. Further, employers will likely wish to define participation in silica programs inclusively so as to avoid limitations on possible worker assignments due to lack of worker readiness to perform silica-generating activities.

ERG classified the affected construction industries according to whether silica-generating tasks are distributed narrowly or widely among workers in the industry. For the industries where such activities are narrowly distributed among relatively specialized workers, ERG estimated that the number of workers requiring participation in silica control programs would be twice the full-time-equivalent number of workers profiled in the compliance cost calculations. For industries where silica-generating work is widely distributed, ERG increased the number of workers to be included in programs by a factor of 5 over number of the full-time-equivalent workers used in the earlier analysis of control costs.[46] Thus, ERG judged that large numbers of workers in certain occupations, such as brickmasons, sometimes will engage in dusty operations, such as grinding. Even though these dusty operations represent a small part of most construction jobs (and thus the full-time-equivalent number of workers incurring incremental compliance costs represent only a small share of the occupational or industry-based total number of workers), most workers will sometimes perform the dusty tasks. Similarly, a potentially large percentage of construction laborers in highway and street construction will sometimes perform impact drilling, even though these activities do not represent a large portion of all hours spent by construction laborers in this industry.

Given the frequent dustiness of the tasks producing silica exposure for the construction occupations recognized in the analysis (as shown in Table V-25 above), widespread participation in the silica program elements would appear to be necessary. As shown in Table V-37, these adjustments result in an estimate of approximately 1.8 million at-risk workers in construction. For three NAICS groups – 237100, Utility System Construction; 237300, Highway Street and Bridge Construction; and 237900, Other Heavy and Civil Engineering Construction – OSHA projects that all workers will be at risk of silica exposure.

[46] These multipliers of 2 and 5 applied to full-time-equivalent workers are subject to the constraint that the number of at-risk workers not exceed the number of workers in at-risk industries.

V-37: Estimated Number of Construction Employees Exposed to Silica (and thus Affected by OSHA's Proposed Standard)

NAICS	Industry	Total No. of Employees in At-Risk Industries	At-Risk FTE Employees	FTE Adjustment Factor	Total At-Risk Employees [a]
236100	Residential Building Construction	574,527	27,669	2	55,338
236200	Nonresidential Building Construction	394,565	34,788	5	173,939
237100	Utility System Construction	217,070	96,181	5	217,070
237200	Land Subdivision	13,076	3,255	2	6,511
237300	Highway, Street, and Bridge Construction	204,899	66,916	5	204,899
237900	Other Heavy and Civil Engineering Construction	46,813	18,835	5	46,813
238100	Foundation, Structure, and Building Exterior Contractors	643,349	111,946	5	559,729
238200	Building Equipment Contractors	128,499	10,179	2	20,358
238300	Building Finishing Contractors	405,094	60,006	2	120,012
238900	Other Specialty Trade Contractors	326,852	137,219	2	274,439
999000	State and Local Governments	300,770	85,034	2	170,068
	Total	**3,255,514**	**652,029**		**1,849,175**

[a] The total number of at-risk employees in each construction industry was constrained so as not to exceed the number of employees in that at-risk industry.

Source: U.S. Dept. of Labor, OSHA, Directorate of Evaluation and Analysis, Office of Regulatory Analysis, based on ERG (2007a and 2011).

Exposure Assessment Costs

Paragraph (d)(8)(1) of the proposed rule for the construction industry specifies that, where employees perform operations listed in Table 1 and where the engineering controls, work practices, and respiratory protection specified in Table 1 for that operation have been implemented, the employer is not required to assess the exposure of employees performing such operations. OSHA anticipates that many employers, aware that their operations currently expose their workers to silica levels above the PEL, will simply choose to comply with Table 1 and avoid the costs of conducting exposure assessments. However, for purposes of estimating costs, OSHA has taken a more conservative approach and assumed that all employers in at-risk construction activities will conduct initial exposure assessments and additional exposure monitoring as needed.

In particular, consistent with ERG (2007a), OSHA, in estimating the costs of the exposure assessment requirements in the proposed rule, assumed the following:

(1) Employers will perform initial exposure assessments of workers who perform dusty tasks;

(2) For workers found to be exposed below the action level, no further action is necessary.

(3) For workers found to be over the PEL, the employer will choose to comply with Table 1. Because the employer would then be in compliance with Table 1 requirements, there would be no further monitoring requirements.

(4) For workers exposed at or above the action level, but below the PEL, periodic monitoring will be performed (as required by paragraphs (d)(3) and (d)(4) in the proposed rule).

Table V-9, presented in the discussion of exposure assessment costs for general industry and maritime, also displays the parameters, unit costs, and other assumptions employed by OSHA to estimate exposure assessment costs for construction. The costing methodology and unit costs are identical to the earlier estimates for general industry and maritime with the exception that construction industry wages are used to calculate productivity losses and recordkeeping costs.

OSHA again assumed that most establishments wishing to perform exposure monitoring will require the assistance of an outside consulting industrial hygienist (IH) to obtain accurate results. While some firms might already employ or train qualified staff, ERG judged that the testing protocols are fairly challenging and that few firms have competent staff to obviate the need for outside consultants.

The OSH Act provides for the right of an employee-designated representative to observe exposure monitoring and measuring procedures. OSHA is not aware of any published studies presenting data on the frequency by which this right is exercised. OSHA believes that in some cases union officials are given the opportunity to observe monitoring at no direct cost to the employer. For these reasons, ERG included no additional cost for this provision.

The proposed standard does not require that each worker be monitored, and ERG (2007a) estimated that the exposure assessment requirement would be satisfied through testing, on average, of one in every four workers. This level was judged sufficient to characterize exposures among at-risk workers across the range of activities likely to be undertaken. Therefore, OSHA, based on ERG (2007a), estimated in its cost model that there are four workers per work area and, furthermore, interpreted the initial exposure assessment as requiring first-year testing of at least one worker in each distinct job classification and work area who is, or may reasonably be expected to be, exposed to airborne concentrations of respirable crystalline silica at or above the action level. The four workers in each work area who would be subject to exposure assessment consist of a combination of key and secondary occupations described above in Table V-26 and the surrounding text. The exact combination of key and secondary occupation categories will vary by task.

For periodic monitoring, the proposed standard provides employers an option of assessing employee exposures either under a fixed schedule (paragraph (d)(3)(i)) or a performance–based schedule (paragraph (d)(3)(ii)). Under the fixed schedule, the proposed standard requires semi-annual periodic sampling for exposures above the action level and quarterly sampling exposures above the PEL. Monitoring must be continued until the employer can demonstrate that exposures are no longer at or above the action level. OSHA used the fixed schedule option under the frequency of monitoring requirements to estimate, for costing purposes, that exposure monitoring will be conducted twice a year where initial or subsequent exposure monitoring reveals that employee exposures are at or above the action level but at or below the PEL.[47] For exposures above the PEL, OSHA judged that all employers in construction would choose to comply with Table 1 and therefore would not have to conduct periodic exposure monitoring.

As required by paragraph (d)(4) of the proposed rule, whenever there is a change in the production, process, control equipment, personnel, or work practices that may result in new or additional exposures at or above the action level or when the employer has any reason to suspect that a change may result in new or additional exposures at or above the action level, the employer must conduct additional monitoring. Based on ERG (2007a), OSHA estimated that approximately 15 percent of workers whose initial exposure or subsequent monitoring was at or above the action level would undertake additional monitoring.

As in general industry and maritime, ERG (2011) estimated the cost per exposure monitoring sample in construction is projected to range from $195.88 to $383.38 (depending on establishment size). Other costs per exposure monitoring sample stem from the estimated 30-minute loss in employee time while attaching and unattaching the pump and the 15 minutes required for recordkeeping (recording the sampling results and notifying the employee of the sampling results). Overall, OSHA estimates that unit costs in construction will range from approximately $227.98 to $415.48 per sample.

Although OSHA believes that some establishments in construction currently conduct exposure monitoring, the Agency has no evidence to support this belief. Therefore for costing purposes

[47] OSHA anticipates that the performance-based schedule option would generally be less expensive than the fixed schedule option for employers that choose the performance-based option; otherwise they wouldn't have chosen it.

for the proposed silica rule, OSHA has assumed no current compliance with the proposed exposure monitoring requirements. OSHA requests information from interested parties on current levels of exposure monitoring.

The aggregate annual cost estimates, by construction industry, for exposure monitoring requirements under the proposed rule are presented in Table V-38. As shown, costs for exposure monitoring in construction total $44.6 million annually.

Table V-38: Estimated Annualized Costs for Exposure Assessment in Construction for OSHA's Proposed Silica Standard (all establishments)

NAICS	Industry	No. of At-Risk Workers (AL=25)	Initial Assessment	Periodic Assessment	Total Assessment Costs
236100	Residential Building Construction	32,260	$396,823	$1,552,863	**$1,949,685**
236200	Nonresidential Building Construction	83,003	$855,678	$3,298,221	**$4,153,899**
237100	Utility System Construction	76,687	$746,336	$3,712,564	**$4,458,900**
237200	Land Subdivision	1,745	$20,337	$107,846	**$128,183**
237300	Highway, Street, and Bridge Construction	58,441	$561,759	$2,976,386	**$3,538,146**
237900	Other Heavy and Civil Engineering Construction	12,904	$130,579	$694,668	**$825,247**
238100	Foundation, Structure, and Building Exterior Contractors	396,582	$4,344,489	$13,000,639	**$17,345,127**
238200	Building Equipment Contractors	6,752	$74,147	$320,123	**$394,270**
238300	Building Finishing Contractors	49,202	$559,017	$2,064,746	**$2,623,763**
238900	Other Specialty Trade Contractors	87,267	$999,421	$4,879,176	**$5,878,597**
999000	State and Local Governments [c]	45,847	$525,062	$2,732,070	**$3,257,131**
	Total - Construction	**850,690**	**$9,213,648**	**$35,339,300**	**$44,552,948**

Source: U.S. Dept. of Labor, OSHA, Directorate of Evaluation and Analysis, Office of Regulatory Analysis, based on ERG (2007a and 2011).

SBREFA Panel Comments on Exposure Assessment Costs

A SBREFA commenter asserted that ERG's calculation of compliance costs related to exposure assessments was "plagued by a number of inappropriate assumptions and omissions." In support, the commenter gave the example that ERG's methodology of computing a unit cost per tested sample and applying that cost to a calculated pool of at-risk workers, using an assumption of one test per four workers, is "at odds with OSHA's own recommendations requiring more tests."[48] In response to this comment, OSHA notes that the proposed standard, at paragraph (d)(1)(iii), permits *representative* sampling of employees who are or may be exposed to respirable crystalline silica at or above the action level. Specifically, proposed paragraph (d)(1)(iii) requires:

> 8-hour TWA employee exposures [to be determined] on the basis of *one or more samples that reflect the full-shift exposures on each shift, for each job classification, in each work area*. Where several employees perform the same job tasks on the same shift and in the same work area, the employer may sample a representative fraction of the employees in order to meet this requirement. In representative sampling, the employer shall sample the employee(s) who are expected to have the highest exposure to respirable crystalline silica. (emphasis added)

Consistent with the language in the proposed standard, ERG estimated that one out of every four workers would be sampled.

The commenter also argued that ERG failed to identify several costs, including the cost of the cartridge needed to take the sample, the costs of blanks, and the cost of analyzing bulk samples.[49] However, OSHA notes that the cost per sample ($133.38) used by ERG includes the relevant testing supplies such as the cartridge and blanks. No costs were included for bulk sampling, but such a procedure would not be required on a regular basis anyway, and therefore OSHA believes that ERG's methodology was appropriate.

The commenter stated that the draft standard lacked clarity on the schedule for exposure assessment and criticized ERG's assumption "through its exposed labor force analysis that employees get tested once during initial assessment and at least semi-annually thereafter (Option 1)."[50] In response, OSHA believes that the draft standard was in fact clear in stating that Option 1 required semi-annual periodic sampling for the 75 $\mu g/m^3$ and 100 $\mu g/m^3$ PEL options and quarterly sampling for the 50 $\mu g/m^3$ PEL option (see paragraph (f)(3) in the draft standard, Docket H006A, Ex. 3-2). In the current proposal, employers not in compliance with Table 1 would only need to conduct semi-annual periodic sampling for exposures between the proposed action level of 25 $\mu g/m^3$ and the proposed PEL of 50 $\mu g/m^3$.

The commenter further stated that ERG had significantly underestimated the amount of professional time required for any single sample, arguing instead that it would take as much as

[48] Reform OSHA Coalition, (2003) p. 14.

[49] Reform OSHA Coalition, (2003) p. 16.

[50] Reform OSHA Coalition, (2003) p. 18.

ten hours to collect a single sample at a job site.[51] ERG originally specified one hour of professional time per sample based the assumption that a typical job site would be large enough for a fully occupied industrial hygiene technician to collect eight samples during an 8-hour work shift. ERG (2011) later revised this figure to two samples during an 8-hour work shift for small (1-19 employee) establishments and six samples during an 8-hour work shift for medium-sized (20-499 employee) establishments, while retaining eight samples during an 8-hour work shift for large (500+ employee) establishments.

OSHA solicits comment on its responses to all these issues raised during the SBREFA Panel process.

Medical Surveillance Costs

Paragraph (h) of the proposed standard requires an initial health screening and then triennial periodic screenings for workers exposed above the proposed PEL of 50 $\mu g/m^3$ for 30 days or more per year.[52] ERG (2011) assembled information on representative unit costs of initial and periodic medical surveillance. Separate costs were estimated for current employees and for new hires as a function of the employment size (i.e., 1-19, 20-499, or 500+) of affected establishments. Table V-39 presents ERG's unit cost data and modeling assumptions used by OSHA to estimate medical surveillance costs.

OSHA's analysis of costs for medical surveillance in construction is, with the exception of certain unit costs and a few baseline assumptions, virtually identical to its methodology for modeling medical surveillance costs for general industry and maritime. The latter analysis was presented earlier in this chapter.

In accordance with paragraph (h)(2) of the proposed rule, the initial (baseline) medical examination would consist of (1) a medical and work history, (2) a physical examination with special emphasis on the respiratory system, (3) a chest x-ray that meets certain standards of the International Labour Organization, (4) a pulmonary function test that meets certain criteria and is administered by a NIOSH-certified spirometry technician, (5) testing for latent TB infection, and (6) any other tests deemed appropriate by the physician or PLHCP.

As shown in Table V-39, the estimated unit cost of the initial health screening for current employees in construction ranges from approximately $389.38 to $424.94 and includes direct medical costs, the opportunity cost of worker time (evaluated at the worker's 2009 hourly wage, including fringe benefits) for offsite travel and for the initial health screening itself, and recordkeeping costs. The variation in the unit cost of the initial health screening is due entirely to differences in the percentage of workers expected to travel offsite for the health screening. In OSHA's experience, the larger the establishment the more likely it is that the selected physician

[51] Reform OSHA Coalition, (2003) p. 9.

[52] As previously noted, approximately 46 percent of at-risk workers in construction are at or above the action level.

Table V-39: Unit Costs and Analytical Assumptions Applied in OSHA's Cost Model for Medical Surveillance in the Silica Construction Standard
(Coverage: All employees exposed above PEL)

Screening Tool	Cost Parameter	Initial Screening	Periodic Screening	Comments/Assumptions
Direct Costs				
Complete occupational and health history survey	$33.33	Yes	Yes	Assumed one third of physical exam cost
Triennial review and updating of health history	$33.33	N/A	Yes	Assumed one third of physical exam cost
Physical examination by knowledgeable HCP [a]	$100.00	Yes	Yes	Evaluation and office consultation including detailed examination.
Chest X-ray	$79.61	Yes	Yes	Radiologic examination, chest; stereo, frontal. Costs include consultation and written report.
Chest X-ray classified by a NIOSH-certified B Reader	$39.19	Yes	Yes	Average of three estimates made by B Readers to ERG.
Pulmonary function test	$54.69	Yes	Yes	Spirometry, including graphic record, total and timed vital capacity, expiratory flow rate measurements(s), and/or maximal voluntary ventilation.
Examination by a pulmonary specialist [b]	$190.28	Yes	N/A	Office consultation and evaluation by a pulmonary specialist
Other necessary tests	$60.00	Yes	Yes	Assumed required by 10 percent of workers
Dermal TB Test [a]	$15.00			Assumed required by 20 percent of workers

Table V-39: Unit Costs and Analytical Assumptions Applied in OSHA's Cost Model for Medical Surveillance in the Silica Construction Standard

(Coverage: All employees exposed above PEL) (continued)

Time Requirements for Medical Examination	**Minutes**			
Complete occupational and health history survey and exam, including x-ray	120			Per survey and exam
Health history review and update	30			Per review
Physical exam and tests (without x-ray)	60			Per exam
Chest x-ray	30			Per x-ray
Reading of Dermal TB Test (return exam)	5			
Examination by a pulmonary specialist	60			
Recordkeeping (initial and periodic screenings)	15			Average per screening
Recordkeeping (referrals)	60			Includes time for referrals and notification of NIOSH of new silica-related disease cases
Percentage of employees seeing off-site physician by establishment size				
	Small (<20)	Medium (20-499)	Large (500+)	
-Initial examination	80.0%	25.0%	0.0%	
-New hires	90.0%	50.0%	10.0%	
Travel Time (minutes) – off-site location				
Initial Test	90			
Return for reading	90			
Separations rate (layoffs, quits, and retirements)	64.0%			2008 separations rate for construction industries. BLS, Job Openings and Labor Turnover Survey (JOLTS)
Share of new hires requiring initial health screening	40.0%			

Medical Exam or Other	Establishment Size	Comments/Assumptions

Table V-39: Unit Costs and Analytical Assumptions Applied in OSHA's Cost Model for Medical Surveillance in the Silica Construction Standard
(Coverage: All employees exposed above PEL) (continued)

Cost Variable				
	Small (<20)	Medium (20-499)	Large (500+)	
Initial screening:				
Medical costs	312.83	$312.83	$312.83	Including components specified above in "Direct Costs"
Lost work time - exam	$59.27	$59.27	$59.27	Based on average construction worker wage, adjusted for benefits
Lost work time - travel	$35.56	$11.11	$0.00	Based on average construction worker wage, adjusted for benefits
Record keeping	$17.28	$17.28	$17.28	Based on manager's wage rate, adjusted for benefits
Total	**$424.94**	**$400.49**	**$389.38**	
Initial screening: New hires:				
Medical costs	$312.83	$312.83	$312.83	Including components specified above in "Direct Costs"
Lost work time - exam	$59.27	$59.27	$59.27	Based on average construction worker wage, adjusted for benefits
Lost work time - travel	$40.00	$22.22	$4.44	Based on average construction worker wage, adjusted for benefits
Record keeping	$17.28	$17.28	$17.28	Based on manager's wage rate, adjusted for benefits
Total	**$429.38**	**$411.60**	**$393.82**	
Triennial screening				
Medical costs	$312.83	$312.83	$312.83	Including components specified above in "Direct Costs"
Lost work time - exam	$59.27	$59.27	$59.27	Based on average production worker wage, adjusted for benefits (BLS, 2008). Inflated to 2009 value.
Lost work time - travel	$35.56	$11.11	$0.00	Based on average production worker wage, adjusted for benefits (BLS, 2008). Inflated to 2009 value. Assumes all exams are off site.
Record keeping	$17.28	$17.28	$17.28	Based on manager's wage rate, adjusted for benefits (BLS, 2008). Inflated to 2009 value.
Total	**$424.94**	**$400.49**	**$389.38**	

Medical Exam or Other Cost Variable	**Establishment Size**			**Comments/Assumptions**
	Small (<20)	Medium (20-499)	Large (500+)	

Table V-39: Unit Costs and Analytical Assumptions Applied in OSHA's Cost Model for Medical Surveillance in the Silica Construction Standard
(Coverage: All employees exposed above PEL) (continued)

Examination by pulmonary specialist				
Medical costs	$190.28	$190.28	$190.28	Including components specified above in "Direct Costs"
Lost work time - exam	$29.63	$29.63	$29.63	Based on average production worker wage, adjusted for benefits (BLS, 2008). Inflated to 2009 value.
Lost work time - travel	$44.45	$44.45	$44.45	Based on average production worker wage, adjusted for benefits (BLS, 2008). Inflated to 2009 value. Assumes all exams are off site.
Record keeping	$69.12	$69.12	$69.12	Based on manager's wage rate, adjusted for benefits (BLS, 2008). Inflated to 2009 value.
Total	**$333.48**	**$333.48**	**$333.48**	
Initial TB Testing				
Test cost	$15.00	$15.00	$15.00	
Lost work time - exam	$2.47	$2.47	$2.47	Based on average production worker wage, adjusted for benefits (BLS, 2008). Inflated to 2009 value.
Lost work time - travel	$23.71	$7.41	$0.00	Based on average production worker wage, adjusted for benefits (BLS, 2008). Inflated to 2009 value. Assumes all exams are off site.
Total	**$41.18**	**$24.88**	**$17.47**	
New Hire and subsequent TB testing				
Test cost	$15.00	$15.00	$15.00	
Lost work time - exam	$2.47	$2.47	$2.47	Based on average production worker wage, adjusted for benefits (BLS, 2008). Inflated to 2009 value.
Lost work time - travel	$26.67	$14.82	$2.96	Based on average production worker wage, adjusted for benefits (BLS, 2008). Inflated to 2009 value. Assumes all exams are off site.
Total	**$44.14**	**$32.29**	**$20.43**	
Annualized costs – initial testing	$5.86	$3.54	$2.49	
Annualized costs – new hire and subsequent testing	$44.14	$32.29	$20.43	
Percentage of employees tested in initial year				
Current Employees		100.0%		
New Hires		40.0%		

Table V-39: Unit Costs and Analytical Assumptions Applied in OSHA's Cost Model for Medical Surveillance in the Silica Construction Standard
(Coverage: All employees exposed above PEL) (continued)

Percent of employees recommended for annual TB testing	20.0%

[a] Typical charge based on ERG contacts with occupational health providers.
[b] Mean expense per office-based physician visit to a pulmonary specialist for diagnosis and treatment, based on data from the 2004 Medical Expenditure Panel Survey (MEPS, 2004). Inflated to 2009 dollars using the consumer price deflator for medical services.
Other costs for physical exams and tests, chest X-ray, and pulmonary tests are direct medical costs used in bundling services under Medicare (Intellimed, 2003). Costs are inflated by 30% to eliminate the effect of Medicare discounts that are unlikely to apply to occupational medicine environments. Inflated to 2009 costs based on medical care services component of the CPI inflator.

Source: U.S. Dept. of Labor, OSHA, Directorate of Evaluation and Analysis, Office of Regulatory Analysis, based on ERG (2007a and 2011).

or PLHCP would provide the health screening services at the establishment's worksite. OSHA estimates that, on average, 20 percent of establishments with fewer than 20 employees, 75 percent of establishments with 20-499 employees, and 100 percent of establishments with 500 or more employees would have the initial health screening for current employees conducted onsite.

The unit cost components of the initial health screening for new hires in construction are identical to those for existing construction employees with the exception that the percentage of workers expected to travel offsite for the health screening would be somewhat larger (due to fewer workers being screened annually, in the case of new hires, and therefore yielding fewer economies of onsite screening). OSHA estimates that, on average, 10 percent of establishments with fewer than 20 employees, 50 percent of establishments with 20-499 employees, and 90 percent of establishments with 500 or more employees would have the initial health screening for new hires conducted onsite. As shown in Table V-39, the estimated unit cost of the initial health screening for new hires in construction ranges from approximately $393.82 to $429.38.

In accordance with paragraph (h)(3) of the proposed rule, the periodic medical examination (every third year after the initial health screening) would consist of (1) a medical and work history review and update, (2) a physical examination with special emphasis on the respiratory system, (3) a chest x-ray that meets certain standards of the International Labour Organization, (4) a pulmonary function test that meets certain criteria and is administered by a NIOSH-certified spirometry technician, (5) testing for latent TB infection, if recommended by the physician or PLHCP, and (6) any other tests deemed appropriate by the physician or PLHCP.

The estimated unit cost of periodic health screening also includes direct medical costs, the opportunity cost of worker time, and recordkeeping costs. As shown in Table V-39, these triennial unit costs vary from roughly $389.38 to $424.94. The variation in the unit cost (with or without the chest x-ray and pulmonary function test) is due entirely to differences in the percentage of workers expected to travel offsite for the periodic health screening. OSHA estimated that the share of workers traveling offsite, as a function of establishment size, would be the same for the periodic health screening as for the initial health screening for existing employees.

Although OSHA believes that some affected establishments in construction currently provide some medical testing to their silica-exposed employees, the Agency doubts that many provide the comprehensive health screening required under the proposed rule. Therefore for costing purposes for the proposed rule, OSHA has assumed no current compliance with the proposed health screening requirements. OSHA requests information from interested parties on the current levels and the comprehensiveness of health screening in construction.

In order to estimate turnover rates in construction, ERG (2011) used the separations rate (layoffs, quits, retirements) of 64.0 percent in construction as estimated by the Bureau of Labor Statistics (BLS, 2007). However, not all new hires would require initial medical testing. As specified in paragraph (h)(2) of the proposed rule, employees who had received a qualifying medical examination within the previous twelve months would be exempt from the initial medical examination. OSHA estimates that 60 percent of new hires in construction would be exempt from the initial medical examination.

Based on a ten-year time horizon, OSHA estimated the total annualized costs in construction for health screenings (to include initial health screenings for existing employees and new hires and periodic health screenings) as required by the proposed rule. These estimates, disaggregated by affected NAICS industry, are presented in Table V-40.

Finally, OSHA estimated the unit cost of a medical examination by a pulmonary specialist for those employees found to have signs or symptoms of silica-related disease (1/0 or higher on the ILO scale) or are otherwise referred by the PLHCP. As shown in Table V-39, the estimated unit cost of a medical examination by a pulmonary specialist is $333.48. This cost includes direct medical costs, the opportunity cost of worker time, and recordkeeping costs (to include the cost of the employer's time to make a referral to a pulmonary specialist). In all cases, OSHA anticipates that the worker will travel offsite to receive the medical examination by a pulmonary specialist.

Based on its calculation of residual risk after the silica rule takes effect, OSHA estimates that there would be 117 new cases a year of silicosis of 2/1 or higher identified as a result of the proposed medical surveillance requirements for construction workers. OSHA used the Buchannan et al. (2003) silicosis risk model to estimate that there would be 396 new cases a year of silicosis of 1/0 or higher identified as a result of the proposed medical surveillance requirements for construction workers. ERG distributed these disease cases among industries in proportion to the number of at-risk workers. Table V-41, which multiplies the unit cost by the number of referred workers, shows the total annualized cost in construction of medical examinations by a pulmonary specialist.

Tables V-42, which combines total health screening costs and the total costs of medical examinations by a pulmonary specialist, shows the aggregate annual cost in construction, by NAICS industry, for the medical surveillance requirements in the proposed rule. Combined over all affected NAICS construction industries, the estimated cost of these medical surveillance requirements is $76.0 million annually.

Table V-40: Estimated Medical Surveillance Costs in Construction for OSHA's Proposed Silica Standard (all establishments)

NAICS	Industry	No. of At-Risk Workers (AL=25)	Initial Screening	Screening for New Hires	Triennial Screening	TB Testing	Total
236100	Residential Building Construction	8,842	$521,701	$953,879	$483,458	$69,356	**$2,028,394**
236200	Nonresidential Building Construction	27,658	$1,596,768	$2,931,643	$1,476,796	$186,774	**$6,191,980**
237100	Utility System Construction	10,756	$615,729	$1,129,756	$568,848	$67,582	**$2,381,914**
237200	Land Subdivision	225	$13,191	$24,147	$12,216	$1,684	**$51,239**
237300	Highway, Street, and Bridge Construction	10,090	$578,285	$1,063,758	$534,515	$64,643	**$2,241,201**
237900	Other Heavy and Civil Engineering Construction	1,641	$94,587	$173,825	$87,476	$10,984	**$366,872**
238100	Foundation, Structure, and Building Exterior Contractors	221,887	$12,904,253	$23,664,291	$11,943,068	$1,580,395	**$50,092,007**
238200	Building Equipment Contractors	1,398	$81,394	$149,329	$75,343	$10,039	**$316,105**
238300	Building Finishing Contractors	26,169	$1,529,159	$2,802,588	$1,415,930	$192,803	**$5,940,479**
238900	Other Specialty Trade Contractors	21,314	$1,247,020	$2,285,587	$1,154,855	$158,503	**$4,845,965**
999000	State and Local Governments [c]	6,264	$366,501	$671,737	$339,414	$46,584	**$1,424,236**
	Totals	**336,244**	**$19,548,587**	**$35,850,541**	**$18,091,919**	**$2,389,344**	**$75,880,392**

Source: U.S. Dept. of Labor, OSHA, Directorate of Evaluation and Analysis, Office of Regulatory Analysis, based on ERG (2007a and 2011).

Table V-41: Estimated Costs in Construction for Medical Examinations by a Pulmonary Specialist, as Required under the Proposed Silica Standard (2009 dollars)

NAICS	Industry	No. of At-Risk Workers	No. of Annual Referrals	Cost
236100	Residential Building Construction	8,842	10	**$3,473**
236200	Nonresidential Building Construction	27,658	33	**$10,863**
237100	Utility System Construction	10,756	13	**$4,224**
237200	Land Subdivision	225	0	**$88**
237300	Highway, Street, and Bridge Construction	10,090	12	**$3,963**
237900	Other Heavy and Civil Engineering Construction	1,641	2	**$644**
238100	Foundation, Structure, and Building Exterior Contractors	221,887	261	**$87,145**
238200	Building Equipment Contractors	1,398	2	**$549**
238300	Building Finishing Contractors	26,169	31	**$10,278**
238900	Other Specialty Trade Contractors	21,314	25	**$8,371**
999000	State and Local Governments [c]	6,264	7	**$2,460**
	Totals	**336,244**	**396**	**$132,059**

Source: U.S. Dept. of Labor, OSHA, Directorate of Evaluation and Analysis, Office of Regulatory Analysis, based on ERG (2011).

Table V-42: Aggregate Costs in Construction, by NAICS industry, for the Medical Surveillance Requirements in the Proposed Silica Rule (2009 dollars)

NAICS	Industry	Total Cost of Examinations	Cost of Pulmonary Specialist Examinations	Total Cost
236100	Residential Building Construction	$2,028,394	$3,473	$2,031,866.45
236200	Nonresidential Building Construction	$6,191,980	$10,863	$6,202,842.46
237100	Utility System Construction	$2,381,914	$4,224	$2,386,138.65
237200	Land Subdivision	$51,239	$88	$51,327.44
237300	Highway, Street, and Bridge Construction	$2,241,201	$3,963	$2,245,163.95
237900	Other Heavy and Civil Engineering Construction	$366,872	$644	$367,516.51
238100	Foundation, Structure, and Building Exterior Contractors	$50,092,007	$87,145	$50,179,151.99
238200	Building Equipment Contractors	$316,105	$549	$316,654.52
238300	Building Finishing Contractors	$5,940,479	$10,278	$5,950,756.67
238900	Other Specialty Trade Contractors	$4,845,965	$8,371	$4,854,335.72
999000	State and Local Governments [c]	$1,424,236	$2,460	$1,426,696.18
	Totals	**$75,880,392**	**$132,059**	**$76,012,451**

Source: U.S. Dept. of Labor, OSHA, Directorate of Evaluation and Analysis, Office of Regulatory Analysis, based on ERG (2011).

SBREFA Comments on Medical Surveillance Costs

One SBREFA commenter asked why ERG annualized the one-time expense of an initial screening over a 10-year period when essentially similar exams are scheduled for the same worker every 3 years under Option 1 of the proposed rule.[53] To clarify, OSHA notes that ERG's costs for the required health screenings (initial and follow-up), embodied in the aggregate costs shown in Tables 4-33 through 4-38 in ERG (2007a), reflect the annualized value of the discounted costs of the required screenings and medical tests over a ten-year period. An earlier version of this chapter, at the time of the SBREFA panel, failed to indicate that all health screening costs were, in fact, discounted and annualized.

The commenter also argued that ERG's source for medical costs might have resulted in low estimates for health care services required by the standard. The commenter provided examples of costs for certain procedures that are higher than the unit costs specified by ERG and are taken from the *Physicians' Fee Reference* and described as the average of the 50th and 75th percentile values. However the commenter did not provide details regarding the types of procedures performed.[54] In response, OSHA notes that ERG's unit costs were primarily derived from Medicare reimbursement rates for representative procedures required by the draft standard. ERG inflated these rates by 30 percent to represent charges that small employers or individual workers might encounter. Larger employers or those represented by major insurance companies, HMOs, PPOs, or other large health management organizations might negotiate lower rates. Codes for the specific medical procedures costed by ERG are shown in Table 4-32 in ERG (2007a).

OSHA solicits comment on its responses to all these issues raised during the SBREFA Panel process.

[53] Reform OSHA Coalition (2003), p. 21.

[54] Reform OSHA Coalition (2003), p. 9. The Physician Fee Reference is a licensed American Medical Association product that provides, by 3-digit zip code, 50th, 75th, and 90th percentile physicians' fees charged for a variety of CPT-coded (current procedure terminology) procedures. Fees negotiated by insurance companies, PPOs, and other large payers are typically less than the listed fee.

Information and Training Costs

As specified in paragraph (i)(1) of the proposed rule and 29 CFR 1910.1200, training is required for all employees in construction in jobs where there is potential exposure to respirable crystalline silica. In addition, new hires would require training before starting work. ERG (2011) provided an estimate of the new-hire rate in construction, based on the BLS-estimated separations rate of 64.0 percent in construction (BLS, 2008). OSHA estimated separate costs for training current employees and for training new hires. Given that new hire training might need to be performed frequently during the year, OSHA estimated a smaller class size for new hires. OSHA notes that the training discussed in this section does not include respirator training, whose costs were included as part of the respirator costs presented earlier in this chapter.

OSHA anticipates that training, in accordance with the requirements of the proposed rule (to include hazard communication under proposed paragraph (i)(1) and employee information and training under proposed paragraph (i)(2)), will be conducted by in-house safety or supervisory staff with the use of training modules or videos and will last, on average, one hour. ERG (2007b) judged that establishments could purchase sufficient training materials at an average cost of $2 per worker, encompassing the cost of handouts, video presentations, and training manuals and exercises. ERG (2011) included in the cost estimates for training the value of worker and trainer time as measured by 2009 hourly wage rates (to include fringe benefits) in construction for employees and supervisors, respectively. ERG also developed estimates of average class sizes as a function of establishment size.

For initial training, ERG estimated an average class size of 5 workers for establishments with fewer than 20 employees; 10 workers for establishments with 20 to 499 employees; and 20 workers for establishments with 500 or more employees. For new hire training, ERG estimated an average class size of 2 workers for establishments with fewer than 20 employees; 5 workers for establishments with 20 to 499 employees; and 10 workers for establishments with 500 or more employees. The unit costs of training are presented below in Table V-43. Based on ERG's work, OSHA estimated the annualized cost (annualized over 10 years) of initial training at between $3.68 and $4.37 per employee and the annual cost of new hire training at between $27.46 and $40.39 per employee, depending on establishment size.

OSHA recognizes that many affected establishments in construction currently provide training on the hazards of respirable crystalline silica in the workplace. Consistent with some estimates developed by ERG(2007b), OSHA estimates that 50 percent of affected establishments already provide such training. However, some of the training specified in the proposed rule requires that workers be familiar with the training and medical surveillance provisions in the rule. OSHA expects that this training is not currently being provided. Therefore, for costing purposes for the proposed rule, OSHA has estimated that 50 percent of affected establishments currently provide their workers, and would provide new hires, with training that would comply with approximately 50 percent of the training requirements. In other words, OSHA estimates that those (50 percent of) establishments currently providing training on workplace silica hazards would provide an additional 30 minutes of training to comply with the proposed rule; the remaining (50 percent of) establishments would provide 60 minutes of training to comply with the proposed rule. As clarified above, this hazards-centered training would not include the respirator training described earlier in this chapter. OSHA also recognizes that many new hires in construction may have been previously employed in construction, and in some cases by the same establishment, so that they might have already received (partial) silica training. However, for costing purposes, OSHA estimates that all new hires will receive the full silica training from the new employer. OSHA requests comments from interested parties on the reasonableness of these estimates and on the reasonableness of all of the other assumptions and estimates applied in this analysis of information and training costs, including any upfront costs associated with familiarizing employees with new procedures they would have to conduct and equipment they would have to operate as part of their employers' compliance with the proposed standard.

Table V-44 summarizes the annual costs in the construction sector, by NAICS industry, of the training requirements in the proposed rule. Combined over all NAICS construction industries, the cost of the training requirements is $47.3 million annually.

Table V-43: Analytical Assumptions and Unit Costs Applied in OSHA's Cost Model for Training in Construction

Cost Category	Cost Parameter			Comments/Assumptions
Direct Costs				
Instructor cost per hour		$43.12		Based on supervisor wage, adjusted for fringe benefits (BLS, 2008), updated to 2009 dollars
Materials for class per attendee		$2.00		Estimated cost of $2 per worker for the training/reading materials.
Labor Costs				
Time spent in class (min)				ERG estimates.
Establishments without existing silica training		60		
Establishments with existing silica training		30		
Percentage of establishments with existing silica training program		50%		
Class size by Establishment Size Class				
	Small (<20)	Medium (20-499)	Large (500+	
Initial training	5	10	20	
New hire training	2	5	10	
Value of worker time spent in class	$22.22	$22.22	$22.22	Based on worker wage, adjusted for fringe benefits (BLS, 2008)
Annualized Training Cost per Employee by Establishment Size				
	Small (<20)	Medium (20-499)	Large (500+)	
Initial training				
Value of instructor's time	$6.47	$3.23	$1.62	
Value of employee's time	$22.22	$22.22	$22.22	
Cost of materials	$2.00	$2.00	$2.00	
Total	$30.69	$27.46	$25.48	
Annualized total	$4.37	$3.91	$3.68	

Table V-43: Analytical Assumptions and Unit Costs Applied in OSHA's Cost Model for Training in Construction (continued)

Cost Category	Cost Parameter			Comments/Assumptions
New hire training				
Value of instructor's time	$16.17	$6.47	$3.23	
Value of employee's time	$22.22	$22.22	$22.22	
Cost of materials	$2.00	$2.00	$2.00	
Total	$40.39	$30.69	$27.46	
Separations rate (layoffs, quits, and retirements)		64.0%		2008 annual hires rate for the construction industry (BLS *Job Openings and Labor Turnover Survey*)

Source: U.S. Dept. of Labor, OSHA, Directorate of Evaluation and Analysis, Office of Regulatory Analysis, based on ERG (2007a and 2011).

Table V-44: Estimated Training Costs in Construction for OSHA's Proposed Silica Standard (all establishments)

NAICS	Industry	Number of At-Risk Workers	Initial Training	New Hire Training	Total Cost
236100	Residential Building Construction	55,338	$230,831	$1,284,217	**$1,515,047**
236200	Nonresidential Building Construction	173,939	$695,939	$3,653,578	**$4,349,517**
237100	Utility System Construction	217,070	$853,897	$4,391,824	**$5,245,721**
237200	Land Subdivision	6,511	$26,791	$146,392	**$173,183**
237300	Highway, Street, and Bridge Construction	204,899	$808,466	$4,152,500	**$4,960,966**
237900	Other Heavy and Civil Engineering Construction	46,813	$186,787	$975,318	**$1,162,105**
238100	Foundation, Structure, and Building Exterior Contractors	559,729	$2,271,434	$12,164,420	**$14,435,854**
238200	Building Equipment Contractors	20,358	$82,762	$443,793	**$526,555**
238300	Building Finishing Contractors	120,012	$491,505	$2,664,500	**$3,156,004**
238900	Other Specialty Trade Contractors	274,439	$1,126,700	$6,125,224	**$7,251,924**
999000	State and Local Governments [c]	170,068	$698,209	$3,795,760	**$4,493,968**
	Total – Construction	**1,849,175**	**$7,473,320**	**$39,797,524**	**$47,270,844**

Source: U.S. Dept. of Labor, OSHA, Directorate of Evaluation and Analysis, Office of Regulatory Analysis, based on ERG (2007a and 2011).

SBREFA Panel Comments on Training Costs

One participant in the silica SBREFA process objected to ERG's analytical assumption (used in OSHA's Preliminary Initial Regulatory Flexibility Analysis) that training is needed only for those workers exposed above the action level and suggested that training might be necessary for all at-risk workers.[55] For the proposed rule, the scope feature in this requirement was revised so that the provision now would apply to all at-risk workers—those with any potential workplace exposure to respirable crystalline silica—and OSHA has estimated training costs in this PEA accordingly. Therefore, the participant's comment is no longer germane. OSHA solicits comment on its responses to this issue raised during the SBREFA Panel process.

Regulated Areas and Access Control Plan Costs

Paragraph (e)(1) of the proposed standard requires employers to implement measures to minimize silica exposure for employees not directly involved in operations that generate respirable crystalline silica. To meet this performance objective, employers have the option of either establishing regulated areas in accordance with proposed paragraph (e)(2) or establishing and implementing an access control plan in accordance with proposed paragraph (e)(3).

Under the first option, the proposed standard requires employers to establish a regulated area whenever an employee's exposure to airborne concentrations of silica is or can reasonably be expected to exceed the PEL. Based on the respirator specifications developed by ERG (2007a) and shown in Table V-34, ERG derived the full-time-equivalent number of workers engaged in tasks where respirators are required and estimated the costs of establishing a regulated area for these workers.

Under the second option for access control plans, the employer must include the following elements in the plan: competent person provisions; notification and demarcation procedures; multi-employer workplace procedures; provisions for limiting access; provisions for supplying respirators, and protective work clothing procedures. OSHA anticipates that employers will incur costs for labor, materials, and respiratory protection to comply with the proposed access control requirements.

Table V-45 shows the unit costs and assumptions for developing costs for regulated areas and for access control plans. ERG estimated separate costs for developing an access control plan and for implementing the plan. ERG judged that developing either a regulated area or an access control plan would take approximately 4 hours of a supervisor's time. The time allowed to set up a regulated area or an access control plan is intended to allow for the communication of access restrictions and locations at multi-employer worksites. ERG estimated a cost of $115.92 per job based on job frequency and the costs for hazard tape and warning signs (which are reusable). ERG estimated a labor cost of $26.94 per job for implementing a written access control plan (covering the time expended for revision of the access control plan for individual jobs and communication of the plan). In addition, ERG estimated that there would be annual disposable clothing costs of $333 per crew and annual respirator costs of $60 per crew for employers who

[55] Reform OSHA Coalition (2003), p. 22.

implement either the regulated area or the access control plan option.

ERG aggregated costs by estimating an average crew size of four in construction and an average job length of ten days. ERG judged that in 75 percent of the cases regulated areas would be selected. OSHA requests comments from interested parties on these estimates.

Applying these parameters to the full-time-equivalent number of construction workers affected by this provision, OSHA estimates, in Table V-46, annual costs of $16.7 million for regulated areas and access control plans under the proposed rule and provides a breakdown of annual costs by NAICS construction industry.

Table V- 45: Unit Costs and Analytical Assumptions Applied in OSHA's Cost Model for Access Control Plans and Regulated Areas under the Proposed Silica Construction Standard

Access Control Plan	Parameter	Unit cost	Comment
Time to develop plan (hours)	4	$172.48	One time cost. Valued at supervisors' wage rate. Includes provisions for limiting access and procedures for respirator provision. (BLS, 2008)
Number of workers covered by plan	8		Average. Estimated by ERG
Cost per worker		$21.56	Based on worker wage, adjusted for fringe benefits (BLS, 2008)
Annualized cost per worker		$3.07	
Implementation of Access Control Plan Option			
Revise plan for specific job (hours)	0.25	$10.78	Per job. Valued at supervisor's wage.
Communication of plan provisions (hours)	0.1		Per job. Value of supervisors' and workers' time for briefing on job specific site-control provisions.
		$4.31	Per job. Valued at supervisor's wage.
		$11.85	Crew members; based on crew size assumption below
Total cost for implementing plan (per job)		$26.94	
Disposable clothing (annual costs per crew)		$333.00	$5.55 per suit. Assumes daily clothing for 10% of workers (Lab Safety Supply, 2010).
Extra respirators (annual costs per crew)		$60.00	$1.00 per respirator, typical cost for N95 disposable respirator (Lab Safety Supply, 2010). Assumes extra respirators equal to 10% of workers
Implementation of Regulated Areas Option			
Access control materials (per crew)			
Hazard tape per job (100 ft)		$5.80	(Lab Safety Supply, 2010)
Warning signs (3)		$75.90	$25.30 per sign (Lab Safety Supply, 2010)
Warning signs - annualized cost		$28.92	Assumes 3 year life
Total annualized costs		$115.92	Based on job frequency and crew size assumptions below
Material cost per worker (per year)		$28.98	
Disposable clothing (annual costs per crew)		$333.00	$5.55 per suit. Assumes daily clothing for 10% of workers (Lab Safety Supply, 2010).
Extra respirators (annual costs per crew)		$60.00	$1.00 per respirator, typical cost for N95 disposable respirator (Lab Safety Supply, 2010). Assumes extra respirators equal to 10% of workers.
Supervisor time to identify and set up regulated area (hours)	0.25	$10.78	Per job

Table V- 45: Unit Costs and Analytical Assumptions Applied in OSHA's Cost Model for Access Control Plans and Regulated Areas under the Proposed Silica Construction Standard (continued)

Access Control Plan	Parameter	Unit cost	Comment
Job Frequency and Crew Size Assumptions			
Share of jobs requiring a regulated area rather than an access control plan	75.0%		Estimated by ERG.
Average crew size (workers)	4		Estimated by ERG.
Average job length (days)	10		Estimated by ERG.
Working days per year	150		Estimated by ERG.
Per-worker costs for access control plan or regulated area setup implementation			
Annual cost per worker - briefing only		$199.29	
Annual cost per worker - regulated area set up only		$167.65	
Weighted average annual cost per worker		$175.56	Applies to workers with exposures above the PEL.

Source: U.S. Dept. of Labor, OSHA, Directorate of Evaluation and Analysis, Office of Regulatory Analysis, based on ERG (2007a and 2011).

Table V-46: Estimated Annualized Costs for Regulated Areas and Access Control Plans in Construction for OSHA's Proposed Silica Standard (all establishments)

NAICS	Industry	Number of At-Risk Workers	Number of Workers Using Respirators	Develop Plan	Implement Plan	Total Cost
236100	Residential Building Construction	24,445	8,842	$49,512	$776,142	**$825,654**
236200	Nonresidential Building Construction	63,198	27,658	$50,957	$971,159	**$1,022,115**
237100	Utility System Construction	53,073	10,756	$104,302	$836,732	**$941,034**
237200	Land Subdivision	1,172	225	$2,678	$19,766	**$22,443**
237300	Highway, Street, and Bridge Construction	39,273	10,090	$58,585	$578,497	**$637,082**
237900	Other Heavy and Civil Engineering Construction	8,655	1,641	$15,937	$115,905	**$131,843**
238100	Foundation, Structure, and Building Exterior Contractors	323,119	221,887	$243,468	$7,791,062	**$8,034,530**
238200	Building Equipment Contractors	4,947	1,398	$10,363	$122,750	**$133,113**
238300	Building Finishing Contractors	37,952	26,169	$75,514	$949,891	**$1,025,405**
238900	Other Specialty Trade Contractors	60,894	21,314	$133,937	$2,681,081	**$2,815,017**
999000	State and Local Governments [c]	31,080	6,264	$70,366	$1,087,061	**$1,157,427**
	Total - Construction	**647,807**	**336,244**	**$815,618**	**$15,930,046**	**$16,745,663**

Source: U.S. Dept. of Labor, OSHA, Directorate of Evaluation and Analysis, Office of Regulatory Analysis, based on ERG (2007a and 2011).

SBREFA Panel Comments on Regulated Area Costs

During the SBREFA process for OSHA's draft silica rule, one commenter questioned ERG's interpretation of the draft standard with respect to regulated areas, arguing that while ERG's analysis requires employers to establish a regulated area around any of the operations listed in Table 1 where respiratory protection is required, the draft standard did not in fact mention Table 1 in paragraph (e) specifying provisions for regulated area. The commenter stated that the draft standard requires that the employer ensure that the competent person establishes regulated areas *wherever* the airborne concentration of respirable crystalline silica exceeds or can reasonably be expected to exceed the PEL (emphasis added). According to the commenter, this wording suggests that Table 4-22 in ERG (2007a) would be the appropriate source for determining the number of at-risk FTE workers (and not Table 4-30 in ERG, 2007a).[56]

In response to the concerns of this commenter, OSHA draws attention to the fact that in the draft standard, paragraph (e)(1) requires that employers "ensure that the competent person establishes regulated areas wherever the airborne concentration of respirable crystalline silica exceeds or can reasonably be expected to exceed the PEL." (Similar language, with the exception of the reference to a competent person, is found in paragraph (e)(2) in the proposed standard.) Since the cost analysis assumes compliance with the requirements of Table 1 and since such compliance is presumed to result in exposures below the PEL, except, possibly, where respirator use is also required, a direct correspondence exists between required respirator use and the need for regulated areas. OSHA believes that the use of all at-risk full-time-equivalent workers, as shown in Table 4-22 of ERG (2007a), would, therefore, overestimate the extent to which regulated areas would be required and that the use of the number of FTE workers in Table 4-30 of ERG (2007a) was appropriate.

The commenter also noted that ERG relied on BLS wage data to estimate the value of time required to set up regulated areas and that higher costs would be obtained if RSMeans wage data had been used.[57] To clarify the methodology used in this PEA, it should be understood that OSHA and ERG used the RSMeans data only to cost the representative jobs and to estimate incremental control costs and labor share of project costs necessary to aggregate controls costs into industry totals. Elsewhere, OSHA and ERG consistently used BLS wage data to estimate the cost of labor time required to comply with the program requirements of the proposed standard.

OSHA solicits comment on its responses to all these issues raised during the SBREFA Panel process.

[56] Reform OSHA Coalition (2003), p. 19.

[57] Reform OSHA Coalition, (2003), p. 19.

Combined Construction Control, Respirator, and Program Costs

Table V-47 summarizes the engineering control costs, respirator costs, and program costs of the proposed rule for the construction industry. Annualized compliance costs in construction are expected to total $511.2 million, of which $242.6 million are for engineering controls, $84.0 million are for respirators, and $184.6 million are to meet the ancillary provisions of the proposed rule. These ancillary annual costs consist of $44.6 million for exposure monitoring; $76.0 million for medical surveillance; $47.3 million for training; and $16.7 million for restricted areas and access control.

Among affected industry groups, foundation, structure, and building exterior contractors (NAICS 238100) will face the largest compliance costs at $215.9 million annually, followed by other specialty trade contractors (NAICS 238900), at $68.0 million annually in compliance costs, and building finishing contractors (NAICS 238300), at $50.3 million annually in compliance costs.

Table V-B-1 in Appendix B presents estimated compliance costs by NAICS industry code and program element for small entities (as defined by the Small Business Administration) in construction, while Table V-B-2 presents estimated compliance costs, by NAICS code and program element, for very small entities (fewer than twenty employees) in construction.

Table V-47: Annualized Compliance Costs for Construction Employers Affected by OSHA's Proposed Silica Standard (2009 dollars)

NAICS	Industry	Engineering Controls (includes Abrasive Blasting)	Respirators	Exposure Assessment	Medical Surveillance	Training	Regulated Areas and Access Control	Total
236100	Residential Building Construction	$14,610,121	$2,356,507	$1,949,685	$2,031,866	$1,515,047	$825,654	**$23,288,881**
236200	Nonresidential Building Construction	$16,597,147	$7,339,394	$4,153,899	$6,202,842	$4,349,517	$1,022,115	**$39,664,913**
237100	Utility System Construction	$30,877,799	$2,808,570	$4,458,900	$2,386,139	$5,245,721	$941,034	**$46,718,162**
237200	Land Subdivision	$676,046	$59,606	$128,183	$51,327	$173,183	$22,443	**$1,110,789**
237300	Highway, Street, and Bridge Construction	$16,771,688	$2,654,815	$3,538,146	$2,245,164	$4,960,966	$637,082	**$30,807,861**
237900	Other Heavy and Civil Engineering Construction	$4,247,372	$430,127	$825,247	$367,517	$1,162,105	$131,843	**$7,164,210**
238100	Foundation, Structure, and Building Exterior Contractors	$66,484,670	$59,427,878	$17,345,127	$50,179,152	$14,435,854	$8,034,530	**$215,907,211**
238200	Building Equipment Contractors	$3,165,237	$366,310	$394,270	$316,655	$526,555	$133,113	**$4,902,138**
238300	Building Finishing Contractors	$34,628,392	$2,874,918	$2,623,763	$5,950,757	$3,156,004	$1,025,405	**$50,259,239**
238900	Other Specialty Trade Contractors	$43,159,424	$4,044,680	$5,878,597	$4,854,336	$7,251,924	$2,815,017	**$68,003,978**
999000	State and Local Governments [c]	$11,361,299	$1,641,712	$3,257,131	$1,426,696	$4,493,968	$1,157,427	**$23,338,234**
	Total - Construction	**$242,579,193**	**$84,004,516**	**$44,552,948**	**$76,012,451**	**$47,270,844**	**$16,745,663**	**$511,165,616**

Source: U.S. Dept. of Labor, OSHA, Directorate of Evaluation and Analysis, Office of Regulatory Analysis, based on ERG (2007a and 2011).

TOTAL COST SUMMARY

As shown in Table V-48, annualized compliance costs associated with the proposed rule are expected to total $657.9 million. Table V-48 also provides total annualized costs for general industry, maritime, and construction, by major provision or program element included in the proposed rule. This table shows that engineering control costs represent 69 percent of the costs of the proposed standard for general industry and maritime and 47 percent of the costs of the proposed standard for construction. Considering other leading cost categories, costs for exposure assessment and respirators represent, respectively, 20 percent and 5 percent of the costs of the proposed standard for general industry and maritime; costs for respirators and medical surveillance represent, respectively, 16 percent and 15 percent of the costs of the proposed standard for construction.

While the costs presented here represent the Agency's best estimate of the costs to industry of complying with the proposed rule under static conditions (that is, using existing technology and the current deployment of workers), OSHA recognizes that the actual costs could be somewhat higher or lower, depending on the Agency's possible overestimation or underestimation of various cost factors. In Chapter VII of this PEA, OSHA provides a sensitivity analysis of its cost estimates by modifying certain critical unit cost factors. Beyond the sensitivity analysis, OSHA notes that its cost estimates do not reflect the possibility that, in response to the rule, industry may be able to take two types of actions to reduce compliance costs.

First, in construction, 53 percent of the estimated costs of the proposed rule (all costs except engineering controls) vary directly with the number of workers exposed to silica. However, as shown in Table III-2 in this PEA, almost three times as many construction workers would be affected by the proposed rule as would the number of full-time-equivalent construction workers necessary to do the work. This is because most construction workers currently do work involving silica exposure for only a portion of their workday. In response to the proposed rule, many employers are likely to assign work so that fewer construction workers perform tasks involving silica exposure; correspondingly, construction work involving silica exposure will tend to become a full-time job for some construction workers.[58] Were this approach fully implemented in construction, the actual cost of the proposed rule would decline by over 25 percent, or by $180 million annually, to under $480 million annually.[59]

Second, the costs presented here do not take into account the likely development and dissemination of cost-reducing compliance technology in response to the proposed rule.[60] One

[58] There are numerous instances of job reassignments and job specialties arising in response to OSHA regulation. For example, asbestos removal and confined space work in construction have become activities performed by well-trained specialized employees, not general laborers (whose only responsibility is to identify the presence of asbestos or a confined space situation and then to notify the appropriate specialist).

[59] OSHA expects that such a structural change in construction work assignments would not have a significant effect on the benefits of the proposed rule. As discussed in Chapter VII of this PEA, the estimated benefits of the proposed rule are relatively insensitive to changes in average occupational tenure or how total silica exposure in an industry is distributed among individual workers.

[60] Evidence of such technological responses to regulation is widespread (see for example Ashford, Ayers,

possible example is the development of safe substitutes for silica sand in abrasive blasting

and Stone (1985), OTA (1995), and OSHA's regulatory reviews of existing standards under § 610 of the Regulatory Flexibility Act ("610 lookback reviews")).

Table V-48: Annualized Compliance Costs for Employers in General Industry, Maritime, and Construction Affected by OSHA's Proposed Silica Standard (2009 dollars)

Industry	Engineering Controls (includes Abrasive Blasting)	Respirators	Exposure Assessment	Medical Surveillance	Training	Regulated Areas or Access Control	Total
General Industry	$88,442,480	$6,914,225	$29,197,633	$2,410,253	$2,952,035	$2,580,728	**$132,497,353**
Maritime	$12,797,027	N/A	$671,175	$646,824	$43,865	$70,352	**$14,229,242**
Construction	$242,579,193	$84,004,516	$44,552,948	$76,012,451	$47,270,844	$16,745,663	**$511,165,616**
Total	**$343,818,700**	**$90,918,741**	**$74,421,757**	**$79,069,527**	**$50,266,744**	**$19,396,743**	**$657,892,211**

Source: U.S. Dept. of Labor, OSHA, Directorate of Evaluation and Analysis, Office of Regulatory Analysis, based on ERG (2007a, 2007b, and 2011).

operations, repair and replacement of refractory materials, foundry operations, and the railroad transportation industry. Another is expanded uses of automated processes, which would allow workers to be isolated from the points of operation that involve silica exposure (such as tasks between the furnace and the pouring machine in foundries and at sand transfer stations in structural clay production facilities). Yet another example is the further development and use of bags with valves that seal effectively when filled, thereby preventing product leakage and worker exposure (for example, in mineral processing and concrete products industries). Probably the most pervasive and significant technological advances, however, will likely come from the integration of compliant control technology into production equipment as standard equipment. Such advances would both increase the effectiveness and reduce the costs of silica controls retrofitted to production equipment. Possible examples include local exhaust ventilation (LEV) systems attached to portable tools used by grinders and tuckpointers; enclosed operator cabs equipped with air filtration and air conditioning in industries that mechanically transfer silica or silica-containing materials; and machine-integrated wet dust suppression systems used, for example, in road milling operations. Of course, all the possible technological advances in response to the proposed rule and their effects on costs are difficult to predict.[61]

OSHA has decided at this time not to create a more dynamic and predictive analysis of possible cost-reducing technological advances or worker specialization because the technological and economic feasibility of the proposed rule can easily be demonstrated using existing technology and employment patterns. However, OSHA believes that actual costs, if future developments of this type were fully accounted for, would be lower than those estimated here.

OSHA invites comment on this discussion concerning the costs of the proposed rule.

COSTS UNDER ALTERNATIVE PEL (100 $\mu g/m^3$) SCENARIO

Appendix V-C presents annualized compliance costs (totaling $352.3 million) for an alternative PEL of 100 $\mu g/m^3$ (examined for analytical purposes). Table V-C-1 displays costs for general industry, maritime, and construction by program element. Tables V-C-2 and V-C-3 show total costs by NAICS industry code for all affected establishments, for business entities defined as small by the Small Business Administration, and for very small business entities (those with fewer than twenty employees).

[61] A dramatic example from OSHA's 610 lookback review of its 1984 ethylene oxide (EtO) standard is the use of EtO as a sterilant. OSHA estimated the costs of add-on controls for EtO sterilization, but in response to the standard, improved EtO sterilizers with built-in controls were developed and widely disseminated at about half the cost of the equipment with add-on controls. (See OSHA, 2005.) Lower-cost EtO sterilizers with built-in controls did not exist, and their development had not been predicted by OSHA, at the time the final rule was published in 1984.

COSTS UNDER ALTERNATIVE DISCOUNT RATES

An appropriate discount rate[62] is needed to reflect the timing of costs after the rule takes effect and to allow conversion to an equivalent steady stream of annualized costs.

Alternative Discount Rates for Annualizing Costs

Following OMB (2003) guidelines, OSHA has estimated the annualized costs of the proposed rule using separate discount rates of 3 percent and 7 percent. Consistent with the Agency's own practices in recent proposed and final rules,[63] OSHA has also estimated, for benchmarking purposes, undiscounted costs—that is, costs using a zero percent discount rate.

The question remains, what is the "appropriate" or "preferred" discount rate to use to annualize costs? OSHA believes that the appropriate discount rate for annualizing costs is one based on an "opportunity cost of capital" approach.[64] Consistent with OMB's (2003) position, the opportunity cost of capital is the appropriate discount rate to use whenever regulatory costs displace or alter the use of capital in the private sector. Alternatively, it can be viewed as the cost to business of borrowing capital to comply with a regulation.

The relevant measure of the opportunity cost of capital is the pre-tax rate of return on the foregone investment (Lind, 1982, pp. 24-32). Based on OMB (2003), the average pre-tax rate of return to private capital in the United States in recent decades has been approximately 7 percent. Accordingly, OSHA believes that a reasonable estimate of the opportunity cost of capital would be 7 percent and will use this as its preferred discount rate for reporting the annualized costs of the proposed rule.

Summary of Annualized Costs under Alternative Discount Rates

In addition to using a seven percent discount rate in its cost analysis, OSHA estimated compliance costs, in Appendix V-D, using alternative discount rates of three percent and zero percent. Table V-D-1 and V-D-2 in Appendix V-D present total costs at a three percent discount rate for, respectively, (1) all employers by major industry category and program element, and (2) affected employers by NAICS industry code and employment size class (all establishments, small entities, and very small entities). Tables V-D-3 and V-D-4 in Appendix V-D present total costs at a zero percent discount rate, where the data are displayed as in Tables V-D-1 and V-D-2.

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[62] Here and elsewhere throughout this PEA, unless otherwise noted, the term "discount rate" always refers to the real discount rate—that is, the discount rate net of any inflationary effects.

[63] See, for example, 70 *FR* 34822 and 71 *FR* 10099, the preambles for the proposed and final hexavalent chromium rule.

[64] As explained in Chapter VII of this PEA, OSHA recommends a different approach for choosing a discount rate to annualize benefits and subsequently selected a discount rate different from the one chosen here.

As shown in Appendix V-D, the choice of discount rate has only a minor effect on total annualized compliance costs, with annualized costs declining from $658 million using a seven percent discount rate to $637 million using a three percent discount rate to $623 million using a zero percent discount rate. The reason is that the preponderance of compliance costs would be borne annually. For example, even for control costs, many expenses would be for recurring labor costs (e.g., housekeeping practices) and for equipment maintenance and operating costs, and a significant portion of the equipment costs would involve rental, not purchase.

TIME DISTRIBUTION OF COSTS

OSHA analyzed the stream of (unannualized) compliance costs, by industry sector, for the first ten years after the rule would take effect. As shown in Table V-49, compliance costs are expected to decline from Year 1 to Years 2 and 3 after the initial set of capital and program start-up expenditures has been incurred. Costs are then projected to rise moderately in Year 4 as a result of the triennial medical examinations. OSHA notes that the differences between costs for Year 1 and costs for subsequent years are narrower than might otherwise be the case due to (1) the expectation that, in the construction sector, control equipment will be rented (leading to annual expenses) and not purchased as capital in Year 1; (2) the expectation that the only engineering controls needed in the maritime sector would be wet methods, which do not require capital expenditures; and (3) the fact that, other than engineering controls in general industry and respirators, there are very few capital expenses that would be incurred to comply with the proposed rule.

Table V-49: Distribution of Compliance Costs by Year for Establishments Affected by the Proposed Silica Standard (2009 dollars)

Year	Engineering controls	Program Requirements [a]	Total
General Industry			
1	$212,244,940	$63,320,427	**$275,565,368**
2	$67,578,707	$38,744,874	**$106,323,581**
3	$68,151,942	$39,136,399	**$107,288,341**
4	$67,578,707	$41,056,230	**$108,634,937**
5	$68,151,942	$39,607,916	**$107,759,858**
6	$67,578,707	$39,216,391	**$106,795,098**
7	$68,151,942	$40,773,668	**$108,925,609**
8	$67,578,707	$39,454,204	**$107,032,911**
9	$68,151,942	$39,845,729	**$107,997,671**
10	$67,578,707	$40,042,160	**$107,620,868**
Maritime			
1	$12,797,027	$2,625,430	**$15,422,456**
2	$12,797,027	$968,123	**$13,765,150**
3	$12,797,027	$968,123	**$13,765,150**
4	$12,797,027	$1,592,698	**$14,389,725**
5	$12,797,027	$1,095,536	**$13,892,563**
6	$12,797,027	$1,095,536	**$13,892,563**
7	$12,797,027	$1,410,546	**$14,207,573**
8	$12,797,027	$1,159,798	**$13,956,825**
9	$12,797,027	$1,159,798	**$13,956,825**
10	$12,797,027	$1,318,676	**$14,115,703**
Construction [b]			
1	$242,579,193	$493,477,084	**$736,056,277**
2	$242,579,193	$213,334,029	**$455,913,223**
3	$242,579,193	$217,987,824	**$460,567,017**
4	$242,579,193	$343,785,625	**$586,364,818**
5	$242,579,193	$231,410,029	**$473,989,222**
6	$242,579,193	$226,756,234	**$469,335,428**
7	$242,579,193	$264,594,347	**$507,173,540**
8	$242,579,193	$233,525,835	**$476,105,028**
9	$242,579,193	$238,179,630	**$480,758,823**
10	$242,579,193	$250,262,623	**$492,841,816**

Table V-49: Distribution of Compliance Costs by Year for Establishments Affected by the Proposed Silica Standard (2009 dollars) (continued)

Year	Engineering controls	Program Requirements [a]	Total
Total			
1	$467,621,160	$559,422,941	**$1,027,044,101**
2	$322,954,928	$253,047,026	**$576,001,954**
3	$323,528,162	$258,092,346	**$581,620,508**
4	$322,954,928	$386,434,553	**$709,389,481**

5	$323,528,162	$272,113,481	**$595,641,643**
6	$322,954,928	$267,068,161	**$590,023,089**
7	$323,528,162	$306,778,560	**$630,306,722**
8	$322,954,928	$274,139,837	**$597,094,765**
9	$323,528,162	$279,185,157	**$602,713,319**
10	$322,954,928	$291,623,459	**$614,578,387**

[a] Includes costs for respirators and respirator programs.

[b] Engineering control costs for construction based on short term equipment rental rates.

Source: U.S. Dept. of Labor, OSHA, Directorate of Evaluation and Analysis, Office of Regulatory Analysis, based on ERG (2007a, 2007b, and 2011).

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APPENDIX V-A
Background Data Supporting OSHA's Analysis of Control Costs for General Industry and Maritime

Table V-A-1: Detailed Exposure Control Requirements, Analytical Assumptions and Sources for the Cost Data Applied in OSHA's Analysis of Control Costs in General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Annualized Cost (b)	Applicability [c]	Estimate Source and Assumptions
Cut Stone					
Sawyer					
Control other dust sources in area	Addressed by other controls	N/A	N/A	N/A	
Rigorous housekeeping- capital	HEPA vacuum	N/A	$1,009	100.0%	Nilfisk HEPA vacuum, 15 gal. capacity (Bibbo, 2003)
Rigorous housekeeping- labor	Labor costs	N/A	$913	100.0%	Additional 20 minutes/day
Manage slurry-assumed included in housekeeping costs		N/A	N/A	N/A	
Pre-wash stone to be cut	Incremental labor	N/A	$456	100.0%	5 mins per worker per day
Keep floors wet; washdown with high pressure hose	Includes major plumbing, floor work	N/A	$8,443	100.0%	Includes cost of water and labor time.
Increase water use at saw blade	Extra saw maintenance	N/A	$456	25.0%	5 mins per worker per day; equipment has water capabilities
Use water-fed equipment	Applicable to sites over 100 µg/m^3	N/A	$456	100.0%	5 mins per worker per day; equipment has water capabilities
Enclose saw	Build enclosure	N/A	$238	10.0%	8'x8'x8' dust partition, with plastic sheeting, assumes 5 year life (Means, 2003)
Exhaust saw	LEV	450	$2,399	100.0%	Based on saw LEV (e.g., pg. 10-158, 159, 160, ACGIH, 2001)
Fabricator					
Use water fed equipment	No cost, most tools have water capability	N/A	N/A	N/A	
Management of dust-carrying water slurry	Incremental housekeeping	N/A	N/A	N/A	
Rigorous housekeeping- capital	HEPA vacuum	N/A	$1,009	100.0%	Nilfisk HEPA vacuum, 15 gal. capacity (Bibbo, 2003)
Rigorous housekeeping- labor	Labor costs	N/A	$456	100.0%	5 mins per worker per day
Splitter/chipper		N/A			

Table V-A-1: Detailed Exposure Control Requirements, Analytical Assumptions and Sources for the Cost Data Applied in OSHA's Analysis of Control Costs in General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Annualized Cost (b)	Applicability [c]	Estimate Source and Assumptions
Use work practices to position work near duct	Judged to be a negligible cost	N/A	N/A	N/A	Work practices adjustments assumed to be negligible cost.
Rigorous housekeeping- capital	HEPA vacuum	N/A	$1,009	100.0%	Nilfisk HEPA vacuum, 15 gal. capacity (Bibbo, 2003)
Rigorous housekeeping- labor	Labor costs	N/A	$913	100.0%	30 mins per worker per day
Pre-wash stone	Labor	N/A	$456	100.0%	5 mins per worker per day
Use flexible trunk LEV for hand chipping	Flexible trunk LEV	600	$3,199	75.0%	Granite cutting and finishing; (pg. 10-94, ACGIH, 2001); granite, limestone, and marble assumed to account for 75 percent of establishments.
Tool-mounted LEV for hand-held chipping tools	Shroud and vacuum	N/A	$823	37.5%	Vacuum plus shroud adapter; 35% for maintenance and operating costs; assumes one half of the non-slate establishments (75%) need this control.
Keep floors wet; washdown with high pressure hose	Already costed (see sawyers)	N/A	N/A	N/A	High-pressure hose and floor trough installation
Machine operator					
Control other dust sources in area	Addressed by other controls	N/A	N/A	N/A	
Rigorous housekeeping- capital	HEPA vacuum	N/A	$1,009	100.0%	Nilfisk HEPA vacuum, 15 gal. capacity (Bibbo, 2003)
Rigorous housekeeping- labor	Labor costs	N/A	$913	100.0%	30 mins per worker per day
Wash stone before and after each process	Add misters to conveyor line	N/A	$287	100.0%	Assumes 8 hours of shop labor and $200 in materials to fabricate; 2-year life
Keep conveyor clean and damp	Addressed in other requirements	N/A	N/A	N/A	
Management of dust-carrying water	Included in housekeeping	N/A	N/A	N/A	
Enclose machinery	Build enclosure in machine shop	N/A	$168	100.0%	8'x8'x8' enclosure, plastic sheeting, from Means, 2003. Five-year life.
Exhaust trimming machine	LEV	500	$2,666	100.0%	Based on abrasive cut-off saw (pg. 10-134, ACGIH, 2001)

Table V-A-1: Detailed Exposure Control Requirements, Analytical Assumptions and Sources for the Cost Data Applied in OSHA's Analysis of Control Costs in General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Annualized Cost (b)	Applicability [c]	Estimate Source and Assumptions
Abrasive blasting operator					
For use of maintained, interlocked, ventilated glove-box cabinet	Cost of maintaining blast cabinet	N/A	$1,349	100.0%	Assumes 50% increase in maintenance costs (of up to $2,000) and purchase of new cabinets (25%) at $8,000/cabinet (Norton, 2003), or addit. interlocks at $1,800/cabinet (Heastrup, 2003).
Use only non-silica blasting media	Negligible incremental cost	N/A	N/A	5.0%	Based on ERG manufacturer interviews
Increase blasting cabinet ventilation	Incremental LEV	1,250	$6,663	100.0%	Assumes an increase in cfm for a 7'x7' booth, approximately 25% of ACGIH recommended 100 cfm per square ft. of opening, or 4,900 cfm in total.
Use HEPA vacuums for machine cleaning	Vacuum replaces compressed air cleaning	N/A	$1,009	100.0%	Nilfisk HEPA vacuum, 15 gal. capacity (Bibbo, 2003). Assume negligible impact on labor requirements for cleaning
Flat glass					
Material handler					
Automated and ventilated unloading equipment	Not costed	N/A	N/A	N/A	
Bag opening station (small facilities only)	Add bag opening station	1,513	$8,068	36.0%	Bag opening station (pg. 10-19, ACGIH, 2001); applies to small establishments only (36% with <20 employees.).
Batch operator					
Conveyor enclosures	Limit dust and spills	N/A	$967	100.0%	200 feet at $17.10 per linear foot (Landola, 2003)
LEV for batch operator workstation	LEV	1,050	$5,599	100.0%	Bin & hopper ventilation and unvented mixers (p. 10-69, ACGIH, 2001)
Dust suppressants	Use commercial dry suppressants	N/A	$635	100.0%	Oil-based sawdust sweeping compound

Table V-A-1: Detailed Exposure Control Requirements, Analytical Assumptions and Sources for the Cost Data Applied in OSHA's Analysis of Control Costs in General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Annualized Cost (b)	Applicability [c]	Estimate Source and Assumptions
Substitute wider HEPA vacuum use for compressed air	HEPA available, requires more labor	N/A	$962	100.0%	10 minutes per worker per day
HEPA vacuums	Small HEPA needed	N/A	$1,009	100.0%	Nilfisk HEPA vacuum, 15 gal. capacity (Bibbo, 2003). Assume negligible impact on labor requirements for cleaning
Other glass					
Material handler					
Automated and ventilated unloading equipment	Not costed	N/A	N/A	N/A	
Bag opening station (small facilities only)	LEV	1,513	$8,068	69.0%	Bag opening station (p. 10-19, ACGIH, 2001); applies to small establishments only (69% with <20 employees.).
Batch operator					
Conveyor enclosures	Limit dust and spills	N/A	$967	100.0%	200 feet at $17.10 per linear foot (Landola, 2003)
LEV for batch operator workstation	LEV	1,050	$5,599	100.0%	Bin & hopper ventilation and unvented mixers (p. 10-69, ACGIH, 2001)
Dust suppressants	Use commercial dry suppressants	N/A	$635	100.0%	Oil-based sawdust sweeping compound
Substitute wider HEPA vacuum use for compressed air	HEPA available, requires more labor	N/A	$962	100.0%	10 minutes per worker per day
HEPA vacuums	Small HEPA needed	N/A	$1,009	100.0%	Nilfisk HEPA vacuum, 15 gal. capacity (Bibbo, 2003). Assume negligible impact on labor requirements for cleaning
Mineral Wool					
Material handler					
Automated and ventilated unloading equipment	Not costed	N/A	N/A	N/A	
Bag opening station (small facilities only)	LEV	1,513	$8,068	52.0%	Bag opening station (p. 10-19, ACGIH, 2001); applies to small establishments only (52% with <20 employees.).
Batch operator					

Table V-A-1: Detailed Exposure Control Requirements, Analytical Assumptions and Sources for the Cost Data Applied in OSHA's Analysis of Control Costs in General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Annualized Cost (b)	Applicability [c]	Estimate Source and Assumptions
Conveyor enclosures	Limit dust and spills	N/A	$967	100.0%	200 feet at $17.10 per linear foot (Landola, 2003)
LEV for batch operator workstation	LEV	1,050	$5,599	100.0%	Bin & hopper ventilation and unvented mixers (p. 10-69, ACGIH, 2001)
Dust suppressants	Use commercial dry suppressants	N/A	$635	100.0%	Oil-based sawdust sweeping compound
Substitute wider HEPA vacuum use for compressed air	HEPA available, requires more labor	N/A	$913	100.0%	10 minutes per worker per day
HEPA vacuums	Small HEPA needed	N/A	$1,009	100.0%	Nilfisk HEPA vacuum, 15 gal. Capacity (Bibbo, 2003). Assume negligible impact on labor requirements for cleaning
Concrete Products					
Material handler					
Yard dust suppression	Wetting with yard hose	N/A	$5,614	100.0%	100' of 1" contactor hose and nozzle; 2 year life; (www.pwmall.com). Assumes 1 labor hour per day.
Enclosed cabs	Retrofit with cab or replacement equip	N/A	$7,467	100.0%	ERG estimate based on vendor interviews. Assumes 35% markup for maintenance.
Mixer operator					
Wet methods to clean equipment	Additional cleaning time	N/A	$917	100.0%	10 mins per day per worker
LEV for bag opening stations	LEV with bag dumping station	1,513	$8,068	75.0%	Bag opening station (p. 10-19, ACGIH, 2001)
Ventilated control room and HEPA filter	LEV	200	$3,485	25.0%	ERG estimates based on Means and ACGIH
Forming line operator					
Dust control for adjacent operations	Addressed by other controls	N/A	N/A	N/A	
Abrasive blasting operator					
Use wet process	Shop-built sprayer	N/A	$134	N/A	Assumes 2-year life
Finishing operator					

Table V-A-1: Detailed Exposure Control Requirements, Analytical Assumptions and Sources for the Cost Data Applied in OSHA's Analysis of Control Costs in General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Annualized Cost (b)	Applicability [c]	Estimate Source and Assumptions
Work concrete green	Penalty for overall productivity	N/A	$2,200	25.0%	Assumes 5% productivity penalty per worker; other controls are available
Use wet process	Shop built sprayer	N/A	$134	75.0%	Assumes 2-year life; other controls are available.
LEV where wet methods are infeasible	Shroud and vacuum	not estimated	$993	25.0%	Vacuum plus shroud adapter; 35% for maintenance and operating costs; other controls are available.
Use alternative blast media	Use of more expensive non-silica media	N/A	$33,646	25.0%	Based on 212,000 square feet of coverage per year per crew; assumes 25% of establishments perform open blasting.
Packaging operator					
LEV for bag filling stations	LEV with bag filling station	1,500	$7,998	100.0%	Bag filling station (p. 10-15, ACGIH, 2001)
Extended polyethylene bag valves to reduce dust release	Use bags with dust-control feature	N/A	$4,728	100.0%	Assumes 5 bags per minute; 200 days a year; applies only to bulk product producers in NAICS 327999
Pottery					
Material handler					
Well-ventilated bag dumping stations	LEV	1,513	$5,599	100.0%	Bag opening station (p. 10-19, ACGIH, 2001)
Ventilated cab enclosures	Retrofit with cab or replacement equip	N/A	$7,467	100.0%	ERG estimate based on vendor interviews. Assumes 35% markup for maintenance.
LEV for mixer	LEV	1,050	$5,599	100.0%	Bin & hopper ventilation, unvented mixers (p. 10-69, ACGIH, 2001)
Forming line operator					
LEV- hand grinding bench controls	LEV	1,400	$7,465	100.0%	Bench hood ventilation (p. 10-149, ACGIH, 2001)
Eliminated compressed air (switch to vacuum)	HEPA vacuum plus additional time	N/A	$1,503	100.0%	Nilfisk HEPA vacuum, 15 gal. capacity (Bibbo, 2003). Assume 5 addition minutes of labor time per day.

Table V-A-1: Detailed Exposure Control Requirements, Analytical Assumptions and Sources for the Cost Data Applied in OSHA's Analysis of Control Costs in General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Annualized Cost (b)	Applicability [c]	Estimate Source and Assumptions
Reduce dust generation during mold parting (redesign talc bag)	Cost judged negligible	N/A	N/A	N/A	
Substitute non-silica parting compounds	Option not costed	N/A	N/A	N/A	
Finishing operator					
LEV- hand grinding bench controls	LEV	2,400	$12,797	100.0%	Hand grinding bench (p. 10-135, ACGIH, 2001)
Wet finishing	Option not costed	N/A	N/A	N/A	
Coatings preparer					
Well-ventilated bag dumping stations	LEV	1,513	$8,068	100.0%	Bag opening station (p. 10-19, ACGIH, 2001)
Well-ventilated or enclosed, automated systems for charging mixing equipment with glaze materials	LEV	1,050	$5,599	100.0%	Bin & hopper ventilation and unvented mixers (p. 10-69, ACGIH, 2001)
Coatings operator					
Substitute low silica content inputs	Option not costed	N/A	N/A	N/A	
Improved LEV for spray booths and enclosures	Increased airflow, additional cfm	1,000	$1,333	100.0%	Additional cfm at 25% of installed price
Spray booth maintenance	Booth repairs	N/A	$231	100.0%	Annually, $100 materials plus 4 hours maintenance time
Paint					
Material handler					
No overexposure	No control needed	N/A	N/A	N/A	
Mixer operator					
Substitute low silica content materials	Not generally control of choice	N/A	N/A	N/A	
Well-ventilated bag dumping stations	LEV	1,513	$8,068	100.0%	Bag opening station (p. 10-19 ACGIH, 2001)
Structural Clay					
Material handler/loader operator					
Enclosed, ventilated cab	Retrofit with cab or replace equipment	N/A	$7,467	100.0%	ERG estimate based on vendor interviews. Assumes 35% markup for maintenance.
Thorough, semi-annual professional cleaning	Commercial cleaning service	N/A	N/A	N/A	Addressed in program costs
Improve cab maintenance and keep windows closed	Use existing cabs for dust control	N/A	$758	100.0%	Judged to be incremental cost equal to one-half normal

Table V-A-1: Detailed Exposure Control Requirements, Analytical Assumptions and Sources for the Cost Data Applied in OSHA's Analysis of Control Costs in General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Annualized Cost (b)	Applicability [c]	Estimate Source and Assumptions
					maintenance cost
Cover conveyors in material handling area	Conveyor covers	N/A	$967	100.0%	200 feet at $17.10 per linear foot (Landola, 2003)
Apply LEV to conveyors in material handling area	LEV	10,000	$53,322	100.0%	ERG estimate of cfm requirements.
Material handler/production					
Misters on conveyor line	Water spray to suppress dust	N/A	$2,474	50.0%	100 feet of conveyor. National Environmental Services Company (Kestner, 2003).
LEV, push-pull system	LEV	4,000	$21,329	50.0%	Assumes twice the airflow for a clean air island (1,500 cfm).
Material handler/post-production					
Misters on conveyor line	Water spray to suppress dust	N/A	$2,474	100.0%	100 feet of conveyor. National Environmental Services Company (Kestner, 2003).
Dust suppression in yard	Option not costed	N/A	N/A	N/A	
Grinding operator					
Ventilated control room and HEPA filter	LEV	200	$3,485	30.0%	ERG estimates based on Means, 2003 and ACGIH, 2001; Assumes 30% of establishments need new control room.
Control room improvements and repairs	In-house repairs	N/A	$319	70.0%	Assumes repairs are 20% of new control room cost; assumes 70% of establishments need control room improvements.
Enclosures with LEV for grinding equipment	LEV	17,000	$90,647	100.0%	Additional ventilation equal to half the total cfm required for a medium sized facility; ERG estimate based on consultant input.
Purchase additional HEPA vacuums	0	N/A	$1,009	100.0%	Nilfisk HEPA vacuum, 15 gal. capacity (Bibbo, 2003). Assume negligible impact on labor requirements for cleaning
Enhanced housekeeping with HEPA	Labor costs	N/A	$1,772	100.0%	Additional 20 minutes per day

Table V-A-1: Detailed Exposure Control Requirements, Analytical Assumptions and Sources for the Cost Data Applied in OSHA's Analysis of Control Costs in General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Annualized Cost (b)	Applicability [c]	Estimate Source and Assumptions
vacuums					
Cover conveyors in grinding area	Conveyor covers	N/A	$967	100.0%	200 feet at $17.10 per linear foot (Landola, 2003)
Dust suppression for raw materials	0	N/A	$635	100.0%	$0.22/lb (www.fastenal.com); 2 lbs used per day; 5 labor minutes per day.
Tightly sealed storage units	Option not costed	N/A	N/A	N/A	
Forming line operator/pug mill operator					
Enclosed and ventilated pug mill equipment	0	6,000	$31,993	100.0%	ERG estimate based on consultant input.
Forming line operator/coatings blender					
Well-ventilated bag dumping stations	0	1,513	$8,068	50.0%	Bag opening station (p. 10-19, ACGIH, 2001); installation of control adequate for 50% of establishments.
Enclosed and ventilated feed hopper, conveyors, tumble tote charging, and transfer to transfer tote	Best judgment	9,000	$47,990	50.0%	ERG estimate based on consultant input; more extensive controls needed for 50% of establishments.
Improved area cleanup with HEPA or central vacuum system	0	N/A	$1,009	100.0%	Nilfisk HEPA vacuum, 15 gal. capacity (Bibbo, 2003). Assume negligible impact on labor requirements for cleaning.
Enhanced housekeeping with HEPA vacuums	Labor costs	N/A	$1,772	100.0%	Additional 20 minutes per day
Forming line operator/formers					
Improved area cleanup with HEPA or central vacuum system	0	N/A	$1,009	100.0%	Nilfisk HEPA vacuum, 15 gal. capacity (Bibbo, 2003). Assume negligible impact on labor requirements for cleaning
Enhanced housekeeping with HEPA vacuums	0	N/A	$1,772	100.0%	Additional 20 minutes per day
Well-ventilated bag dumping stations	0	1,513	$8,068	50.0%	Bag opening station (p. 10-19, ACGIH, 2001); installation of control adequate for 50% of establishments.

Table V-A-1: Detailed Exposure Control Requirements, Analytical Assumptions and Sources for the Cost Data Applied in OSHA's Analysis of Control Costs in General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Annualized Cost (b)	Applicability [c]	Estimate Source and Assumptions
Enclosed and ventilated workstations	LEV plus clean air island	3,550	$18,929	50.0%	ERG estimate based on consultant input; assumes control needed for 50% of establishments.
Dental laboratories					
Dental technician					
Improved LEV in grinding, blasting	Dental lab dust control systems	N/A	$194	100.0%	Self-contained dust collection system. Darby Dental Lab Supply, 2005 (www.darbylab.com)
Fine jewelry					
Jewelry workers					
Substitution of low-silica modeling/investment materials	Not costed	N/A	N/A	N/A	
LEV for abrasive blasting and finishing	Small-scale jewelry bench LEV	100	$533	100.0%	Small-scale LEV adequate
Costume Jewelry					
Jewelry workers					
Substitution of low-silica modeling/investment materials	Not costed	N/A	N/A	N/A	
LEV for abrasive blasting and finishing	Small-scale jewelry bench LEV	100	$533	100.0%	Small-scale LEV adequate
Refractories					
Material handler					
Ventilated bag dumping stations with bag compactor	LEV	1,513	$8,068	100.0%	Bag opening station (3.5'x1.5' opening); (p. 10-19, ACGIH, 2001); 3.5'x1.5' opening; with ventilated bag crusher (200 cfm)
Enclosed and ventilated mixing equipment	LEV	1,050	$5,599	100.0%	Mixer & muller hood (p. 10-87, ACGIH, 2001)
Forming Operator					
Increased LEV maintenance	Additional cost per operator	N/A	$344	100.0%	Assumes 1 hour additional maintenance time per operator per month

Table V-A-1: Detailed Exposure Control Requirements, Analytical Assumptions and Sources for the Cost Data Applied in OSHA's Analysis of Control Costs in General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Annualized Cost (b)	Applicability [c]	Estimate Source and Assumptions
Finishing operator					
No overexposures	N/A	N/A	N/A	N/A	
Ceramic fiber furnace operator					
No overexposures	N/A	N/A	N/A	N/A	
Packaging operator					
LEV for bag filling stations	LEV/ per cfm	1,500	$7,998	100.0%	Bag filling station (p. 10-15, ACGIH, 2001). Includes costs for air shower
Bag valves to reduce dust release		N/A	$4,728	100.0%	Assumes 5 bags per minute; 200 days a year
Ready-Mix Concrete					
Material handler					
Yard dust suppression	Wetting with yard hose	N/A	$5,614	50.0%	100' of 1" contactor hose and nozzle; 2 year life; (www.pwmall.com). Assumes 1 labor hour per day.
Enclosed cabs	Retrofit with cab or replacement equip	N/A	$7,467	50.0%	ERG estimate based on vendor interviews. Assumes 35% markup for maintenance.
Batch operator					
No overexposures	No controls necessary	N/A	N/A	N/A	
Maintenance operator					
Wet methods to clean equipment	Additional cleaning time	N/A	$917	100.0%	10 mins per day per worker
Quality control technician					
No overexposures	No controls necessary	N/A	N/A	N/A	
Truck driver					
Wet methods for drum cleaning	Water fed chipping equipment	N/A	$117	100.0%	Estimated annualized retrofit cots.
Ventilation for drum cleaning	Forced ventilation	N/A	$392	100.0%	Electric blower (1,277 cfm) and 25 ft. of duct. Northern Safety Co. (p. 193). Assumed 5-year

Table V-A-1: Detailed Exposure Control Requirements, Analytical Assumptions and Sources for the Cost Data Applied in OSHA's Analysis of Control Costs in General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Annualized Cost (b)	Applicability [c]	Estimate Source and Assumptions
					life.
Iron Foundries					
Sand mixer (muller) operator					
LEV, mixer & muller hood	LEV	1,050	$5,599	100.0%	Mixer & muller hood (p. 10-87, ACGIH, 2001)
Conveyor enclosures	200 feet, ventilated (7 take-off points)	4,900	$26,696	100.0%	Conveyor belt ventilation; (p. 10-70, ACGIH, 2001); 2' wide belt; one take-off point at-least every 30', 7 overall
Bin and hopper ventilation	LEV	1,050	$5,599	100.0%	Bin & hopper ventilation for unvented mixers (p. 10-69, ACGIH, 2001)
Bucket elevator ventilation	LEV	1,600	$8,531	100.0%	Bucket elevator ventilation (p. 10-68; ACGIH, 2001); 2'x3'x30' casing; 4 take-offs @250 cfm; 100 cfm per sq. ft. of cross section
Screen ventilation	LEV	1,200	$6,399	100.0%	Ventilated screen (p. 10-173, ACGIH, 2001); 4'x6' screen; 50 cfm per ft.^{2}
Substitute silica-free materials	Option not costed	N/A	N/A	N/A	
Molder					
Upgraded sand handling equipment - covered elsewhere		N/A	N/A	N/A	
Upgrade or install LEV	LEV	1,050	$5,599	100.0%	Bin & hopper ventilation (p. 10-69, ACGIH, 2001)
Rigorous housekeeping- capital	HEPA vacuum	N/A	$1,009	100.0%	Nilfisk HEPA vacuum, 15 gal. capacity (Bibbo, 2003). Assume negligible impact on labor requirements for cleaning
Rigorous housekeeping- labor	Labor costs	N/A	$1,922	100.0%	Additional 20 minutes of labor time per day
Eliminated compressed air	Included in rigorous housekeeping	N/A	N/A	N/A	
Coremaker					
Eliminated compressed air	Additional labor time	N/A	$961	100.0%	10 minutes per worker per day
Enclosed conveyors, covered elsewhere		N/A	N/A	N/A	

Table V-A-1: Detailed Exposure Control Requirements, Analytical Assumptions and Sources for the Cost Data Applied in OSHA's Analysis of Control Costs in General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Annualized Cost (b)	Applicability [c]	Estimate Source and Assumptions
Non-silica cores and core coatings	Option not costed	N/A	N/A	N/A	
Professional-level cleaning	Covered by program requirements	N/A	N/A	N/A	
Furnace operator					
Control dust releases from adjacent processes - covered elsewhere		N/A	N/A	N/A	
Well-maintained furnace emission control system		N/A	$461	100.0%	20 hours additional maintenance time per year
Minimize dust generated by sand contamination of scrap	Option not costed	N/A	N/A	N/A	
Pouring operator					
Control dust from adjacent processes - covered elsewhere		N/A	N/A	N/A	
Operator booths or cabs	Based on clean-air island costs	2,500	$13,330	100.0%	Assumes 125 cfm/sq. ft. for 20 square feet.
Physical isolation of pouring area (create a pouring room)	Option not costed	N/A	N/A	N/A	
Modify ventilation system to reduce airflow from other areas into the pouring area	Option not costed	N/A	N/A	N/A	
Shakeout operator					
Improve existing ventilation system efficiency (very large castings)	Double-draft shake-out table	28,800	$153,567	10.0%	Shakeout double side-draft table (p. 10-23, ACGIH, 2001); assumes control needed for 10% of establishments producing large castings.
Improve existing ventilation system efficiency	Shakeout enclosing hood	7,040	$12,862	90.0%	Ventilated enclosing hood (p. 10-23, ACGIH, 2001); 4'x4' openings; assumes control adequate except for establishments producing large castings (10%).
Partially enclose process	Enclosed, ventilated shakeout conveyor	10,000	$53,322	100.0%	ERG estimate, based on expert input.
Control emissions from associated operations - covered elsewhere		N/A	N/A	N/A	
Knockout operator					

Table V-A-1: Detailed Exposure Control Requirements, Analytical Assumptions and Sources for the Cost Data Applied in OSHA's Analysis of Control Costs in General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Annualized Cost (b)	Applicability [c]	Estimate Source and Assumptions
Installing and improving LEV	Small knockout table	1,350	$2,466	50.0%	Portable grinding table (p. 10-136, ACGIH, 2001), 3'x3' opening; control assumed appropriate for 50% of establishments.
Installing and improving LEV	Large knockout table	4,800	$8,769	50.0%	Hand grinding table (p. 10-135, ACGIH, 2001), 4'x6' surface; control assumed appropriate for 50% of establishments.
Installing and improving LEV	Ventilated abrasive cutoff saw	1,500	$2,740	50.0%	Ventilated cut-off saw (p. 10-134, ACGIH, 2001), 2'x3' opening; control assumed appropriate for 50% of establishments.
Reduce residual sand on castings	Option not costed	N/A	N/A	N/A	
Automate knockout process	Option not costed	N/A	N/A	N/A	
Abrasive blasting operator					
Improved maintenance for blasting cabinet		N/A	$1,349	100.0%	Assumes 50% increase in maintenance costs (of up to $2,000) and purchase of new cabinets (25%) at $8,000/cabinet (Norton, 2003), or additional interlocks at $1,800/cabinet (Heastrup, 2003).
Cleaning/finishing operator					
LEV for workstations	Hand grinding bench	3,750	$19,996	50.0%	Bench with LEV (p. 10-135, ACGIH, 2001); 3'x5'; control assumed appropriate for 50% of establishments,
LEV on hand tools		200	$767	50.0%	ERG estimate of cfm; control assumed appropriate for 50% of establishments.
Eliminated compressed air (switch to vacuum)	HEPA vacuum plus additional time	N/A	$1,503	100.0%	Nilfisk HEPA vacuum, 15 gal. capacity (Bibbo, 2003). Assume 5 mins additional time per day.
Substitution with non-silica materials	Option not costed	N/A	N/A	N/A	

Table V-A-1: Detailed Exposure Control Requirements, Analytical Assumptions and Sources for the Cost Data Applied in OSHA's Analysis of Control Costs in General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Annualized Cost (b)	Applicability [c]	Estimate Source and Assumptions
Process automation	Option not costed	N/A	N/A	N/A	
Wet methods	Option not costed	N/A	N/A	N/A	
Pre-cleaning with automated equipment	Option not costed	N/A	N/A	N/A	
Material handler					
Enclosed, ventilated cab	Retrofit with cab or replace equipment	N/A	$7,467	100.0%	ERG estimate based on vendor interviews. Assumes 35% markup for maintenance.
Maintenance operator					
Use low silica refractory	Option not costed	N/A	N/A	N/A	
LEV for chipping tools	Dust collector with HEPA vacuum	N/A	$993	100.0%	Vacuum plus shroud adapter; 35% for maintenance and operating costs. Assumes 5-year life.
Pre-wetting lining to be removed	Additional labor	N/A	$3,325	100.0%	2 hours per week
Maintaining moisture level in the refractory applied	Additional labor	N/A	$1,662	100.0%	1 hour per week
Also, use of precast refractories and automated equipment for powdered refractory materials	Option not costed	N/A	N/A	N/A	
Housekeeping worker					
Controls not identified		N/A	N/A	N/A	
Professional-level cleaning	Covered by program requirements	N/A	N/A	N/A	
Other Ferrous Sand Casting Foundries					
Sand mixer (muller) operator					
LEV, mixer & muller hood	LEV	1,050	$5,599	100.0%	Mixer & muller hood (p. 10-87, ACGIH, 2001)
Conveyor enclosures	200 feet, ventilated (7 take-off points)	4,900	$26,696	100.0%	Conveyor belt ventilation; (p. 10-70, ACGIH, 2001); 2' wide belt; one take-off point at-least every 30', 7 overall
Bin and hopper ventilation	LEV	1,050	$5,599	100.0%	Bin & hopper ventilation for unvented mixers (p. 10-69, ACGIH, 2001)
Bucket elevator ventilation	LEV	1,600	$8,531	100.0%	Bucket elevator ventilation (p. 10-68; ACGIH, 2001); 2'x3'x30' casing; 4 take-offs @250 cfm;

Table V-A-1: Detailed Exposure Control Requirements, Analytical Assumptions and Sources for the Cost Data Applied in OSHA's Analysis of Control Costs in General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Annualized Cost (b)	Applicability [c]	Estimate Source and Assumptions
					100 cfm per sq. ft. of cross section
Screen ventilation	LEV	1,200	$6,399	100.0%	Ventilated screen (p. 10-173, ACGIH, 2001); 4'x6' screen; 50 cfm per ft^2
Substitute silica-free materials	Option not costed	N/A	N/A	N/A	
Molder					
Upgraded sand handling equipment - covered elsewhere		N/A	N/A	N/A	
Upgrade or install LEV	LEV	1,050	$5,599	100.0%	Bin & hopper ventilation (p. 10-69, ACGIH, 2001)
Rigorous housekeeping- capital	HEPA vacuum	N/A	$1,009	100.0%	Nilfisk HEPA vacuum, 15 gal. capacity (Bibbo, 2003). Assume negligible impact on labor requirements for cleaning
Rigorous housekeeping- labor	Labor costs	N/A	$1,922	100.0%	Additional 20 minutes of labor time per day
Eliminated compressed air	Included in rigorous housekeeping	N/A	N/A	N/A	
Coremaker					
Eliminated compressed air	Additional labor time	N/A	$961	100.0%	10 minutes per worker per day
Enclosed conveyors, covered elsewhere		N/A	N/A	N/A	
Non-silica cores and core coatings	Option not costed	N/A	N/A	N/A	
Professional-level cleaning	Covered by program requirements	N/A	N/A	N/A	
Furnace operator					
Control dust releases from adjacent processes - covered elsewhere		N/A	N/A	N/A	
Well-maintained furnace emission control system		N/A	$461	100.0%	20 hours additional maintenance time per year
Minimize dust generated by sand contamination of scrap	Option not costed	N/A	N/A	N/A	
Pouring operator					
Control dust from adjacent processes - covered elsewhere		N/A	N/A	N/A	
Operator booths or cabs	Based on clean-air	2,500	$13,330	100.0%	Assumes 125 cfm/sq. ft. for 20

Table V-A-1: Detailed Exposure Control Requirements, Analytical Assumptions and Sources for the Cost Data Applied in OSHA's Analysis of Control Costs in General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Annualized Cost (b)	Applicability [c]	Estimate Source and Assumptions
	island costs				square feet.
Physical isolation of pouring area (create a pouring room)	Option not costed	N/A	N/A	N/A	
Modify ventilation system to reduce airflow from other areas into the pouring area	Option not costed	N/A	N/A	N/A	
Shakeout operator					
Improve existing ventilation system efficiency (very large castings)	Double-draft shake-out table	28,800	$153,567	10.0%	Shakeout double side-draft table (p. 10-23, ACGIH, 2001); assumes control needed for 10% of establishments producing large castings.
Improve existing ventilation system efficiency	Shakeout enclosing hood	7,040	$37,539	90.0%	Ventilated enclosing hood (p. 10-23, ACGIH, 2001); 4'x4' openings; assumes control adequate except for establishments producing large castings (10%).
Partially enclose process	Enclosed, ventilated shakeout conveyor	10,000	$53,322	100.0%	ERG estimate based on expert input.
Control emissions from associated operations - covered elsewhere	Enclosed, ventilated shakeout conveyor	N/A	N/A	N/A	
Knockout operator					
Installing and improving LEV	Small knockout table	1,350	$7,198	50.0%	Portable grinding table (p. 10-136, ACGIH, 2001), 3'x3' opening; control assumed appropriate for 50% of establishments.
Installing and improving LEV	Large knockout table	4,800	$25,594	50.0%	Hand grinding table (p. 10-135, ACGIH, 2001), 4'x6' surface; control assumed appropriate for 50% of establishments.
Installing and improving LEV	Ventilated abrasive cutoff saw	1,500	$7,998	50.0%	Ventilated cut-off saw (p. 10-134, ACGIH, 2001), 2'x3' opening; control assumed appropriate for 50% of establishments.
Reduce residual sand on castings	Option not costed	N/A	N/A	N/A	

Table V-A-1: Detailed Exposure Control Requirements, Analytical Assumptions and Sources for the Cost Data Applied in OSHA's Analysis of Control Costs in General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Annualized Cost (b)	Applicability [c]	Estimate Source and Assumptions
Automate knockout process	Option not costed	N/A	N/A	N/A	
Abrasive blasting operator					
Improved maintenance for blasting cabinet		N/A	$1,349	100.0%	Assumes 50% increase in maintenance costs (of up to $2,000) and purchase of new cabinets (25%) at $8,000/cabinet (Norton, 2003), or additional interlocks at $1,800/cabinet (Heastrup, 2003).
Cleaning/finishing operator					
LEV for workstations	Hand grinding bench	3,750	$19,996	50.0%	Bench with LEV (p. 10-135, ACGIH, 2001); 3'x5'; control assumed appropriate for 50% of establishments,
LEV on hand tools		200	$767	50.0%	ERG estimate of cfm; control assumed appropriate for 50% of establishments.
Eliminated compressed air (switch to vacuum)	HEPA vacuum plus additional time	N/A	$1,503	100.0%	Nilfisk HEPA vacuum, 15 gal. capacity (Bibbo, 2003). Assume 5 mins additional time per day.
Substitution with non-silica materials	Option not costed	N/A	N/A	N/A	
Process automation	Option not costed	N/A	N/A	N/A	
Wet methods	Option not costed	N/A	N/A	N/A	
Pre-cleaning with automated equipment	Option not costed	N/A	N/A	N/A	
Material handler					
Enclosed, ventilated cab	Retrofit with cab or replace equipment	N/A	$7,467	100.0%	ERG estimate based on vendor interviews. Assumes 35% markup for maintenance.
Maintenance operator					
Use low silica refractory	Option not costed	N/A	N/A	N/A	

Table V-A-1: Detailed Exposure Control Requirements, Analytical Assumptions and Sources for the Cost Data Applied in OSHA's Analysis of Control Costs in General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Annualized Cost (b)	Applicability [c]	Estimate Source and Assumptions
LEV for chipping tools	Dust collector with HEPA vacuum	N/A	$993	100.0%	Vacuum plus shroud adapter; 35% for maintenance and operating costs. Assumes 5-year life.
Pre-wetting lining to be removed	Additional labor	N/A	$3,325	100.0%	2 hours per week
Maintaining moisture level in the refractory applied	Additional labor	N/A	$1,662	100.0%	1 hour per week
Also, use of precast refractories and automated equipment for powdered refractory materials	Option not costed	N/A	N/A	N/A	
Housekeeping worker					
Controls not identified		N/A	N/A	N/A	
Professional-level cleaning	Covered by program requirements	N/A	N/A	N/A	
Nonferrous Sand Casting Foundries					
Sand mixer (muller) operator					
LEV, mixer & muller hood	LEV	1,050	$5,599	100.0%	Mixer & muller hood (p. 10-87, ACGIH, 2001)
Conveyor enclosures	200 feet, ventilated (7 take-off points)	4,900	$26,696	100.0%	Conveyor belt ventilation; (p. 10-70, ACGIH, 2001); 2' wide belt; one take-off point at-least every 30', 7 overall
Bin and hopper ventilation	LEV	1,050	$5,599	100.0%	Bin & hopper ventilation for unvented mixers (p. 10-69, ACGIH, 2001)
Bucket elevator ventilation	LEV	1,600	$8,531	100.0%	Bucket elevator ventilation (p. 10-68; ACGIH, 2001); 2'x3'x30' casing; 4 take-offs @250 cfm; 100 cfm per sq. ft. of cross section
Screen ventilation	LEV	1,200	$6,399	100.0%	Ventilated screen (p. 10-173, ACGIH, 2001); 4'x6' screen; 50 cfm per ft^2
Substitute silica-free materials	Option not costed	N/A	N/A	N/A	
Molder					
Upgraded sand handling equipment - covered elsewhere		N/A	N/A	N/A	

Table V-A-1: Detailed Exposure Control Requirements, Analytical Assumptions and Sources for the Cost Data Applied in OSHA's Analysis of Control Costs in General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Annualized Cost (b)	Applicability [c]	Estimate Source and Assumptions
Upgrade or install LEV	LEV	1,050	$5,599	100.0%	Bin & hopper ventilation (p. 10-69, ACGIH, 2001)
Rigorous housekeeping- capital	HEPA vacuum	N/A	$1,009	100.0%	Nilfisk HEPA vacuum, 15 gal. capacity (Bibbo, 2003). Assume negligible impact on labor requirements for cleaning
Rigorous housekeeping- labor	Labor costs	N/A	$1,922	100.0%	Additional 20 minutes of labor time per day
Eliminated compressed air	Included in rigorous housekeeping	N/A	N/A	N/A	
Coremaker					
Eliminated compressed air	Additional labor time	N/A	$961	100.0%	10 minutes per worker per day
Enclosed conveyors, covered elsewhere		N/A	N/A	N/A	
Non-silica cores and core coatings	Option not costed	N/A	N/A	N/A	
Professional-level cleaning	Covered by program requirements	N/A	N/A	N/A	
Furnace operator					
Control dust releases from adjacent processes - covered elsewhere		N/A	N/A	N/A	
Well-maintained furnace emission control system		N/A	$461	100.0%	20 hours additional maintenance time per year
Minimize dust generated by sand contamination of scrap	Option not costed	N/A	N/A	N/A	
Control dust from adjacent processes - covered elsewhere		N/A	N/A	N/A	
Pouring operator					
Operator booths or cabs	Based on clean-air island costs	2,500	$13,330	100.0%	Assumes 125 cfm/sq. ft. for 20 square feet.
Physical isolation of pouring area (create a pouring room)	Option not costed	N/A	N/A	N/A	
Modify ventilation system to reduce airflow from other areas into the pouring area	Option not costed	N/A	N/A	N/A	
Shakeout operator					
Improve existing ventilation system efficiency (very large castings)	Double-draft shake-out table	28,800	$153,567	10.0%	Shakeout double side-draft table (p. 10-23, ACGIH, 2001); assumes control needed for

Table V-A-1: Detailed Exposure Control Requirements, Analytical Assumptions and Sources for the Cost Data Applied in OSHA's Analysis of Control Costs in General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Annualized Cost (b)	Applicability [c]	Estimate Source and Assumptions
					10% of establishments producing large castings.
Improve existing ventilation system efficiency	Shakeout enclosing hood	7,040	$37,539	90.0%	Ventilated enclosing hood (p. 10-23, ACGIH, 2001); 4'x4' openings; assumes control adequate except for establishments producing large castings (10%).
Partially enclose process	Enclosed, ventilated shakeout conveyor	10,000	$53,322	100.0%	ERG estimate based on expert input.
Control emissions from associated operations - covered elsewhere		N/A	N/A	N/A	
Knockout operator					
Installing and improving LEV	Small knockout table	1,350	$7,198	50.0%	Portable grinding table (p. 10-136, ACGIH, 2001), 3'x3' opening; control assumed appropriate for 50% of establishments.
Installing and improving LEV	Large knockout table	4,800	$25,594	50.0%	Hand grinding table (p. 10-135, ACGIH, 2001), 4'x6' surface; control assumed appropriate for 50% of establishments.
Installing and improving LEV	Ventilated abrasive cutoff saw	1,500	$7,998	50.0%	Ventilated cut-off saw (p. 10-134, ACGIH, 2001), 2'x3' opening; control assumed appropriate for 50% of establishments.
Reduce residual sand on castings	Option not costed	N/A	N/A	N/A	
Automate knockout process	Option not costed	N/A	N/A	N/A	
Abrasive blasting operator					
Improved maintenance for blasting cabinet		N/A	$1,349	100.0%	Assumes 50% increase in maintenance costs (of up to $2,000) and purchase of new cabinets (25%) at $8,000/cabinet (Norton, 2003), or additional interlocks at $1,800/cabinet (Heastrup,

Table V-A-1: Detailed Exposure Control Requirements, Analytical Assumptions and Sources for the Cost Data Applied in OSHA's Analysis of Control Costs in General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Annualized Cost (b)	Applicability [c]	Estimate Source and Assumptions
					2003).
Cleaning/finishing operator					
LEV for workstations	Hand grinding bench	3,750	$19,996	50.0%	Bench with LEV (p. 10-135, ACGIH, 2001); 3'x5'; control assumed appropriate for 50% of establishments,
LEV on hand tools		200	$767	50.0%	ERG estimate of cfm; control assumed appropriate for 50% of establishments.
Eliminated compressed air (switch to vacuum)	HEPA vacuum plus additional time	N/A	$1,503	100.0%	Nilfisk HEPA vacuum, 15 gal. capacity (Bibbo, 2003). Assume 5 mins additional time per day.
Substitution with non-silica materials	Option not costed	N/A	N/A	N/A	
Process automation	Option not costed	N/A	N/A	N/A	
Wet methods	Option not costed	N/A	N/A	N/A	
Pre-cleaning with automated equipment	Option not costed	N/A	N/A	N/A	
Material handler					
Enclosed, ventilated cab	Retrofit with cab or replace equipment	N/A	$7,467	100.0%	ERG estimate based on vendor interviews. Assumes 35% markup for maintenance.
Maintenance operator					
Use low silica refractory	Option not costed	N/A	N/A	N/A	
LEV for chipping tools	Dust collector with HEPA vacuum	N/A	$993	100.0%	Vacuum plus shroud adapter; 35% for maintenance and operating costs. Assumes 5-year life.
Pre-wetting lining to be removed	Additional labor	N/A	$3,325	100.0%	2 hours per week
Maintaining moisture level in the refractory applied	Additional labor	N/A	$1,662	100.0%	1 hour per week
Also, use of precast refractories and automated equipment for powdered refractory materials	Option not costed	N/A	N/A	N/A	
Housekeeping worker					

Table V-A-1: Detailed Exposure Control Requirements, Analytical Assumptions and Sources for the Cost Data Applied in OSHA's Analysis of Control Costs in General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Annualized Cost (b)	Applicability [c]	Estimate Source and Assumptions
Controls not identified		N/A	N/A	N/A	
Professional-level cleaning	Covered by program requirements	N/A	N/A	N/A	
Non-Sand Casting Foundries					
Sand mixer (muller) operator					
LEV, mixer & muller hood	LEV	1,050	$5,599	100.0%	Mixer & muller hood (p. 10-87, ACGIH, 2001)
Conveyor enclosures	200 feet, ventilated (7 take-off points)	4,900	$26,696	100.0%	Conveyor belt ventilation; (p. 10-70, ACGIH, 2001); 2' wide belt; one take-off point at-least every 30', 7 overall
Bin and hopper ventilation	LEV	1,050	$5,599	100.0%	Bin & hopper ventilation for unvented mixers (p. 10-69, ACGIH, 2001)
Bucket elevator ventilation	LEV	1,600	$8,531	100.0%	Bucket elevator ventilation (p. 10-68; ACGIH, 2001); 2'x3'x30' casing; 4 take-offs @250 cfm; 100 cfm per sq. ft. of cross section
Screen ventilation	LEV	1,200	$6,399	100.0%	Ventilated screen (p. 10-173, ACGIH, 2001); 4'x6' screen; 50 cfm per ft.[2]
Substitute silica-free materials	Option not costed	N/A	N/A	N/A	
Molder					
Upgraded sand handling equipment - covered elsewhere		N/A	N/A	N/A	
Upgrade or install LEV	LEV	1,050	$5,599	100.0%	Bin & hopper ventilation (p. 10-69, ACGIH, 2001)
Rigorous housekeeping- capital	HEPA vacuum	N/A	$1,009	100.0%	Nilfisk HEPA vacuum, 15 gal. capacity (Bibbo, 2003). Assume negligible impact on labor requirements for cleaning
Rigorous housekeeping- labor	Labor costs	N/A	$1,922	100.0%	Additional 20 minutes of labor time per day
Eliminated compressed air	Included in rigorous housekeeping	N/A	N/A	N/A	
Coremaker					

Table V-A-1: Detailed Exposure Control Requirements, Analytical Assumptions and Sources for the Cost Data Applied in OSHA's Analysis of Control Costs in General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Annualized Cost (b)	Applicability [c]	Estimate Source and Assumptions
Eliminated compressed air	Additional labor time	N/A	$961	100.0%	10 minutes per worker per day
Enclosed conveyors, covered elsewhere		N/A	N/A	N/A	
Non-silica cores and core coatings	Option not costed	N/A	N/A	N/A	
Professional-level cleaning	Covered by program requirements	N/A	N/A	N/A	
Furnace operator					
Control dust releases from adjacent processes - covered elsewhere		N/A	N/A	N/A	
Well-maintained furnace emission control system		N/A	$461	100.0%	20 hours additional maintenance time per year
Minimize dust generated by sand contamination of scrap	Option not costed	N/A	N/A	N/A	
Pouring operator					
Control dust from adjacent processes - covered elsewhere		N/A	N/A	N/A	
Operator booths or cabs	Based on clean-air island costs	2,500	$13,330	100.0%	Assumes 125 cfm/sq. ft. for 20 square feet.
Physical isolation of pouring area (create a pouring room)	Option not costed	N/A	N/A	N/A	
Modify ventilation system to reduce airflow from other areas into the pouring area	Option not costed	N/A	N/A	N/A	
Shakeout operator					
Improve existing ventilation system efficiency (very large castings)	Double-draft shake-out table	28,800	$153,567	10.0%	Shakeout double side-draft table (p. 10-23, ACGIH, 2001); assumes control needed for 10% of establishments producing large castings.
Improve existing ventilation system efficiency	Shakeout enclosing hood	7,040	$37,539	90.0%	Ventilated enclosing hood (p. 10-23, ACGIH, 2001); 4'x4' openings; assumes control adequate except for establishments producing large castings (10%).
Partially enclose process	Enclosed, ventilated shakeout conveyor	10,000	$53,322	100.0%	ERG estimate based on expert input.
Control emissions from associated		N/A	N/A	N/A	

Table V-A-1: Detailed Exposure Control Requirements, Analytical Assumptions and Sources for the Cost Data Applied in OSHA's Analysis of Control Costs in General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Annualized Cost (b)	Applicability [c]	Estimate Source and Assumptions
operations - covered elsewhere					
Knockout operator					
Installing and improving LEV	Small knockout table	1,350	$7,198	50.0%	Portable grinding table (p. 10-136, ACGIH, 2001), 3'x3' opening; control assumed appropriate for 50% of establishments.
Installing and improving LEV	Large knockout table	4,800	$25,594	50.0%	Hand grinding table (p. 10-135, ACGIH, 2001), 4'x6' surface; control assumed appropriate for 50% of establishments.
Installing and improving LEV	Ventilated abrasive cutoff saw	1,500	$7,998	50.0%	Ventilated cut-off saw (p. 10-134, ACGIH, 2001), 2'x3' opening; control assumed appropriate for 50% of establishments.
Reduce residual sand on castings	Option not costed	N/A	N/A	N/A	
Automate knockout process	Option not costed	N/A	N/A	N/A	
Abrasive blasting operator					
Improved maintenance for blasting cabinet		N/A	$1,349	100.0%	Assumes 50% increase in maintenance costs (of up to $2,000) and purchase of new cabinets (25%) at $8,000/cabinet (Norton, 2003), or additional interlocks at $1,800/cabinet (Heastrup, 2003).
Cleaning/finishing operator					
LEV for workstations	Hand grinding bench	3,750	$19,996	50.0%	Bench with LEV (p. 10-135, ACGIH, 2001); 3'x5'; control assumed appropriate for 50% of establishments,
LEV on hand tools		200	$767	50.0%	ERG estimate of cfm; control assumed appropriate for 50% of establishments.
Eliminated compressed air (switch to vacuum)	HEPA vacuum plus additional time	N/A	$1,503	100.0%	Nilfisk HEPA vacuum, 15 gal. capacity (Bibbo, 2003).

Table V-A-1: Detailed Exposure Control Requirements, Analytical Assumptions and Sources for the Cost Data Applied in OSHA's Analysis of Control Costs in General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Annualized Cost (b)	Applicability [c]	Estimate Source and Assumptions
					Assume 5 mins additional time per day.
Substitution with non-silica materials	Option not costed	N/A	N/A	N/A	
Process automation	Option not costed	N/A	N/A	N/A	
Wet methods	Option not costed	N/A	N/A	N/A	
Pre-cleaning with automated equipment	Option not costed	N/A	N/A	N/A	
Material handler					
Enclosed, ventilated cab	Retrofit with cab or replace equipment	N/A	$7,467	100.0%	ERG estimate based on vendor interviews. Assumes 35% markup for maintenance.
Maintenance operator					
Use low silica refractory	Option not costed	N/A	N/A	N/A	
LEV for chipping tools	Dust collector with HEPA vacuum	N/A	$993	100.0%	Vacuum plus shroud adapter; 35% for maintenance and operating costs. Assumes 5-year life.
Pre-wetting lining to be removed	Additional labor	N/A	$3,325	100.0%	2 hours per week
Maintaining moisture level in the refractory applied	Additional labor	N/A	$1,662	100.0%	1 hour per week
Also, use of precast refractories and automated equipment for powdered refractory materials	Option not costed	N/A	N/A	N/A	
Housekeeping worker					
Controls not identified		N/A	N/A	N/A	
Professional-level cleaning	Covered by program requirements	N/A	N/A	N/A	
Captive Foundries					
Sand mixer (muller) operator					
LEV, mixer & muller hood	LEV	1,050	$5,599	100.0%	Mixer & muller hood (p. 10-87, ACGIH, 2001)
Conveyor enclosures	200 feet, ventilated (7 take-off points)	4,900	$26,696	100.0%	Conveyor belt ventilation; (p. 10-70, ACGIH, 2001); 2' wide belt; one take-off point at-least every 30', 7 overall
Bin and hopper ventilation	LEV	1,050	$5,599	100.0%	Bin & hopper ventilation for unvented mixers (p. 10-69, ACGIH, 2001)

Table V-A-1: Detailed Exposure Control Requirements, Analytical Assumptions and Sources for the Cost Data Applied in OSHA's Analysis of Control Costs in General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Annualized Cost (b)	Applicability [c]	Estimate Source and Assumptions
Bucket elevator ventilation	LEV	1,600	$8,531	100.0%	Bucket elevator ventilation (p. 10-68; ACGIH, 2001); 2'x3'x30' casing; 4 take-offs @250 cfm; 100 cfm per sq. ft. of cross section
Screen ventilation	LEV	1,200	$6,399	100.0%	Ventilated screen (p. 10-173, ACGIH, 2001); 4'x6' screen; 50 cfm per ft.[2]
Substitute silica-free materials	Option not costed	N/A	N/A	N/A	
Molder					
Upgraded sand handling equipment - covered elsewhere		N/A	N/A	N/A	
Upgrade or install LEV	LEV	1,050	$5,599	100.0%	Bin & hopper ventilation (p. 10-69, ACGIH, 2001)
Rigorous housekeeping- capital	HEPA vacuum	N/A	$1,009	100.0%	Nilfisk HEPA vacuum, 15 gal. capacity (Bibbo, 2003). Assume negligible impact on labor requirements for cleaning
Rigorous housekeeping- labor	Labor costs	N/A	$1,922	100.0%	Additional 20 minutes of labor time per day
Eliminated compressed air	Included in rigorous housekeeping	N/A	N/A	N/A	
Coremaker					
Eliminated compressed air	Additional labor time	N/A	$961	100.0%	10 minutes per worker per day
Enclosed conveyors, covered elsewhere		N/A	N/A	N/A	
Non-silica cores and core coatings	Option not costed	N/A	N/A	N/A	
Professional-level cleaning	Covered by program requirements	N/A	N/A	N/A	
Furnace operator					
Control dust releases from adjacent processes - covered elsewhere		N/A	N/A	N/A	
Well-maintained furnace emission control system		N/A	$461	100.0%	20 hours additional maintenance time per year
Minimize dust generated by sand contamination of scrap	Option not costed	N/A	N/A	N/A	
Pouring operator					

Table V-A-1: Detailed Exposure Control Requirements, Analytical Assumptions and Sources for the Cost Data Applied in OSHA's Analysis of Control Costs in General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Annualized Cost (b)	Applicability [c]	Estimate Source and Assumptions
Control dust from adjacent processes - covered elsewhere		N/A	N/A	N/A	
Operator booths or cabs	Based on clean-air island costs	2,500	$13,330	100.0%	Assumes 125 cfm/sq. ft. for 20 square feet.
Physical isolation of pouring area (create a pouring room)	Option not costed	N/A	N/A	N/A	
Modify ventilation system to reduce airflow from other areas into the pouring area	Option not costed	N/A	N/A	N/A	
Shakeout operator					
Improve existing ventilation system efficiency (very large castings)	Double-draft shake-out table	28,800	$153,567	10.0%	Shakeout double side-draft table (p. 10-23, ACGIH, 2001); assumes control needed for 10% of establishments producing large castings.
Improve existing ventilation system efficiency	Shakeout enclosing hood	7,040	$37,539	90.0%	Ventilated enclosing hood (p. 10-23, ACGIH, 2001); 4'x4' openings; assumes control adequate except for establishments producing large castings (10%).
Partially enclose process	Enclosed, ventilated shakeout conveyor	10,000	$53,322	100.0%	ERG estimate based on expert input.
Control emissions from associated operations - covered elsewhere		N/A	N/A	N/A	
Knockout operator					
Installing and improving LEV	Small knockout table	1,350	$7,198	50.0%	Portable grinding table (p. 10-136, ACGIH, 2001), 3'x3' opening; control assumed appropriate for 50% of establishments.
Installing and improving LEV	Large knockout table	4,800	$25,594	50.0%	Hand grinding table (p. 10-135, ACGIH, 2001), 4'x6' surface; control assumed appropriate for 50% of establishments.
Installing and improving LEV	Ventilated abrasive cutoff saw	1,500	$7,998	50.0%	Ventilated cut-off saw (p. 10-134, ACGIH, 2001), 2'x3' opening; control assumed

Table V-A-1: Detailed Exposure Control Requirements, Analytical Assumptions and Sources for the Cost Data Applied in OSHA's Analysis of Control Costs in General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Annualized Cost (b)	Applicability [c]	Estimate Source and Assumptions
					appropriate for 50% of establishments.
Reduce residual sand on castings	Option not costed	N/A	N/A	N/A	
Automate knockout process	Option not costed	N/A	N/A	N/A	
Abrasive blasting operator					
Improved maintenance for blasting cabinet		N/A	$1,349	100.0%	Assumes 50% increase in maintenance costs (of up to $2,000) and purchase of new cabinets (25%) at $8,000/cabinet (Norton, 2003), or additional interlocks at $1,800/cabinet (Heastrup, 2003).
Cleaning/finishing operator					
LEV for workstations	Hand grinding bench	3,750	$19,996	50.0%	Bench with LEV (p. 10-135, ACGIH, 2001); 3'x5'; control assumed appropriate for 50% of establishments,
LEV on hand tools		200	$767	50.0%	ERG estimate of cfm; control assumed appropriate for 50% of establishments.
Eliminated compressed air (switch to vacuum)	HEPA vacuum plus additional time	N/A	$1,503	100.0%	Nilfisk HEPA vacuum, 15 gal. capacity (Bibbo, 2003). Assume 5 mins additional time per day.
Substitution with non-silica materials	Option not costed	N/A	N/A	N/A	
Process automation	Option not costed	N/A	N/A	N/A	
Wet methods	Option not costed	N/A	N/A	N/A	
Pre-cleaning with automated equipment	Option not costed	N/A	N/A	N/A	
Material handler					
Enclosed, ventilated cab	Retrofit with cab or replace equipment	N/A	$7,467	100.0%	ERG estimate based on vendor interviews. Assumes 35% markup for maintenance.
Maintenance operator					
Use low silica refractory	Option not costed	N/A	N/A	N/A	
LEV for chipping tools	Dust collector with HEPA vacuum	N/A	$993	100.0%	Vacuum plus shroud adapter; 35% for maintenance and

Table V-A-1: Detailed Exposure Control Requirements, Analytical Assumptions and Sources for the Cost Data Applied in OSHA's Analysis of Control Costs in General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Annualized Cost (b)	Applicability [c]	Estimate Source and Assumptions
					operating costs. Assumes 5-year life.
Pre-wetting lining to be removed	Additional labor	N/A	$3,325	100.0%	2 hours per week
Maintaining moisture level in the refractory applied	Additional labor	N/A	$1,662	100.0%	1 hour per week
Also, use of precast refractories and automated equipment for powdered refractory materials	Option not costed	N/A	N/A	N/A	
Housekeeping worker					
Controls not identified		N/A	N/A	N/A	
Professional-level cleaning	Covered by program requirements	N/A	N/A	N/A	
Railroads					
Ballast dumper					
Spray system for right-of-way maintenance vehicles	Costs estimated per rail car, see Table 3-6	N/A	N/A	N/A	
Machine operator					
Spray system for right-of-way maintenance vehicles	Costs estimated per rail car, see Table 3-6	N/A	N/A	N/A	
Asphalt Roofing Materials					
Production operator					
Process enclosure	Enclose conveyors and equip	N/A	$967	100.0%	200 feet at $17.10 per linear foot (Landola, 2003)
Enhanced ventilation	Conveyor ventilation	700	$3,733	100.0%	Bin & hopper ventilation and unvented mixers (p. 10-69, ACGIH, 2001)
Rigorous housekeeping- capital	HEPA vacuum	N/A	$1,009	100.0%	Nilfisk HEPA vacuum, 15 gal. capacity (Bibbo, 2003).
Rigorous housekeeping- labor	Incremental labor costs	N/A	$1,504	100.0%	Additional 10 minutes labor time per day
Material handler					
No additional controls required	N/A	N/A	N/A	N/A	Controls for production operator adequate
Porcelain Enameling					
Preparer					
Well-ventilated bag dumping stations	LEV	1,513	$8,068	100.0%	Bag opening station (p. 10-19,

Table V-A-1: Detailed Exposure Control Requirements, Analytical Assumptions and Sources for the Cost Data Applied in OSHA's Analysis of Control Costs in General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Annualized Cost (b)	Applicability [c]	Estimate Source and Assumptions
					ACGIH, 2001)
Porcelain applicator					
Improved LEV for spray booths and enclosures	increased airflow\cfm	1,000	$1,333	100.0%	Additional cfm at 25% of installed price
Spray booth maintenance	Materials plus labor	N/A	$231	100.0%	Annually, $100 materials plus 4 hours maintenance time
Mineral Processing					
Production worker					
Enclosed ventilation equipment	Conveyor cover; 200'	N/A	$967	50.0%	200 feet at $17.10 per linear foot (Landola, 2003); assumes cover adequate for 50% of establishments
Conveyor ventilation	LEV	4,900	$26,128	50.0%	Conveyor belt ventilation; (p. 10-70, ACGIH, 2001) One take-off point at-least every 30', 7 overall; assumes 50% of establishments needed ventilated conveyor covers.
Improved maintenance	Labor costs	N/A	$1,139	50.0%	1 hour additional maintenance time per week per production worker; assumes 50% of establishments need improved maintenance of ventilation system.
Professional cleaning	Commercial cleaning service; semiannual	N/A	N/A	N/A	
Improved area cleanup with HEPA	Equipment cost	N/A	$899	100.0%	Nilfisk HEPA vacuum, 15 gal. capacity (Bibbo, 2003)
Enhanced housekeeping with HEPA vacuums	Additional labor time	N/A	$1,825	100.0%	Additional 20 minutes per day
Dental Equipment and Supplies					
Production operator					
Ventilated bag dumping stations with bag compactor	LEV	1,513	$8,068	50.0%	Bag opening station (p. 10-19, ACGIH, 2001); other controls are available.
Enclosed and ventilated mixing equipment	LEV	1,050	$5,599	50.0%	Mixer & muller hood (p. 10-87, ACGIH, 2001); other controls

Table V-A-1: Detailed Exposure Control Requirements, Analytical Assumptions and Sources for the Cost Data Applied in OSHA's Analysis of Control Costs in General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Annualized Cost (b)	Applicability [c]	Estimate Source and Assumptions
					are available.
Increased LEV maintenance	Additional cost per operator	N/A	$280	100.0%	Assumes 1 hour additional maintenance time per operator per month
Asphalt Paving Products					
Plant operator					
No overexposures	Additional controls not needed	N/A	N/A	N/A	
Front-end loader operator					
Enclosed cabs	Retrofit with cab or replacement equip	N/A	$7,467	100.0%	ERG estimate based on vendor interviews. Assumes 35% markup for maintenance.
Maintenance worker					
No overexposures	Additional controls not needed	N/A	N/A	N/A	
Quality control worker					
No overexposures	Additional controls not needed	N/A	N/A	N/A	
Refractory Repair					
Production operator					
Portable exhaust ventilation	LEV	400	$2,133	33.3%	Moveable exhaust hoods example: p. 10-93 (ACGIH, 2001); other controls are available.
Wet methods for chipping tools	Shop-built water feed equipment	N/A	$117	33.3%	Assumes $100 in annual costs; other controls are available.
LEV for chipping tools	LEV	600	$3,199	33.3%	Granite cutting and finishing; (p. 10-94, ACGIH, 2001); other controls are available.
Improved maintenance for spay guns	Labor costs	N/A	$344	100.0%	Assumes 1 hour additional maintenance time per operator per month

a) "Control not costed" means that other less costly control measures were available to achieve the same level of exposure reduction.
b) Costs are annualized using a 7 percent discount rate over the lifetime of the equipment, typically 10 years.
c) Indicates the percentage of establishments for which the control is applied.

Source: U.S. Dept. of Labor, OSHA, Directorate of Evaluation and Analysis, Office of Regulatory Analysis, based on ERG (2007b) and ERG (2011).

Table A-2: Unit and Annualized Costs and Model Specifications for Silica Engineering Controls Applied in OSHA's Cost Analysis for General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Unit Cost	Annual Operating Cost	Annualized Cost (b)	Workers per Control	Annualized Cost per worker	Estimate Source
Cut Stone								
Sawyer								
Control other dust sources in area	Addressed by other controls	N/A	N/A	N/A	N/A	N/A	N/A	
Rigorous housekeeping-capital	HEPA vacuum	N/A	$3,495	$511	$1,009	4	$252	Nilfisk HEPA vacuum, 15 gal. capacity (Bibbo, 2003)
Rigorous housekeeping- labor	Labor costs	N/A	N/A	$913	$913	1	$913	Additional 20 minutes/day
Manage slurry-assumed included in housekeeping costs		N/A	N/A	N/A	N/A	N/A	N/A	
N/A	N/A	N/A	N/A	$456	$456	1	$456	5 mins per worker per day
N/A	Includes major plumbing, floor work	N/A	$36,412	$3,259	$8,443	4	$2,111	Includes cost of water and labor time.
N/A	Extra saw maintenance	N/A	N/A	$456	$456	1	$456	5 mins per worker per day; equipment has water capabilities
N/A	Applicable to sites over 100 μg/m^3	N/A	N/A	$456	$456	2	$228	5 mins per worker per day; equipment has water capabilities
N/A	Build enclosure	N/A	$488	$119	$238	4	$59	8'x8'x8' dust partition, with plastic sheeting, assumes 5 year life (Means, 2003)
Exhaust saw	LEV	450	$5,774	$1,577	$2,399	4	$600	Based on saw LEV (e.g., p. 10-158, 159, 160, ACGIH, 2001)
Fabricator								
Use water fed equipment	No cost, most tools have water capability	N/A	N/A	N/A	N/A	N/A	N/A	
Management of dust-carrying water slurry	Incremental housekeeping	N/A	N/A	N/A	N/A	N/A	N/A	

Table A-2: Unit and Annualized Costs and Model Specifications for Silica Engineering Controls Applied in OSHA's Cost Analysis for General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Unit Cost	Annual Operating Cost	Annualized Cost (b)	Workers per Control	Annualized Cost per worker	Estimate Source
Rigorous housekeeping- capital	HEPA vacuum	N/A	$3,495	$511	$1,009	4	$252	Nilfisk HEPA vacuum, 15 gal. capacity (Bibbo, 2003)
Rigorous housekeeping- labor	Labor costs	N/A	N/A	$456	$456	1	$456	5 mins per worker per day
Splitter/chipper								
Use work practices to position work near duct	Judged to be a negligible cost	N/A	N/A	N/A	N/A	N/A	N/A	Work practices adjustments assumed to be negligible cost.
Rigorous housekeeping- capital	HEPA vacuum	N/A	$3,495	$511	$1,009	4	$252	Nilfisk HEPA vacuum, 15 gal. capacity (Bibbo, 2003)
Rigorous housekeeping- labor	Labor costs	N/A	N/A	$913	$913	1	$913	30 mins per worker per day
Pre-wash stone	Labor	N/A	N/A	$456	$456	1	$456	5 mins per worker per day
Use flexible trunk LEV for hand chipping	Flexible trunk LEV	600	$7,699	$2,103	$3,199	2	$1,600	Granite cutting and finishing; p. 10-94 (ACGIH, 2001); granite, limestone, and marble assumed to account for 75 percent of establishments.
Tool-mounted LEV for hand-held chipping tools	Shroud and vacuum	N/A	$1,672	$585	$823	2	$412	Vacuum plus shroud adapter; 35% for maintenance and operating costs; assumes one half of the non-slate establishments (75%) need this control.
Keep floors wet; washdown with high pressure hose	Already costed (see sawyers)	N/A	N/A	N/A	N/A	N/A	N/A	High-pressure hose and floor trough

Table A-2: Unit and Annualized Costs and Model Specifications for Silica Engineering Controls Applied in OSHA's Cost Analysis for General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Unit Cost	Annual Operating Cost	Annualized Cost (b)	Workers per Control	Annualized Cost per worker	Estimate Source
								installation
Machine operator								
Control other dust sources in area	Addressed by other controls	N/A	N/A	N/A	N/A	N/A	N/A	
Rigorous housekeeping-capital	HEPA vacuum	N/A	$3,495	$511	$1,009	4	$252	Nilfisk HEPA vacuum, 15 gal. capacity (Bibbo, 2003)
Rigorous housekeeping- labor	Labor costs	N/A	N/A	$913	$913	1	$913	30 mins per worker per day
Wash stone before and after each process	Add misters to conveyor line	N/A	$439	$44	$287	2	$143	Assumes 8 hours of shop labor and $200 in materials to fabricate; 2-year life
Keep conveyor clean and damp	Addressed in other requirements	N/A	N/A	N/A	N/A	N/A	N/A	
Management of dust-carrying water	Included in housekeeping	N/A	N/A	N/A	N/A	N/A	N/A	
Enclose machinery	Build enclosure in machine shop	N/A	$488	$49	$168	4	$42	8'x8'x8' enclosure, plastic sheeting, from Means, 2003. Five-year life.
Exhaust trimming machine	LEV	500	$6,416	$1,753	$2,666	4	$667	Based on abrasive cut-off saw (p. 10-134) (ACGIH, 2001)
Abrasive blasting operator								
For use of maintained, interlocked, ventilated glove-box cabinet	Cost of maintaining blast cabinet	N/A	$2,450	$1,000	$1,349	4	$337	Assumes 50% increase in maintenance costs (of up to $2,000) and purchase of new cabinets (25%) at $8,000/cabinet (Norton, 2003), or addit. interlocks at $1,800/cabinet (Heastrup, 2003).

Table A-2: Unit and Annualized Costs and Model Specifications for Silica Engineering Controls Applied in OSHA's Cost Analysis for General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Unit Cost	Annual Operating Cost	Annualized Cost (b)	Workers per Control	Annualized Cost per worker	Estimate Source
Use only non-silica blasting media	Negligible incremental cost	N/A	N/A	N/A	N/A	N/A	N/A	Based on ERG manufacturer interviews
Increase blasting cabinet ventilation	Incremental LEV	1,250	$16,040	$4,382	$6,665	4	$1,666	Assumes an increase in cfm for a 7'x7' booth, approximately 25% of ACGIH recommended 100 cfm per square ft. of opening, or 4,900 cfm in total.
Use HEPA vacuums for machine cleaning	Vacuum replaces compressed air cleaning	N/A	$3,495	$511	$1,009	4	$252	Nilfisk HEPA vacuum, 15 gal. capacity (Bibbo, 2003). Assume negligible impact on labor requirements for cleaning
Flat glass								
Material handler								
Automated and ventilated unloading equipment	Not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Bag opening station (small facilities only)	Add bag opening station	1,513	$19,414	$5,303	$8,068	4	$2,017	Bag opening station (p. 10-19, ACGIH, 2001); applies to small establishments only (36% with <20 employees).
Batch operator								
Conveyor enclosures	Limit dust and spills	N/A	$3,990	$399	$967	4	$242	200 feet at $17.10 per linear foot (Landola, 2003)
LEV for batch operator workstation	LEV	1,050	$13,473	$3,680	$5,599	4	$1,400	Bin & hopper ventilation and unvented mixers (p. 10-69, ACGIH, 2001)
Dust suppressants	Use commercial dry	N/A	N/A	$635	$635	4	$159	Oil-based sawdust

Table A-2: Unit and Annualized Costs and Model Specifications for Silica Engineering Controls Applied in OSHA's Cost Analysis for General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Unit Cost	Annual Operating Cost	Annualized Cost (b)	Workers per Control	Annualized Cost per worker	Estimate Source
	suppressants							sweeping compound
Substitute wider HEPA vacuum use for compressed air	HEPA available, requires more labor	N/A	N/A	$962	$962	1	$962	10 minutes per worker per day
HEPA vacuums	Small HEPA needed	N/A	$3,495	$511	$1,009	4	$252	Nilfisk HEPA vacuum, 15 gal. capacity (Bibbo, 2003). Assume negligible impact on labor requirements for cleaning
Other glass								
Material handler								
Automated and ventilated unloading equipment	Not costed	N/A	N/A	N/A	N/A	0	N/A	
Bag opening station (small facilities only)	LEV	1,513	$19,414	$5,303	$8,068	4	$2,017	Bag opening station (p. 10-19, ACGIH, 2001); applies to small establishments only (69% with <20 employees).
Batch operator								
Conveyor enclosures	Limit dust and spills	N/A	$3,990	$399	$967	4	$242	200 feet at $17.10 per linear foot (Landola, 2003)
LEV for batch operator workstation	LEV	1,050	$13,473	$3,680	$5,599	4	$1,400	Bin & hopper ventilation and unvented mixers (p. 10-69, ACGIH, 2001)
Dust suppressants	Use commercial dry suppressants	N/A	N/A	$635	$635	4	$159	Oil-based sawdust sweeping compound
Substitute wider HEPA vacuum use for compressed air	HEPA available, requires more labor	N/A	N/A	$962	$962	1	$962	10 minutes per worker per day
HEPA vacuums	Small HEPA needed	N/A	$3,493	$511	$1,009	5	$202	Nilfisk HEPA vacuum, 15 gal. capacity (Bibbo,

Table A-2: Unit and Annualized Costs and Model Specifications for Silica Engineering Controls Applied in OSHA's Cost Analysis for General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Unit Cost	Annual Operating Cost	Annualized Cost (b)	Workers per Control	Annualized Cost per worker	Estimate Source
								2003). Assume negligible impact on labor requirements for cleaning
Mineral Wool								
Material handler								
Automated and ventilated unloading equipment	Not costed	N/A	N/A	N/A	N/A	0	N/A	
Bag opening station (small facilities only)	LEV	1,513	$19,414	$5,303	$8,068	4	$2,017	Bag opening station (p. 10-19, ACGIH, 2001); applies to small establishments only (52% with <20 employees).
Batch operator								
Conveyor enclosures	Limit dust and spills	N/A	$3,990	$399	$967	4	$242	200 feet at $17.10 per linear foot (Landola, 2003)
LEV for batch operator workstation	LEV	1,050	$13,473	$3,680	$5,599	4	$1,400	Bin & hopper ventilation and unvented mixers (p. 10-69, ACGIH, 2001)
Dust suppressants	Use commercial dry suppressants	N/A	N/A	$635	$635	4	$159	Oil-based sawdust sweeping compound
Substitute wider HEPA vacuum use for compressed air	HEPA available, requires more labor	N/A	N/A	$913	$913	1	$913	10 minutes per worker per day
HEPA vacuums	Small HEPA needed	N/A	$3,495	$511	$1,009	5	$202	Nilfisk HEPA vacuum, 15 gal. capacity (Bibbo, 2003). Assume negligible impact on labor requirements for cleaning
Concrete Products								
Material handler								
Yard dust suppression	Wetting with yard hose	N/A	$204	$5,501	$5,614	4	$1,403	100' of 1" contactor

Table A-2: Unit and Annualized Costs and Model Specifications for Silica Engineering Controls Applied in OSHA's Cost Analysis for General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Unit Cost	Annual Operating Cost	Annualized Cost (b)	Workers per Control	Annualized Cost per worker	Estimate Source
								hose and nozzle; 2 year life; (www.pwmall.com). Assumes 1 labor hour per day.
Enclosed cabs	Retrofit with cab or replacement equip	N/A	$15,165	$5,308	$7,467	4	$1,867	ERG estimate based on vendor interviews. Assumes 35% markup for maintenance.
Mixer operator								
Wet methods to clean equipment	Additional cleaning time	N/A	N/A	$917	$917	1	$917	10 mins per day per worker
LEV for bag opening stations	LEV with bag dumping station	1,513	$19,414	$5,303	$8,068	4	$2,017	Bag opening station (pg. 10-19, ACGIH, 2001)
Ventilated control room and HEPA filter	LEV	200	$19,557	$701	$3,485	4	$871	ERG estimates based on Means and ACGIH
Forming line operator								
Dust control for adjacent operations	Addressed by other controls	N/A	N/A	N/A	N/A	N/A	N/A	
Abrasive blasting operator								
Use wet process	Shop-built sprayer	N/A	$205	$20	$134	4	$33	
Finishing operator								
Work concrete green	Penalty for overall productivity	N/A	N/A	$2,200	$2,200	1	$2,200	Assumes 5% productivity penalty per worker; other controls are available
Use wet process	Shop built sprayer	N/A	$205	$20	$134	4	$33	Assumes 2-year life; other controls are available.
LEV where wet methods are infeasible	Shroud and vacuum	not estimated	$1,672	$585	$993	2	$496	Vacuum plus shroud adapter; 35% for maintenance and

Table A-2: Unit and Annualized Costs and Model Specifications for Silica Engineering Controls Applied in OSHA's Cost Analysis for General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Unit Cost	Annual Operating Cost	Annualized Cost (b)	Workers per Control	Annualized Cost per worker	Estimate Source
								operating costs; other controls are available.
Use alternative blast media	Use of more expensive non-silica media	N/A	N/A	$33,646	$33,646	4	$8,412	Based on 212,000 square feet of coverage per year per crew; assumes 25% of establishments perform open blasting.
Packaging operator								
LEV for bag filling stations	LEV with bag filling station	1,500	$19,248	$5,258	$7,998	4	$2,000	Bag filling station (pg. 10-15, ACGIH, 2001)
Extended polyethylene bag valves to reduce dust release	Use bags with dust-control feature	N/A	N/A	$4,728	$4,728	1	$4,728	Assumes 5 bags per minute; 200 days a year; applies only to bulk product producers in NAICS 327999
Pottery								
Material handler								
Well-ventilated bag dumping stations	LEV	1,513	$13,473	$3,680	$5,599	4	$1,400	Bag opening station (pg. 10-19, ACGIH, 2001)
Ventilated cab enclosures	Retrofit with cab or replacement equip	N/A	$15,165	$5,308	$7,467	4	$1,867	ERG estimate based on vendor interviews. Assumes 35% markup for maintenance.
LEV for mixer	LEV	1,050	$13,473	$3,680	$5,599	4	$1,400	Bin & hopper ventilation, unvented mixers (pg. 10-69, ACGIH, 2001)
Forming line operator								
LEV- hand grinding bench controls	LEV	1,400	$17,964	$4,907	$7,465	4	$1,866	Bench hood ventilation (pg. 10-

Table A-2: Unit and Annualized Costs and Model Specifications for Silica Engineering Controls Applied in OSHA's Cost Analysis for General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Unit Cost	Annual Operating Cost	Annualized Cost (b)	Workers per Control	Annualized Cost per worker	Estimate Source
								149, ACGIH, 2001)
Eliminated compressed air (switch to vacuum)	HEPA vacuum plus additional time	N/A	$3,495	$1,006	$1,503	4	$376	Nilfisk HEPA vacuum, 15 gal. capacity (Bibbo, 2003). Assume 5 addition minutes of labor time per day.
Reduce dust generation during mold parting (redesign talc bag)	Cost judged negligible	N/A	N/A	N/A	N/A	N/A	N/A	
Substitute non-silica parting compounds	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Finishing operator								
LEV- hand grinding bench controls	LEV	2,400	$30,796	$8,413	$12,797	4	$3,199	Hand grinding bench (pg. 10-135, ACGIH, 2001)
Wet finishing	Option not costed	N/A	N/A	N/A	N/A	1	N/A	
Coatings preparer								
Well-ventilated bag dumping stations	LEV	1,513	$19,414	$5,303	$8,068	4	$2,017	Bag opening station (pg. 10-19, ACGIH, 2001)
Well-ventilated or enclosed, automated systems for charging mixing equipment with glaze materials	LEV	1,050	$13,473	$3,680	$5,599	4	$1,400	Bin & hopper ventilation and unvented mixers (pg. 10-69, ACGIH, 2001)
Coatings operator								
Substitute low silica content inputs	Option not costed	N/A	N/A	N/A	N/A	1	N/A	
Improved LEV for spray booths and enclosures	Increased airflow, additional cfm	1,000	$3,208	$876	$1,333	4	$333	Additional cfm at 25% of installed price
Spray booth maintenance	Booth repairs	N/A	N/A	$231	$231	4	$58	Annually, $100 materials plus 4 hours maintenance time
Paint								
Material handler								

Table A-2: Unit and Annualized Costs and Model Specifications for Silica Engineering Controls Applied in OSHA's Cost Analysis for General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Unit Cost	Annual Operating Cost	Annualized Cost (b)	Workers per Control	Annualized Cost per worker	Estimate Source
No overexposure	No control needed	N/A	N/A	N/A	N/A	N/A	N/A	
Mixer operator								
Substitute low silica content materials	Not generally control of choice	N/A	N/A	N/A	N/A	N/A	N/A	
Well-ventilated bag dumping stations	LEV	1,513	$19,414	$5,303	$8,068	4	$2,017	Bag opening station (pg. 10-19, ACGIH, 2001)
Structural Clay								
Material handler/loader operator								
Enclosed, ventilated cab	Retrofit with cab or replace equipment	N/A	$15,165	$5,308	$7,467	4	$1,867	ERG estimate based on vendor interviews. Assumes 35% markup for maintenance.
Thorough, semi-annual professional cleaning	Commercial cleaning service	N/A	N/A	N/A	N/A	N/A	N/A	Addressed in program costs
Improve cab maintenance and keep windows closed	Use existing cabs for dust control	N/A	N/A	$758	$758	4	$190	Judged to be incremental cost equal to one-half normal maintenance cost
Cover conveyors in material handling area	Conveyor covers	N/A	$3,990	$399	$967	4	$242	200 feet at $17.10 per linear foot (Landola, 2003)
Apply LEV to conveyors in material handling area	LEV	10,000	$128,318	$35,052	$53,322	4	$13,330	ERG estimate of cfm requirements.
Material handler/production								
Misters on conveyor line	Water spray to suppress dust	N/A	$10,207	$1,021	$2,474	4	$618	100 feet of conveyor. National Environmental Services Company (Kestner, 2003).
LEV, push-pull system	LEV	4,000	$51,327	$14,021	$21,329	4	$5,332	Assumes twice the airflow for a clean air island (1,500 cfm).
Material handler/post-								

Table A-2: Unit and Annualized Costs and Model Specifications for Silica Engineering Controls Applied in OSHA's Cost Analysis for General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Unit Cost	Annual Operating Cost	Annualized Cost (b)	Workers per Control	Annualized Cost per worker	Estimate Source
production								
Misters on conveyor line	Water spray to suppress dust	N/A	$10,207	$1,021	$2,474	4	$618	100 feet of conveyor. National Environmental Services Company (Kestner, 2003).
Dust suppression in yard	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Grinding operator								
Ventilated control room and HEPA filter	LEV	200	$19,557	$701	$3,485	4	$871	ERG estimates based on Means, 2003 and ACGIH, 2001; Assumes 30% of establishments need new control room.
Control room improvements and repairs	In-house repairs	N/A	$2,240	NA	$319	4	$80	ERG estimate; assumes repairs are 20% of new control room cost; assumes 70% of establishments need control room improvements.
Enclosures with LEV for grinding equipment	LEV	17,000	$218,140	$59,589	$90,647	4	$22,662	Additional ventilation equal to half the total cfm required for a medium sized facility; ERG estimate based on consultant input.
Purchase additional HEPA vacuums		N/A	$3,495	$511	$1,009	4	$252	Nilfisk HEPA vacuum, 15 gal. capacity (Bibbo, 2003). Assume negligible impact on labor requirements for cleaning

Table A-2: Unit and Annualized Costs and Model Specifications for Silica Engineering Controls Applied in OSHA's Cost Analysis for General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Unit Cost	Annual Operating Cost	Annualized Cost (b)	Workers per Control	Annualized Cost per worker	Estimate Source
Enhanced housekeeping with HEPA vacuums	Labor costs	N/A	N/A	$1,772	$1,772	1	$1,772	Additional 20 minutes per day
Cover conveyors in grinding area	Conveyor covers	N/A	$3,990	$399	$967	4	$242	200 feet at $17.10 per linear foot (Landola, 2003)
Dust suppression for raw materials		N/A	N/A	$635	$635	1	$635	$0.22/lb (www.fastenal.com); 2 lbs used per day; 5 labor minutes per day.
Tightly sealed storage units	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Forming line operator/pug mill operator								
Enclosed and ventilated pug mill equipment		6,000	$76,991	$21,031	$31,993	4	$7,998	ERG estimate based on consultant input.
Forming line operator/coatings blender								
Well-ventilated bag dumping stations		1,513	$19,414	$5,303	$8,068	4	$2,017	Bag opening station (pg. 10-19, ACGIH, 2001); installation of control adequate for 50% of establishments.
Enclosed and ventilated feed hopper, conveyors, tumble tote charging, and transfer to transfer tote	Best judgment	9,000	$115,486	$31,547	$47,990	4	$11,997	ERG estimate based on consultant input; more extensive controls needed for 50% of establishments.
Improved area cleanup with HEPA or central vacuum system		N/A	$3,495	$511	$1,009	4	$252	Nilfisk HEPA vacuum, 15 gal. capacity (Bibbo, 2003). Assume negligible impact on labor requirements for cleaning.

Table A-2: Unit and Annualized Costs and Model Specifications for Silica Engineering Controls Applied in OSHA's Cost Analysis for General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Unit Cost	Annual Operating Cost	Annualized Cost (b)	Workers per Control	Annualized Cost per worker	Estimate Source
Enhanced housekeeping with HEPA vacuums	Labor costs	N/A	N/A	$1,772	$1,772	1	$1,772	Additional 20 minutes per day
Forming line operator/formers								
Improved area cleanup with HEPA or central vacuum system		N/A	$3,495	$511	$1,009	4	$252	Nilfisk HEPA vacuum, 15 gal. capacity (Bibbo, 2003). Assume negligible impact on labor requirements for cleaning
Enhanced housekeeping with HEPA vacuums		N/A	N/A	$1,772	$1,772	1	$1,772	Additional 20 minutes per day
Well-ventilated bag dumping stations		1,513	$19,414	$5,303	$8,068	4	$2,017	Bag opening station (pg. 10-19, ACGIH, 2001); installation of control adequate for 50% of establishments.
Enclosed and ventilated workstations	LEV plus clean air island	3,550	$45,553	$12,444	$18,929	4	$4,732	ERG estimate based on consultant input; assumes control needed for 50% of establishments.
Dental laboratories								
Dental technician								
Improved LEV in grinding, blasting	Dental lab dust control systems	N/A	$800	$80	$194	2	$97	Self-contained dust collection system. Darby Dental Lab Supply, 2005 (www.darbylab.com)
Fine jewelry								
Jewelry workers								
Substitution of low-silica modeling/investment materials	Not costed	N/A	N/A	N/A	N/A	2	N/A	
LEV for abrasive blasting and	Small-scale jewelry	100	$1,283	$351	$533	2	$267	Small-scale LEV

Table A-2: Unit and Annualized Costs and Model Specifications for Silica Engineering Controls Applied in OSHA's Cost Analysis for General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Unit Cost	Annual Operating Cost	Annualized Cost (b)	Workers per Control	Annualized Cost per worker	Estimate Source
finishing	bench LEV							adequate
Costume Jewelry								
Jewelry workers								
Substitution of low-silica modeling/investment materials	Not costed	N/A	N/A	N/A	N/A	2	N/A	
LEV for abrasive blasting and finishing	Small-scale jewelry bench LEV	100	$1,283	$351	$533	2	$267	Small-scale LEV adequate
Refractories								
Material handler								
Ventilated bag dumping stations with bag compactor	LEV	1,513	$19,414	$5,303	$8,068	4	$2,017	Bag opening station (3.5'x1.5' opening); (pg. 10-19, ACGIH, 2001); 3.5'x1.5' opening; with ventilated bag crusher (200 cfm)
Enclosed and ventilated mixing equipment	LEV	1,050	$13,473	$3,680	$5,599	4	$1,400	Mixer & muller hood (pg. 10-87, ACGIH, 2001)
Forming Operator								
Increased LEV maintenance	Additional cost per operator	N/A	N/A	$344	$344	1	$344	Assumes 1 hour additional maintenance time per operator per month
Finishing operator								
No overexposures	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
Ceramic fiber furnace operator								
No overexposures	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
Packaging operator								
LEV for bag filling stations	LEV/per cfm	1,500	$19,248	$5,258	$7,998	4	$2,000	Bag filling station (pg. 10-15, ACGIH, 2001). Includes costs for air shower
Bag valves to reduce dust		N/A	N/A	$4,728	$4,728	1	$4,728	Assumes 5 bags per

Table A-2: Unit and Annualized Costs and Model Specifications for Silica Engineering Controls Applied in OSHA's Cost Analysis for General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Unit Cost	Annual Operating Cost	Annualized Cost (b)	Workers per Control	Annualized Cost per worker	Estimate Source
release								minute; 200 days a year
Ready-Mix Concrete								
Material handler								
Yard dust suppression	Wetting with yard hose	N/A	$204	$5,523	$5,614	2	$2,807	100' of 1" contactor hose and nozzle; 2 year life; (www.pwmall.com). Assumes 1 labor hour per day.
Enclosed cabs	Retrofit with cab or replacement equip	N/A	$15,165	$5,308	$7,467	2	$3,733	ERG estimate based on vendor interviews. Assumes 35% markup for maintenance.
Batch operator								
No overexposures	No controls necessary	N/A	N/A	N/A	N/A	N/A	N/A	
Maintenance operator								
Wet methods to clean equipment	Additional cleaning time	N/A	N/A	$917	$917	1	$917	10 mins per day per worker
Quality control technician								
No overexposures	No controls necessary	N/A	N/A	N/A	N/A	N/A	N/A	
Truck driver								
Wet methods for drum cleaning	Water fed chipping equipment	N/A	$117	N/A	$117	4	$29	Estimated annualized retrofit cots.
Ventilation for drum cleaning	Forced ventilation	N/A	792	198	391	4	$98	Electric blower (1,277 cfm) and 25 ft. of duct. Northern Safety Co. (p. 193). Assumed 5-year life.
Iron Foundries								
Sand mixer (muller) operator								
LEV, mixer & muller hood	LEV	1,050	$13,473	$3,680	$5,599	4	$1,400	Mixer & muller hood (pg. 10-87, ACGIH, 2001)

Table A-2: Unit and Annualized Costs and Model Specifications for Silica Engineering Controls Applied in OSHA's Cost Analysis for General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Unit Cost	Annual Operating Cost	Annualized Cost (b)	Workers per Control	Annualized Cost per worker	Estimate Source
Conveyor enclosures	200 feet, ventilated (7 take-off points)	4,900	$66,865	$17,176	$26,696	4	$6,674	Conveyor belt ventilation; (pg. 10-70, ACGIH, 2001); 2' wide belt; one take-off point at-least every 30', 7 overall
Bin and hopper ventilation	LEV	1,050	$13,473	$3,680	$5,599	4	$1,400	Bin & hopper ventilation for unvented mixers (pg. 10-69, ACGIH, 2001)
Bucket elevator ventilation	LEV	1,600	$20,531	$5,608	$8,531	4	$2,133	Bucket elevator ventilation (pg. 10-68; ACGIH, 2001); 2'x3'x30' casing; 4 take-offs @250 cfm; 100 cfm per sq. ft. of cross section
Screen ventilation	LEV	1,200	$15,398	$4,206	$6,399	4	$1,600	Ventilated screen (pg. 10-173, ACGIH, 2001); 4'x6' screen; 50 cfm per ft^2
Substitute silica-free materials	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Molder								
Upgraded sand handling equipment - covered elsewhere		N/A	N/A	N/A	N/A	N/A	N/A	
Upgrade or install LEV	LEV	1,050	$13,473	$3,680	$5,599	4	$1,400	Bin & hopper ventilation (pg. 10-69, ACGIH, 2001)
Rigorous housekeeping-capital	HEPA vacuum	N/A	$3,495	$511	$1,009	5	$202	Nilfisk HEPA vacuum, 15 gal. capacity (Bibbo, 2003). Assume negligible impact on labor requirements for cleaning

Table A-2: Unit and Annualized Costs and Model Specifications for Silica Engineering Controls Applied in OSHA's Cost Analysis for General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Unit Cost	Annual Operating Cost	Annualized Cost (b)	Workers per Control	Annualized Cost per worker	Estimate Source
Rigorous housekeeping- labor	Labor costs	N/A	N/A	$1,922	$1,922	1	$1,922	Additional 20 minutes of labor time per day
Eliminated compressed air	Included in rigorous housekeeping	N/A	N/A	N/A	N/A	N/A	N/A	
Coremaker								
Eliminated compressed air	Additional labor time	N/A	N/A	$961	$961	1	$961	10 minutes per worker per day
Enclosed conveyors, covered elsewhere		N/A	N/A	N/A	N/A	N/A	N/A	
Non-silica cores and core coatings	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Professional-level cleaning	Covered by program requirements	N/A	N/A	N/A	N/A	N/A	N/A	
Furnace operator								
Control dust releases from adjacent processes - covered elsewhere		N/A	N/A	N/A	N/A	N/A	N/A	
Well-maintained furnace emission control system		N/A	N/A	$461	$461	4	$115	20 hours additional maintenance time per year
Minimize dust generated by sand contamination of scrap	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Pouring operator								
Control dust from adjacent processes - covered elsewhere		N/A	N/A	N/A	N/A	N/A	N/A	
Operator booths or cabs	Based on clean-air island costs	2,500	$32,079	$8,763	$13,330	4	$3,333	Assumes 125 cfm/sq. ft. for 20 square feet.
Physical isolation of pouring area (create a pouring room)	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Modify ventilation system to reduce airflow from other areas into the pouring area	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Shakeout operator								
Improve existing ventilation	Double-draft shake-out	28,800	$369,555	$100,951	$153,567	4	$38,392	Shakeout double

Table A-2: Unit and Annualized Costs and Model Specifications for Silica Engineering Controls Applied in OSHA's Cost Analysis for General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Unit Cost	Annual Operating Cost	Annualized Cost (b)	Workers per Control	Annualized Cost per worker	Estimate Source
system efficiency (very large castings)	table							side-draft table (pg. 10-23, ACGIH, 2001); assumes control needed for 10% of establishments producing large castings.
Improve existing ventilation system efficiency	Shakeout enclosing hood	7,040	$90,336	$24,677	$37,539	4	$9,385	Ventilated enclosing hood (pg. 10-23, ACGIH, 2001); 4'x4' openings; assumes control adequate except for establishments producing large castings (10%).
Partially enclose process	Enclosed, ventilated shakeout conveyor	10,000	$128,318	$35,052	$53,322	4	$13,330	ERG estimate based on expert input.
Control emissions from associated operations - covered elsewhere		N/A	N/A	N/A	N/A	N/A	N/A	
Knockout operator								
Installing and improving LEV	Small knockout table	1,350	$17,323	$4,732	$7,198	4	$1,800	Portable grinding table (pg. 10-136, ACGIH, 2001), 3'x3' opening; control assumed appropriate for 50% of establishments.
Installing and improving LEV	Large knockout table	4,800	$61,593	$16,825	$25,594	4	$6,399	Hand grinding table (pg. 10-135, ACGIH, 2001), 4'x6' surface; control assumed appropriate for 50% of establishments.
Installing and improving LEV	Ventilated abrasive cutoff saw	1,500	$19,248	$5,258	$7,998	4	$2,000	Ventilated cut-off saw (pg. 10-134, ACGIH,

Table A-2: Unit and Annualized Costs and Model Specifications for Silica Engineering Controls Applied in OSHA's Cost Analysis for General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Unit Cost	Annual Operating Cost	Annualized Cost (b)	Workers per Control	Annualized Cost per worker	Estimate Source
								2001), 2'x3' opening; control assumed appropriate for 50% of establishments.
Reduce residual sand on castings	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Automate knockout process	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Abrasive blasting operator								
Improved maintenance for blasting cabinet		N/A	$2,450	$1,000	$1,349	2	$674	Assumes 50% increase in maintenance costs (of up to $2,000) and purchase of new cabinets (25%) at $8,000/cabinet (Norton, 2003), or additional interlocks at $1,800/cabinet (Heastrup, 2003).
Cleaning/finishing operator								
LEV for workstations	Hand grinding bench	3,750	$48,119	$13,145	$19,996	4	$4,999	Bench with LEV (pg. 10-135, ACGIH, 2001); 3'x5'; control assumed appropriate for 50% of establishments,
LEV on hand tools		200	$464	$701	$767	2	$384	ERG estimate of cfm; control assumed appropriate for 50% of establishments.
Eliminated compressed air (switch to vacuum)	HEPA vacuum plus additional time	N/A	$3,495	$1,006	$1,503	4	$376	Nilfisk HEPA vacuum, 15 gal. capacity (Bibbo, 2003). Assume 5 mins additional time per day.

Table A-2: Unit and Annualized Costs and Model Specifications for Silica Engineering Controls Applied in OSHA's Cost Analysis for General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Unit Cost	Annual Operating Cost	Annualized Cost (b)	Workers per Control	Annualized Cost per worker	Estimate Source
Substitution with non-silica materials	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Process automation	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Wet methods	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Pre-cleaning with automated equipment	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Material handler								
Enclosed, ventilated cab	Retrofit with cab or replace equipment	N/A	$15,165	$5,308	$7,467	4	$1,867	ERG estimate based on vendor interviews. Assumes 35% markup for maintenance.
Maintenance operator								
Use low silica refractory	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
LEV for chipping tools	Dust collector with HEPA vacuum	N/A	$1,672	$585	$993	4	$248	Vacuum plus shroud adapter; 35% for maintenance and operating costs. Assumes 5-year life.
Pre-wetting lining to be removed	Additional labor	N/A	N/A	$3,325	$3,325	8	$416	2 hours per week
Maintaining moisture level in the refractory applied	Additional labor	N/A	N/A	$1,662	$1,662	8	$208	1 hour per week
Also, use of precast refractories and automated equipment for powdered refractory materials	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Housekeeping worker								
Controls not identified		N/A	N/A	N/A	N/A	N/A	N/A	
Professional-level cleaning	Covered by program requirements	N/A	N/A	N/A	N/A	N/A	N/A	
Other Ferrous Sand Casting Foundries								
Sand mixer (muller) operator								
LEV, mixer & muller hood	LEV	1,050	$13,473	$3,680	$5,599	4	$1,400	Mixer & muller hood

Table A-2: Unit and Annualized Costs and Model Specifications for Silica Engineering Controls Applied in OSHA's Cost Analysis for General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Unit Cost	Annual Operating Cost	Annualized Cost (b)	Workers per Control	Annualized Cost per worker	Estimate Source
								(pg. 10-87, ACGIH, 2001)
Conveyor enclosures	200 feet, ventilated (7 take-off points)	4,900	$66,865	$17,176	$26,696	4	$6,674	Conveyor belt ventilation; (pg. 10-70, ACGIH, 2001); 2' wide belt; one take-off point at-least every 30', 7 overall
Bin and hopper ventilation	LEV	1,050	$13,473	$3,680	$5,599	4	$1,400	Bin & hopper ventilation for unvented mixers (pg. 10-69, ACGIH, 2001)
Bucket elevator ventilation	LEV	1,600	$20,531	$5,608	$8,531	4	$2,133	Bucket elevator ventilation (pg. 10-68; ACGIH, 2001); 2'x3'x30' casing; 4 take-offs @250 cfm; 100 cfm per sq. ft. of cross section
Screen ventilation	LEV	1,200	$15,398	$4,206	$6,399	4	$1,600	Ventilated screen (pg. 10-173, ACGIH, 2001); 4'x6' screen; 50 cfm per ft.[2]
Substitute silica-free materials	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Molder								
Upgraded sand handling equipment - covered elsewhere		N/A	N/A	N/A	N/A	N/A	N/A	
Upgrade or install LEV	LEV	1,050	$13,473	$3,680	$5,599	4	$1,400	Bin & hopper ventilation (pg. 10-69, ACGIH, 2001)
Rigorous housekeeping-capital	HEPA vacuum	N/A	$3,495	$511	$1,009	5	$202	Nilfisk HEPA vacuum, 15 gal. capacity (Bibbo, 2003). Assume negligible impact on labor requirements

Table A-2: Unit and Annualized Costs and Model Specifications for Silica Engineering Controls Applied in OSHA's Cost Analysis for General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Unit Cost	Annual Operating Cost	Annualized Cost (b)	Workers per Control	Annualized Cost per worker	Estimate Source
								for cleaning
Rigorous housekeeping- labor	Labor costs	N/A	N/A	$1,922	$1,922	1	$1,922	Additional 20 minutes of labor time per day
Eliminated compressed air	Included in rigorous housekeeping	N/A	N/A	NA	NA	NA	NA	
Coremaker								
Eliminated compressed air	Additional labor time	N/A	N/A	$961	$961	1	$961	10 minutes per worker per day
Enclosed conveyors, covered elsewhere		N/A	N/A	N/A	N/A	N/A	N/A	
Non-silica cores and core coatings	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Professional-level cleaning	Covered by program requirements	N/A	N/A	N/A	N/A	N/A	N/A	
Furnace operator								
Control dust releases from adjacent processes - covered elsewhere		N/A	N/A	N/A	N/A	N/A	N/A	
Well-maintained furnace emission control system		N/A	N/A	$461	$461	4	$115	20 hours additional maintenance time per year
Minimize dust generated by sand contamination of scrap	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Pouring operator								
Control dust from adjacent processes - covered elsewhere		N/A	N/A	N/A	N/A	N/A	N/A	
Operator booths or cabs	Based on clean-air island costs	2,500	$32,079	$8,763	$13,330	4	$3,333	Assumes 125 cfm/sq. ft. for 20 square feet.
Physical isolation of pouring area (create a pouring room)	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Modify ventilation system to reduce airflow from other areas into the pouring area	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Shakeout operator								

Table A-2: Unit and Annualized Costs and Model Specifications for Silica Engineering Controls Applied in OSHA's Cost Analysis for General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Unit Cost	Annual Operating Cost	Annualized Cost (b)	Workers per Control	Annualized Cost per worker	Estimate Source
Improve existing ventilation system efficiency (very large castings)	Double-draft shake-out table	28,800	$369,555	$100,951	$153,567	4	$38,392	Shakeout double side-draft table (pg. 10-23, ACGIH, 2001); assumes control needed for 10% of establishments producing large castings.
Improve existing ventilation system efficiency	Shakeout enclosing hood	7,040	$90,336	$24,677	$37,539	4	$9,385	Ventilated enclosing hood (pg. 10-23, ACGIH, 2001); 4'x4' openings; assumes control adequate except for establishments producing large castings (10%).
Partially enclose process	Enclosed, ventilated shakeout conveyor	10,000	$128,318	$35,052	$53,322	4	$13,330	ERG estimate based on expert input.
Control emissions from associated operations - covered elsewhere	Enclosed, ventilated shakeout conveyor	N/A	N/A	N/A	N/A	N/A	N/A	
Knockout operator								
Installing and improving LEV	Small knockout table	1,350	$17,323	$4,732	$7,198	4	$1,800	Portable grinding (table pg. 10-136, ACGIH, 2001), 3'x3' opening; control assumed appropriate for 50% of establishments.
Installing and improving LEV	Large knockout table	4,800	$61,593	$16,825	$25,594	4	$6,399	Hand grinding table (pg. 10-135, ACGIH, 2001), 4'x6' surface; control assumed appropriate for 50% of establishments.
Installing and improving LEV	Ventilated abrasive	1,500	$19,248	$5,258	$7,998	4	$2,000	Ventilated cut-off saw

Table A-2: Unit and Annualized Costs and Model Specifications for Silica Engineering Controls Applied in OSHA's Cost Analysis for General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Unit Cost	Annual Operating Cost	Annualized Cost (b)	Workers per Control	Annualized Cost per worker	Estimate Source
	cutoff saw							(pg. 10-134, ACGIH, 2001), 2'x3' opening; control assumed appropriate for 50% of establishments.
Reduce residual sand on castings	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Automate knockout process	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Abrasive blasting operator								
Improved maintenance for blasting cabinet		N/A	$2,450	$1,000	$1,349	2	$674	Assumes 50% increase in maintenance costs (of up to $2,000) and purchase of new cabinets (25%) at $8,000/cabinet (Norton, 2003), or additional interlocks at $1,800/cabinet (Heastrup, 2003).
Cleaning/finishing operator								
LEV for workstations	Hand grinding bench	3,750	$48,119	$13,145	$19,996	4	$4,999	Bench with LEV (pg. 10-135, ACGIH, 2001); 3'x5'; control assumed appropriate for 50% of establishments,
LEV on hand tools		200	$464	$701	$767	2	$384	ERG estimate of cfm; control assumed appropriate for 50% of establishments.
Eliminated compressed air (switch to vacuum)	HEPA vacuum plus additional time	N/A	$3,493	$1,000	$1,497	4	$374	Nilfisk HEPA vacuum, 15 gal. capacity (Bibbo, 2003). Assume 5 mins additional time per day.

Table A-2: Unit and Annualized Costs and Model Specifications for Silica Engineering Controls Applied in OSHA's Cost Analysis for General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Unit Cost	Annual Operating Cost	Annualized Cost (b)	Workers per Control	Annualized Cost per worker	Estimate Source
Substitution with non-silica materials	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Process automation	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Wet methods	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Pre-cleaning with automated equipment	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Material handler								
Enclosed, ventilated cab	Retrofit with cab or replace equipment	N/A	$15,165	$5,308	$7,467	4	$1,867	ERG estimate based on vendor interviews. Assumes 35% markup for maintenance.
Maintenance operator								
Use low silica refractory	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
LEV for chipping tools	Dust collector with HEPA vacuum	N/A	$1,672	$585	$993	4	$248	Vacuum plus shroud adapter; 35% for maintenance and operating costs. Assumes 5-year life.
Pre-wetting lining to be removed	Additional labor	N/A	N/A	$3,325	$3,325	8	$416	2 hours per week
Maintaining moisture level in the refractory applied	Additional labor	N/A	N/A	$1,662	$1,662	8	$208	1 hour per week
Also, use of precast refractories and automated equipment for powdered refractory materials	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Housekeeping worker								
Controls not identified		N/A	N/A	N/A	N/A	N/A	N/A	
Professional-level cleaning	Covered by program requirements	N/A	N/A	N/A	N/A	N/A	N/A	
Nonferrous Sand Casting Foundries								
Sand mixer (muller) operator								
LEV, mixer & muller hood	LEV	1,050	$13,473	$3,680	$5,599	4	$1,400	Mixer & muller hood

Table A-2: Unit and Annualized Costs and Model Specifications for Silica Engineering Controls Applied in OSHA's Cost Analysis for General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Unit Cost	Annual Operating Cost	Annualized Cost (b)	Workers per Control	Annualized Cost per worker	Estimate Source
								(pg. 10-87, ACGIH, 2001)
Conveyor enclosures	200 feet, ventilated (7 take-off points)	4,900	$66,833	$17,173	$26,688	4	$6,672	Conveyor belt ventilation; (pg. 10-70, ACGIH, 2001); 2' wide belt; one take-off point at-least every 30', 7 overall
Bin and hopper ventilation	LEV	1,050	$13,467	$3,680	$5,597	4	$1,399	Bin & hopper ventilation for unvented mixers (pg. 10-69, ACGIH, 2001)
Bucket elevator ventilation	LEV	1,600	$20,521	$5,607	$8,529	4	$2,132	Bucket elevator ventilation (pg. 10-68; ACGIH, 2001); 2'x3'x30' casing; 4 take-offs @250 cfm; 100 cfm per sq. ft. of cross section
Screen ventilation	LEV	1,200	$15,391	$4,206	$6,397	4	$1,599	Ventilated screen (pg. 10-173, ACGIH, 2001); 4'x6' screen; 50 cfm per ft.^{2}
Substitute silica-free materials	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Molder								
Upgraded sand handling equipment - covered elsewhere		N/A	N/A	N/A	N/A	N/A	N/A	
Upgrade or install LEV	LEV	1,050	$13,473	$3,680	$5,599	4	$1,400	Bin & hopper ventilation (pg. 10-69, ACGIH, 2001)
Rigorous housekeeping-capital	HEPA vacuum	N/A	$3,495	$511	$1,009	5	$202	Nilfisk HEPA vacuum, 15 gal. capacity (Bibbo, 2003). Assume negligible impact on labor requirements

Table A-2: Unit and Annualized Costs and Model Specifications for Silica Engineering Controls Applied in OSHA's Cost Analysis for General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Unit Cost	Annual Operating Cost	Annualized Cost (b)	Workers per Control	Annualized Cost per worker	Estimate Source
								for cleaning
Rigorous housekeeping- labor	Labor costs	N/A	N/A	$1,922	$1,922	1	$1,922	Additional 20 minutes of labor time per day
Eliminated compressed air	Included in rigorous housekeeping	N/A	N/A	N/A	N/A	N/A	N/A	
Coremaker								
Eliminated compressed air	Additional labor time	N/A	N/A	$961	$961	1	$961	10 minutes per worker per day
Enclosed conveyors, covered elsewhere		N/A	N/A	N/A	N/A	N/A	N/A	
Non-silica cores and core coatings	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Professional-level cleaning	Covered by program requirements	N/A	N/A	N/A	N/A	N/A	N/A	
Furnace operator								
Control dust releases from adjacent processes - covered elsewhere		N/A	N/A	N/A	N/A	N/A	N/A	
Well-maintained furnace emission control system		N/A	N/A	$461	$461	4	$115	20 hours additional maintenance time per year
Minimize dust generated by sand contamination of scrap	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Control dust from adjacent processes - covered elsewhere		N/A	N/A	N/A	N/A	N/A	N/A	
Pouring operator								
Operator booths or cabs	Based on clean-air island costs	2,500	$32,079	$8,763	$13,330	4	$3,333	Assumes 125 cfm/sq. ft. for 20 square feet.
Physical isolation of pouring area (create a pouring room)	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Modify ventilation system to reduce airflow from other areas into the pouring area	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Shakeout operator								

Table A-2: Unit and Annualized Costs and Model Specifications for Silica Engineering Controls Applied in OSHA's Cost Analysis for General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Unit Cost	Annual Operating Cost	Annualized Cost (b)	Workers per Control	Annualized Cost per worker	Estimate Source
Improve existing ventilation system efficiency (very large castings)	Double-draft shake-out table	28,800	$369,555	$100,951	$153,567	4	$38,392	Shakeout double side-draft table (pg. 10-23, ACGIH, 2001); assumes control needed for 10% of establishments producing large castings.
Improve existing ventilation system efficiency	Shakeout enclosing hood	7,040	$90,336	$24,677	$37,539	4	$9,385	Ventilated enclosing hood (pg. 10-23, ACGIH, 2001); 4'x4' openings; assumes control adequate except for establishments producing large castings (10%).
Partially enclose process	Enclosed, ventilated shakeout conveyor	10,000	$128,318	$35,052	$53,322	4	$13,330	ERG estimate based on expert input.
Control emissions from associated operations - covered elsewhere		N/A	N/A	N/A	N/A	N/A	N/A	
Knockout operator								
Installing and improving LEV	Small knockout table	1,350	$17,323	$4,732	$7,198	4	$1,800	Portable grinding table (pg. 10-13, ACGIH, 2001), 3'x3' opening; control assumed appropriate for 50% of establishments.
Installing and improving LEV	Large knockout table	4,800	$61,563	$16,825	$25,594	4	$6,399	Hand grinding table (pg. 10-135, ACGIH, 2001), 4'x6' surface; control assumed appropriate for 50% of establishments.
Installing and improving LEV	Ventilated abrasive	1,500	$19,238	$5,257	$7,998	4	$2,000	Ventilated cut-off saw

Table A-2: Unit and Annualized Costs and Model Specifications for Silica Engineering Controls Applied in OSHA's Cost Analysis for General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Unit Cost	Annual Operating Cost	Annualized Cost (b)	Workers per Control	Annualized Cost per worker	Estimate Source
	cutoff saw							(pg. 10-134, ACGIH, 2001), 2'x3' opening; control assumed appropriate for 50% of establishments.
Reduce residual sand on castings	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Automate knockout process	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Abrasive blasting operator								
Improved maintenance for blasting cabinet		N/A	$2,450	$1,000	$1,349	2	$674	Assumes 50% increase in maintenance costs (of up to $2,000) and purchase of new cabinets (25%) at $8,000/cabinet (Norton, 2003), or additional interlocks at $1,800/cabinet (Heastrup, 2003).
Cleaning/finishing operator								
LEV for workstations	Hand grinding bench	3,750	$48,119	$13,145	$19,996	4	$4,999	Bench with LEV (pg. 10-135, ACGIH, 2001); 3'x5'; control assumed appropriate for 50% of establishments,
LEV on hand tools		200	$464	$701	$767	2	$384	ERG estimate of cfm; control assumed appropriate for 50% of establishments.
Eliminated compressed air (switch to vacuum)	HEPA vacuum plus additional time	N/A	$3,495	$1,006	$1,503	4	$376	Nilfisk HEPA vacuum, 15 gal. capacity (Bibbo, 2003). Assume 5 mins additional time per day.

Table A-2: Unit and Annualized Costs and Model Specifications for Silica Engineering Controls Applied in OSHA's Cost Analysis for General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Unit Cost	Annual Operating Cost	Annualized Cost (b)	Workers per Control	Annualized Cost per worker	Estimate Source
Substitution with non-silica materials	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Process automation	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Wet methods	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Pre-cleaning with automated equipment	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Material handler								
Enclosed, ventilated cab	Retrofit with cab or replace equipment	N/A	$15,165	$5,308	$7,467	4	$1,867	ERG estimate based on vendor interviews. Assumes 35% markup for maintenance.
Maintenance operator								
Use low silica refractory	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
LEV for chipping tools	Dust collector with HEPA vacuum	N/A	$1,672	$585	$993	4	$248	Vacuum plus shroud adapter; 35% for maintenance and operating costs. Assumes 5-year life.
Pre-wetting lining to be removed	Additional labor	N/A	N/A	$3,325	$3,325	8	$416	2 hours per week
Maintaining moisture level in the refractory applied	Additional labor	N/A	N/A	$1,662	$1,662	8	$208	1 hour per week
Also, use of precast refractories and automated equipment for powdered refractory materials	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Housekeeping worker								
Controls not identified		N/A	N/A	N/A	N/A	N/A	N/A	
Professional-level cleaning	Covered by program requirements	N/A	N/A	N/A	N/A	N/A	N/A	
Non-Sand Casting Foundries								
Sand mixer (muller) operator								
LEV, mixer & muller hood	LEV	1,050	$13,473	$3,680	$5,599	4	$1,400	Mixer & muller hood

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Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Unit Cost	Annual Operating Cost	Annualized Cost (b)	Workers per Control	Annualized Cost per worker	Estimate Source
								(pg. 10-87, ACGIH, 2001)
Conveyor enclosures	200 feet, ventilated (7 take-off points)	4,900	$66,865	$17,176	$26,696	4	$6,674	Conveyor belt ventilation; (pg. 10-70, ACGIH, 2001); 2' wide belt; one take-off point at-least every 30', 7 overall
Bin and hopper ventilation	LEV	1,050	$13,473	$3,680	$5,599	4	$1,400	Bin & hopper ventilation for unvented mixers (pg. 10-69, ACGIH, 2001)
Bucket elevator ventilation	LEV	1,600	$20,521	$5,607	$8,529	4	$2,132	Bucket elevator ventilation (pg. 10-68; ACGIH, 2001); 2'x3'x30' casing; 4 take-offs @250 cfm; 100 cfm per sq. ft. of cross section
Screen ventilation	LEV	1,200	$15,391	$4,206	$6,397	4	$1,599	Ventilated screen (pg. 10-173, ACGIH, 2001); 4'x6' screen; 50 cfm per ft^2
Substitute silica-free materials	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Molder								
Upgraded sand handling equipment - covered elsewhere		N/A	N/A	N/A	N/A	N/A	N/A	
Upgrade or install LEV	LEV	1,050	$13,473	$3,680	$5,599	4	$1,400	Bin & hopper ventilation (pg. 10-69, ACGIH, 2001)
Rigorous housekeeping-capital	HEPA vacuum	N/A	$3,495	$511	$1,009	5	$202	Nilfisk HEPA vacuum, 15 gal. capacity (Bibbo, 2003). Assume negligible impact on labor requirements

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								for cleaning
Rigorous housekeeping- labor	Labor costs	N/A	N/A	$1,922	$1,922	1	$1,922	Additional 20 minutes of labor time per day
Eliminated compressed air	Included in rigorous housekeeping	N/A	N/A	N/A	N/A	N/A	N/A	
Coremaker								
Eliminated compressed air	Additional labor time	N/A	N/A	$961	$961	1	$961	10 minutes per worker per day
Enclosed conveyors, covered elsewhere		N/A	N/A	N/A	N/A	N/A	N/A	
Non-silica cores and core coatings	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Professional-level cleaning	Covered by program requirements	N/A	N/A	N/A	N/A	N/A	N/A	
Furnace operator								
Control dust releases from adjacent processes - covered elsewhere		N/A	N/A	N/A	N/A	N/A	N/A	
Well-maintained furnace emission control system		N/A	N/A	$461	$461	4	$115	20 hours additional maintenance time per year
Minimize dust generated by sand contamination of scrap	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Pouring operator								
Control dust from adjacent processes - covered elsewhere		N/A	N/A	N/A	N/A	N/A	N/A	
Operator booths or cabs	Based on clean-air island costs	2,500	$32,079	$8,763	$13,330	4	$3,333	Assumes 125 cfm/sq. ft. for 20 square feet.
Physical isolation of pouring area (create a pouring room)	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Modify ventilation system to reduce airflow from other areas into the pouring area	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Shakeout operator								

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Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Unit Cost	Annual Operating Cost	Annualized Cost (b)	Workers per Control	Annualized Cost per worker	Estimate Source
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Improve existing ventilation system efficiency	Shakeout enclosing hood	7,040	$90,336	$24,677	$37,539	4	$9,385	Ventilated enclosing hood (pg. 10-23, ACGIH, 2001); 4'x4' openings; assumes control adequate except for establishments producing large castings (10%).
Partially enclose process	Enclosed, ventilated shakeout conveyor	10,000	$128,318	$35,052	$53,322	4	$13,330	ERG estimate based on expert input.
Control emissions from associated operations - covered elsewhere		N/A	N/A	N/A	N/A	N/A	N/A	
Knockout operator								
Installing and improving LEV	Small knockout table	1,350	$17,323	$4,732	$7,198	4	$1,800	Portable grinding table (pg. 10-136, ACGIH, 2001), 3'x3' opening; control assumed appropriate for 50% of establishments.
Installing and improving LEV	Large knockout table	4,800	$61,593	$16,825	$25,594	4	$6,399	Hand grinding table (pg. 10-135, ACGIH, 2001), 4'x6' surface; control assumed appropriate for 50% of establishments.
Installing and improving LEV	Ventilated abrasive	1,500	$19,248	$5,258	$7,998	4	$2,000	Ventilated cut-off saw

Table A-2: Unit and Annualized Costs and Model Specifications for Silica Engineering Controls Applied in OSHA's Cost Analysis for General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Unit Cost	Annual Operating Cost	Annualized Cost (b)	Workers per Control	Annualized Cost per worker	Estimate Source
	cutoff saw							(pg. 10-134, ACGIH, 2001), 2'x3' opening; control assumed appropriate for 50% of establishments.
Reduce residual sand on castings	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Automate knockout process	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Abrasive blasting operator								
Improved maintenance for blasting cabinet		N/A	$2,450	$1,000	$1,349	2	$674	Assumes 50% increase in maintenance costs (of up to $2,000) and purchase of new cabinets (25%) at $8,000/cabinet (Norton, 2003), or additional interlocks at $1,800/cabinet (Heastrup, 2003).
Cleaning/finishing operator								
LEV for workstations	Hand grinding bench	3,750	$48,119	$13,145	$19,996	4	$4,999	Bench with LEV (pg. 10-135, ACGIH, 2001); 3'x5'; control assumed appropriate for 50% of establishments,
LEV on hand tools		200	$464	$701	$767	2	$384	ERG estimate of cfm; control assumed appropriate for 50% of establishments.
Eliminated compressed air (switch to vacuum)	HEPA vacuum plus additional time	N/A	$3,495	$1,006	$1,503	4	$376	Nilfisk HEPA vacuum, 15 gal. capacity (Bibbo, 2003). Assume 5 mins additional time per day.

Table A-2: Unit and Annualized Costs and Model Specifications for Silica Engineering Controls Applied in OSHA's Cost Analysis for General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Unit Cost	Annual Operating Cost	Annualized Cost (b)	Workers per Control	Annualized Cost per worker	Estimate Source
Substitution with non-silica materials	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Process automation	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Wet methods	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Pre-cleaning with automated equipment	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Material handler								
Enclosed, ventilated cab	Retrofit with cab or replace equipment	N/A	$15,165	$5,308	$7,467	4	$1,867	ERG estimate based on vendor interviews. Assumes 35% markup for maintenance.
Maintenance operator								
Use low silica refractory	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
LEV for chipping tools	Dust collector with HEPA vacuum	N/A	$1,672	$585	$993	4	$248	Vacuum plus shroud adapter; 35% for maintenance and operating costs. Assumes 5-year life.
Pre-wetting lining to be removed	Additional labor	N/A	N/A	$3,325	$3,325	8	$416	2 hours per week
Maintaining moisture level in the refractory applied	Additional labor	N/A	N/A	$1,662	$1,662	8	$208	1 hour per week
Also, use of precast refractories and automated equipment for powdered refractory materials	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Housekeeping worker								
Controls not identified		N/A	N/A	N/A	N/A	N/A	N/A	
Professional-level cleaning	Covered by program requirements	N/A	N/A	N/A	N/A	N/A	N/A	
Captive Foundries								
Sand mixer (muller) operator								
LEV, mixer & muller hood	LEV	1,050	$13,473	$3,680	$5,599	4	$1,400	Mixer & muller hood (pg. 10-87, ACGIH,

Table A-2: Unit and Annualized Costs and Model Specifications for Silica Engineering Controls Applied in OSHA's Cost Analysis for General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Unit Cost	Annual Operating Cost	Annualized Cost (b)	Workers per Control	Annualized Cost per worker	Estimate Source
								2001)
Conveyor enclosures	200 feet, ventilated (7 take-off points)	4,900	$66,865	$17,176	$26,696	4	$6,674	Conveyor belt ventilation; (pg. 10-70, ACGIH, 2001); 2' wide belt; one take-off point at-least every 30', 7 overall
Bin and hopper ventilation	LEV	1,050	$13,473	$3,680	$5,599	4	$1,400	Bin & hopper ventilation for unvented mixers (pg. 10-69, ACGIH, 2001)
Bucket elevator ventilation	LEV	1,600	$20,531	$5,608	$8,531	4	$2,133	Bucket elevator ventilation (pg. 10-68; ACGIH, 2001); 2'x3'x30' casing; 4 take-offs @250 cfm; 100 cfm per sq. ft. of cross section
Screen ventilation	LEV	1,200	$15,398	$4,206	$6,399	4	$1,600	Ventilated screen (pg. 10-173, ACGIH, 2001); 4'x6' screen; 50 cfm per ft.[2]
Substitute silica-free materials	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Molder								
Upgraded sand handling equipment - covered elsewhere		N/A	N/A	N/A	N/A	N/A	N/A	
Upgrade or install LEV	LEV	1,050	$13,473	$3,680	$5,599	4	$1,400	Bin & hopper ventilation (pg. 10-69, ACGIH, 2001)
Rigorous housekeeping-capital	HEPA vacuum	N/A	$3,495	$511	$1,009	5	$202	Nilfisk HEPA vacuum, 15 gal. capacity (Bibbo, 2003). Assume negligible impact on labor requirements for cleaning

Table A-2: Unit and Annualized Costs and Model Specifications for Silica Engineering Controls Applied in OSHA's Cost Analysis for General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Unit Cost	Annual Operating Cost	Annualized Cost (b)	Workers per Control	Annualized Cost per worker	Estimate Source
Rigorous housekeeping- labor	Labor costs	N/A	N/A	$1,922	$1,922	1	$1,922	Additional 20 minutes of labor time per day
Eliminated compressed air	Included in rigorous housekeeping	N/A	N/A	N/A	N/A	N/A	N/A	
Coremaker								
Eliminated compressed air	Additional labor time	N/A	N/A	$961	$961	1	$961	10 minutes per worker per day
Enclosed conveyors, covered elsewhere		N/A	N/A	N/A	N/A	N/A	N/A	
Non-silica cores and core coatings	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Professional-level cleaning	Covered by program requirements	N/A	N/A	N/A	N/A	N/A	N/A	
Furnace operator								
Control dust releases from adjacent processes - covered elsewhere		N/A	N/A	N/A	N/A	N/A	N/A	
Well-maintained furnace emission control system		N/A	N/A	$461	$461	4	$115	20 hours additional maintenance time per year
Minimize dust generated by sand contamination of scrap	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Pouring operator								
Control dust from adjacent processes - covered elsewhere		N/A	N/A	N/A	N/A	N/A	N/A	
Operator booths or cabs	Based on clean-air island costs	2,500	$32,079	$8,763	$13,330	4	$3,333	Assumes 125 cfm/sq. ft. for 20 square feet.
Physical isolation of pouring area (create a pouring room)	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Modify ventilation system to reduce airflow from other areas into the pouring area	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Shakeout operator								
Improve existing ventilation	Double-draft shake-out	28,800	$369,555	$100,951	$153,567	4	$38,392	Shakeout double

Table A-2: Unit and Annualized Costs and Model Specifications for Silica Engineering Controls Applied in OSHA's Cost Analysis for General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Unit Cost	Annual Operating Cost	Annualized Cost (b)	Workers per Control	Annualized Cost per worker	Estimate Source
system efficiency (very large castings)	table							side-draft table (pg. 10-23, ACGIH, 2001); assumes control needed for 10% of establishments producing large castings.
Improve existing ventilation system efficiency	Shakeout enclosing hood	7,040	$90,336	$24,677	$37,539	4	$9,385	Ventilated enclosing hood (pg. 10-23, ACGIH, 2001); 4'x4' openings; assumes control adequate except for establishments producing large castings (10%).
Partially enclose process	Enclosed, ventilated shakeout conveyor	10,000	$128,318	$35,052	$53,322	4	$13,330	ERG estimate based on expert input.
Control emissions from associated operations - covered elsewhere		N/A	N/A	N/A	N/A	N/A	N/A	
Knockout operator								
Installing and improving LEV	Small knockout table	1,350	$17,323	$4,732	$7,198	4	$1,800	Portable grinding table (pg. 10-136, ACGIH, 2001), 3'x3' opening; control assumed appropriate for 50% of establishments.
Installing and improving LEV	Large knockout table	4,800	$61,593	$16,825	$25,594	4	$6,399	Hand grinding table (pg. 10-135, ACGIH, 2001), 4'x6' surface; control assumed appropriate for 50% of establishments.
Installing and improving LEV	Ventilated abrasive cutoff saw	1,500	$19,248	$5,258	$7,998	4	$2,000	Ventilated cut-off saw (pg. 10-134, ACGIH,

Table A-2: Unit and Annualized Costs and Model Specifications for Silica Engineering Controls Applied in OSHA's Cost Analysis for General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Unit Cost	Annual Operating Cost	Annualized Cost (b)	Workers per Control	Annualized Cost per worker	Estimate Source
								2001), 2'x3' opening; control assumed appropriate for 50% of establishments.
Reduce residual sand on castings	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Automate knockout process	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Abrasive blasting operator								
Improved maintenance for blasting cabinet		N/A	$2,450	$1,000	$1,349	2	$674	Assumes 50% increase in maintenance costs (of up to $2,000) and purchase of new cabinets (25%) at $8,000/cabinet (Norton, 2003), or additional interlocks at $1,800/cabinet (Heastrup, 2003).
Cleaning/finishing operator								
LEV for workstations	Hand grinding bench	3,750	$48,119	$13,145	$19,996	4	$4,999	Bench with LEV (pg. 10-135, ACGIH, 2001); 3'x5'; control assumed appropriate for 50% of establishments,
LEV on hand tools		200	$464	$701	$767	2	$384	ERG estimate of cfm; control assumed appropriate for 50% of establishments.
Eliminated compressed air (switch to vacuum)	HEPA vacuum plus additional time	N/A	$3,495	$1,000	$1,503	4	$376	Nilfisk HEPA vacuum, 15 gal. capacity (Bibbo, 2003). Assume 5 mins additional time per day.

Table A-2: Unit and Annualized Costs and Model Specifications for Silica Engineering Controls Applied in OSHA's Cost Analysis for General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Unit Cost	Annual Operating Cost	Annualized Cost (b)	Workers per Control	Annualized Cost per worker	Estimate Source
Substitution with non-silica materials	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Process automation	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Wet methods	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Pre-cleaning with automated equipment	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Material handler								
Enclosed, ventilated cab	Retrofit with cab or replace equipment	N/A	$15,165	$5,308	$7,467	4	$1,867	ERG estimate based on vendor interviews. Assumes 35% markup for maintenance.
Maintenance operator								
Use low silica refractory	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
LEV for chipping tools	Dust collector with HEPA vacuum	N/A	$1,672	$585	$993	4	$248	Vacuum plus shroud adapter; 35% for maintenance and operating costs. Assumes 5-year life.
Pre-wetting lining to be removed	Additional labor	N/A	N/A	$3,325	$3,325	8	$416	2 hours per week
Maintaining moisture level in the refractory applied	Additional labor	N/A	N/A	$1,662	$1,662	8	$208	1 hour per week
Also, use of precast refractories and automated equipment for powdered refractory materials	Option not costed	N/A	N/A	N/A	N/A	N/A	N/A	
Housekeeping worker								
Controls not identified		N/A	N/A	N/A	N/A	N/A	N/A	
Professional-level cleaning	Covered by program requirements	N/A	N/A	N/A	N/A	N/A	N/A	
Railroads								
Ballast dumper								
Spray system for right-of-way maintenance vehicles	Costs estimated per rail car, see Table 3-6	N/A	N/A	N/A	N/A	N/A	N/A	
Machine operator								

Table A-2: Unit and Annualized Costs and Model Specifications for Silica Engineering Controls Applied in OSHA's Cost Analysis for General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Unit Cost	Annual Operating Cost	Annualized Cost (b)	Workers per Control	Annualized Cost per worker	Estimate Source
Spray system for right-of-way maintenance vehicles	Costs estimated per rail car, see Table 3-6	N/A	N/A	N/A	N/A	N/A	N/A	
Asphalt Roofing Materials								
Production operator								
Process enclosure	Enclose conveyors and equip	N/A	$3,990	$399	$967	4	$242	200 feet at $17.10 per linear foot (Landola, 2003)
Enhanced ventilation	Conveyor ventilation	700	$8,982	$2,454	$3,733	4	$933	Bin & hopper ventilation and unvented mixers (pg. 10-69, ACGIH, 2001)
Rigorous housekeeping-capital	HEPA vacuum	N/A	$3,495	$511	$1,009	4	$252	Nilfisk HEPA vacuum, 15 gal. capacity (Bibbo, 2003).
Rigorous housekeeping- labor	Incremental labor costs	N/A	N/A	$1,486	$1,486	1	$1,486	Additional 10 minutes labor time per day
Material handler								
No additional controls required	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Controls for production operator adequate
Porcelain Enameling								
Preparer								
Well-ventilated bag dumping stations	LEV	1,513	$19,414	$5,303	$8,068	4	$2,017	Bag opening station; (pg. 10-19, ACGIH, 2001)
Porcelain applicator								
Improved LEV for spray booths and enclosures	increased airflow\cfm	1,000	$3,208	$876	$1,333	4	$333	Additional cfm at 25% of installed price
Spray booth maintenance	Materials plus labor	N/A	N/A	$231	$231	4	$58	Annually, $100 materials plus 4 hours maintenance time
Mineral Processing								
Production worker								

Table A-2: Unit and Annualized Costs and Model Specifications for Silica Engineering Controls Applied in OSHA's Cost Analysis for General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Unit Cost	Annual Operating Cost	Annualized Cost (b)	Workers per Control	Annualized Cost per worker	Estimate Source
Enclosed ventilation equipment	Conveyor cover; 200'	N/A	$3,990	$399	$967	4	$242	200 feet at $17.10 per linear foot (Landola, 2003); assumes cover adequate for 50% of establishments
Conveyor ventilation	LEV	4,900	$62,876	$17,176	$26,128	4	$6,532	Conveyor belt ventilation; (pg. 10-70, ACGIH, 2001) One take-off point at-least every 30', 7 overall; assumes 50% of establishments needed ventilated conveyor covers.
Improved maintenance	Labor costs	N/A	N/A	$1,139	$1,139	1	$1,139	1 hour additional maintenance time per week per production worker; assumes 50% of establishments need improved maintenance of ventilation system.
Professional cleaning	Commercial cleaning service; semiannual	N/A	N/A	N/A	N/A	1	N/A	
Improved area cleanup with HEPA	Equipment cost	N/A	$3,495	$511	$1,009	4	$252	Nilfisk HEPA vacuum, 15 gal. capacity (Bibbo, 2003)
Enhanced housekeeping with HEPA vacuums	Additional labor time	N/A	N/A	$1,825	$1,825	1	$1,825	Additional 20 minutes per day
Dental Equipment and Supplies								
Production operator								
Ventilated bag dumping	LEV	1,513	$19,414	$5,303	$8,068	4	$2,017	Bag opening station

Table A-2: Unit and Annualized Costs and Model Specifications for Silica Engineering Controls Applied in OSHA's Cost Analysis for General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Unit Cost	Annual Operating Cost	Annualized Cost (b)	Workers per Control	Annualized Cost per worker	Estimate Source
stations with bag compactor								(pg. 10-19, ACGIH, 2001); other controls are available.
Enclosed and ventilated mixing equipment	LEV	1,050	$13,473	$3,680	$5,599	4	$1,400	Mixer & muller hood (pg. 10-87, ACGIH, 2001); other controls are available.
Increased LEV maintenance	Additional cost per operator	N/A	N/A	$280	$280	1	$280	Assumes 1 hour additional maintenance time per operator per month
Asphalt Paving Products								
Plant operator								
No overexposures	Additional controls not needed	N/A	N/A	N/A	N/A	N/A	N/A	
Front-end loader operator								
Enclosed cabs	Retrofit with cab or replacement equip	N/A	$15,165	$5,308	$7,467	2	$3,733	ERG estimate based on vendor interviews. Assumes 35% markup for maintenance.
Maintenance worker								
No overexposures	Additional controls not needed	N/A	N/A	N/A	N/A	N/A	N/A	
Quality control worker								
No overexposures	Additional controls not needed	N/A	N/A	N/A	N/A	N/A	N/A	
Refractory Repair								
Production operator								
Portable exhaust ventilation	LEV	400	$5,133	$1,402	$2,133	2	$1,066	Moveable exhaust hoods example: pg. 10-93 (ACGIH, 2001); other controls are available.
Wet methods for chipping tools	Shop-built water feed equipment	N/A	$117	0	$117	1	$117	Assumes $100 in annual costs; other

Table A-2: Unit and Annualized Costs and Model Specifications for Silica Engineering Controls Applied in OSHA's Cost Analysis for General Industry and Maritime

Sector/Job Category - Control Requirements/Options	Control Description (a)	LEV Airflow (cfm)	Unit Cost	Annual Operating Cost	Annualized Cost (b)	Workers per Control	Annualized Cost per worker	Estimate Source
								controls are available.
LEV for chipping tools	LEV	600	$7,699	$2,103	3,199	2	$1,600	Granite cutting and finishing; (pg. 10-94, ACGIH, 2001); other controls are available.
Improved maintenance for spay guns	Labor costs	N/A	N/A	$344	$344	1	$344	Assumes 1 hour additional maintenance time per operator per month

a) "Control not costed" means that other less costly control measures were available to achieve the same level of exposure reduction.
b) Costs are annualized using a 7 percent discount rate over the lifetime of the equipment, typically 10 years.

Source: U.S. Dept. of Labor, OSHA, Directorate of Evaluation and Analysis, Office of Regulatory Analysis, based on ERG (2007b) and ERG (2011).

Table V-A-3: Total Control Costs by Sector, Job Category, and Control for General Industry and Maritime Employers Affected by the Proposed Silica PEL and an Alternative Silica PEL of 100 μg/m³

Sector/Job Category - Control Requirements/Options	No. of Workers At Risk				% of Overexposed Employees Needing Control to Achieve Control Level		Total Cost	
	50	100	Cost per Worker	Percent Applicability	50	100	50	100
Cut Stone								
Sawyer	1,808	556						
Control other dust sources in area			N/A	N/A	N/A	N/A	$0	$0
Rigorous housekeeping- capital			$252	100.0%	100.0%	100.0%	$455,985	$140,303
Rigorous housekeeping- labor			$913	100.0%	100.0%	100.0%	$1,649,995	$507,691
Manage slurry-assumed included in housekeeping costs			N/A	N/A	N/A	N/A	$0	$0
Pre-wash stone to be cut			$456	100.0%	100.0%	100.0%	$824,998	$253,845
Keep floors wet; washdown with high pressure hose			$2,111	100.0%	0.0%	100.0%	$1,174,284	$1,174,284
Increase water use at saw blade			$456	25.0%	100.0%	100.0%	$206,249	$63,461
Use water-fed equipment			$228	100.0%	0.0%	100.0%	$126,923	$126,923
Enclose saw			$59	10.0%	100.0%	100.0%	$10,753	$3,309
Exhaust saw			$600	100.0%	100.0%	100.0%	$1,084,596	$333,722
Fabricator	1,189	991						
Use water fed equipment			N/A	N/A	N/A	N/A	$0	$0
Management of dust-carrying water slurry			N/A	N/A	N/A	N/A	$0	$0
Rigorous housekeeping- capital			$252	100.0%	100.0%	100.0%	$299,861	$249,884
Rigorous housekeeping- labor			$456	100.0%	100.0%	100.0%	$542,527	$452,106
Splitter/chipper	543	380						
Use work practices to position work near duct			N/A	N/A	N/A	N/A	$0	$0
Rigorous housekeeping- capital			$252	100.0%	100.0%	100.0%	$136,886	$95,820
Rigorous housekeeping- labor			$913	100.0%	100.0%	100.0%	$495,325	$346,728
Pre-wash stone			$456	100.0%	100.0%	100.0%	$247,663	$173,364
Use flexible trunk LEV for hand chipping			$1,600	75.0%	0.0%	100.0%	$455,831	$455,831
Tool-mounted LEV for hand-held chipping tools			$412	37.5%	0.0%	100.0%	$58,635	$58,635
Keep floors wet; washdown with high pressure hose			N/A	N/A	N/A	N/A	$0	$0
Machine operator	3,321	2,214						

Table V-A-3: Total Control Costs by Sector, Job Category, and Control for General Industry and Maritime Employers Affected by the Proposed Silica PEL and an Alternative Silica PEL of 100 μg/m³

Sector/Job Category - Control Requirements/Options	No. of Workers At Risk				% of Overexposed Employees Needing Control to Achieve Control Level		Total Cost	
	50	100	Cost per Worker	Percent Applicability	50	100	50	100
Control other dust sources in area			N/A	N/A	N/A	N/A	$0	$0
Rigorous housekeeping- capital			$252	100.0%	100.0%	100.0%	$837,626	$558,418
Rigorous housekeeping- labor			$913	100.0%	100.0%	100.0%	$3,030,976	$2,020,651
Wash stone before and after each process			$143	100.0%	100.0%	100.0%	$476,380	$317,587
Keep conveyor clean and damp			N/A	N/A	N/A	N/A	$0	$0
Management of dust-carrying water			N/A	N/A	N/A	N/A	$0	$0
Enclose machinery			$42	100.0%	100.0%	100.0%	$139,260	$92,840
Exhaust trimming machine			$667	100.0%	100.0%	100.0%	$2,213,734	$1,475,822
Abrasive blasting operator	580	435						
For use of maintained, interlocked, ventilated glove-box cabinet			$337	100.0%	100.0%	100.0%	$195,678	$146,758
Use only non-silica blasting media			N/A	5.0%	100.0%	100.0%	$0	$0
Increase blasting cabinet ventilation			$1,666	100.0%	100.0%	100.0%	$966,944	$725,208
Use HEPA vacuums for machine cleaning			$252	100.0%	100.0%	100.0%	$146,348	$109,761
Flat glass								
Material handler	48	29						
Automated and ventilated unloading equipment			N/A	N/A	N/A	N/A	$0	$0
Bag opening station (small facilities only)			$2,017	36.0%	100.0%	100.0%	$34,919	$20,952
Batch operator	106	35						
Conveyor enclosures			$242	100.0%	100.0%	100.0%	$25,723	$8,574
LEV for batch operator workstation			$1,400	100.0%	100.0%	100.0%	$148,935	$49,645
Dust suppressants			$159	100.0%	100.0%	100.0%	$16,880	$5,627
Substitute wider HEPA vacuum use for compressed air			$962	100.0%	100.0%	100.0%	$102,384	$34,128
HEPA vacuums			$252	100.0%	100.0%	100.0%	$26,835	$8,945
Other glass								
Material handler	322	193						
Automated and ventilated unloading equipment			N/A	N/A	N/A	N/A	$0	$0
Bag opening station (small facilities only)			$2,017	69.0%	100.0%	100.0%	$448,148	$268,889

Table V-A-3: Total Control Costs by Sector, Job Category, and Control for General Industry and Maritime Employers Affected by the Proposed Silica PEL and an Alternative Silica PEL of 100 μg/m³

Sector/Job Category - Control Requirements/Options	No. of Workers At Risk				% of Overexposed Employees Needing Control to Achieve Control Level		Total Cost	
	50	100	Cost per Worker	Percent Applicability	50	100	50	100
Batch operator	685	228						
Conveyor enclosures			$242	100.0%	100.0%	100.0%	$165,587	$55,196
LEV for batch operator workstation			$1,400	100.0%	100.0%	100.0%	$958,758	$319,586
Dust suppressants			$159	100.0%	100.0%	100.0%	$108,662	$36,221
Substitute wider HEPA vacuum use for compressed air			$962	100.0%	100.0%	100.0%	$659,087	$219,696
HEPA vacuums			$202	100.0%	100.0%	100.0%	$138,199	$46,066
Mineral Wool								
Material handler	216	130						
Automated and ventilated unloading equipment			N/A	N/A	N/A	N/A	$0	$0
Bag opening station (small facilities only)			$2,017	52.0%	100.0%	100.0%	$226,808	$136,085
Batch operator	415	138						
Conveyor enclosures			$242	100.0%	100.0%	100.0%	$100,439	$33,480
LEV for batch operator workstation			$1,400	100.0%	100.0%	100.0%	$581,548	$193,849
Dust suppressants			$159	100.0%	100.0%	100.0%	$65,910	$21,970
Substitute wider HEPA vacuum use for compressed air			$913	100.0%	100.0%	100.0%	$379,161	$126,387
HEPA vacuums			$202	100.0%	100.0%	100.0%	$83,826	$27,942
Concrete Products								
Material handler	7265	3,302						
Yard dust suppression			$1,403	100.0%	100.0%	100.0%	$10,196,244	$4,634,656
Enclosed cabs			$1,867	100.0%	0.0%	100.0%	$6,164,453	$6,164,453
Mixer operator	1,986	1,986						
Wet methods to clean equipment			$917	100.0%	100.0%	100.0%	$1,820,752	$1,820,752
LEV for bag opening stations			$2,017	75.0%	100.0%	100.0%	$3,004,087	$3,004,087
Ventilated control room and HEPA filter			$871	25.0%	100.0%	100.0%	$432,625	$432,625
Forming line operator	1,215	304						
Dust control for adjacent operations			N/A	N/A	N/A	N/A	$0	$0
Abrasive blasting operator	3,546	3,102						
Use wet process			$33	100.0%	100.0%	100.0%	$118,483	$88,862

Table V-A-3: Total Control Costs by Sector, Job Category, and Control for General Industry and Maritime Employers Affected by the Proposed Silica PEL and an Alternative Silica PEL of 100 μg/m³

Sector/Job Category - Control Requirements/Options	No. of Workers At Risk				% of Overexposed Employees Needing Control to Achieve Control Level		Total Cost	
	50	100	Cost per Worker	Percent Applicability	50	100	50	100
Finishing operator	3,354	2,396						
Work concrete green			$2,200	25.0%	100.0%	100.0%	$1,844,991	$1,317,851
Use wet process			$33	25.0%	100.0%	100.0%	$28,020	$20,014
LEV where wet methods are infeasible			$496	25.0%	100.0%	100.0%	$416,214	$297,295
Use alternative blast media			$8,412	25.0%	100.0%	100.0%	$7,052,986	$5,037,847
Packaging operator	1,838	919						
LEV for bag filling stations			$2,000	100.0%	100.0%	100.0%	$3,675,349	$1,837,675
Extended polyethylene bag valves to reduce dust release			$4,728	100.0%	100.0%	100.0%	$8,691,020	$4,345,510
Pottery								
Material handler	578	321						
Well-ventilated bag dumping stations			$1,400	100.0%	100.0%	100.0%	$809,444	$449,691
Ventilated cab enclosures			$1,867	100.0%	100.0%	100.0%	$1,079,514	$599,730
LEV for mixer			$1,400	100.0%	100.0%	100.0%	$809,444	$449,691
Forming line operator	1,866	1,083						
LEV- hand grinding bench controls			$1,866	100.0%	100.0%	100.0%	$3,481,721	$2,021,644
Eliminate compressed air (switch to vacuum)			$376	100.0%	100.0%	100.0%	$701,158	$407,124
Reduce dust generation during mold parting (redesign talc bag)			N/A	N/A	N/A	N/A	$0	$0
Substitute non-silica parting compounds			N/A	N/A	N/A	N/A	$0	$0
Finishing operator	355	218						
LEV- hand grinding bench controls			$3,199	100.0%	100.0%	100.0%	$1,134,477	$698,140
Wet finishing			N/A	N/A	N/A	N/A	$0	$0
Coatings preparer	466	302						
Well-ventilated bag dumping stations			$2,017	100.0%	100.0%	100.0%	$940,044	$608,264
Well-ventilated or enclosed, automated systems for charging mixing equipment with glaze materials			$1,400	100.0%	100.0%	100.0%	$652,377	$422,126
Coatings operator	1,513	1,164						
Substitute low silica content inputs			N/A	N/A	N/A	N/A	$0	$0

Table V-A-3: Total Control Costs by Sector, Job Category, and Control for General Industry and Maritime Employers Affected by the Proposed Silica PEL and an Alternative Silica PEL of 100 μg/m³

Sector/Job Category - Control Requirements/Options	No. of Workers At Risk				% of Overexposed Employees Needing Control to Achieve Control Level		Total Cost	
	50	100	Cost per Worker	Percent Applicability	50	100	50	100
Improved LEV for spray booths and enclosures			$333	100.0%	100.0%	100.0%	$504,129	$387,792
Spray booth maintenance			$58	100.0%	100.0%	100.0%	$87,485	$67,296
Paint								
Material handler	0	0						
No overexposure			N/A	N/A	N/A	N/A	$0	$0
Mixer operator	404	404						
Substitute low silica content materials			N/A	N/A	N/A	N/A	$0	$0
Well-ventilated bag dumping stations			$2,017	100.0%	100.0%	100.0%	$815,448	$815,448
Structural Clay								
Material handler/loader operator	118	59						
Enclosed, ventilated cab			$1,867	100.0%	100.0%	100.0%	$219,462	$109,731
Thorough, semi-annual professional cleaning			N/A	N/A	N/A	N/A	$0	$0
Improve cab maintenance and keep windows closed			$190	100.0%	100.0%	100.0%	$22,286	$11,143
Cover conveyors in material handling area			$242	100.0%	0.0%	100.0%	$14,210	$14,210
Apply LEV to conveyors in material handling area			$13,330	100.0%	0.0%	100.0%	$783,609	$783,609
Material handler/production	1,360	544						
Misters on conveyor line			$618	50.0%	100.0%	100.0%	$420,631	$168,252
LEV, push-pull system			$5,332	50.0%	100.0%	100.0%	$3,626,367	$1,450,547
Material handler/post-production	161	32						
Misters on conveyor line			$618	100.0%	100.0%	100.0%	$99,354	$19,871
Dust suppression in yard			N/A	N/A	N/A	N/A	$0	$0
Grinding operator	580	406						
Ventilated control room and HEPA filter			$871	30.0%	100.0%	100.0%	$151,532	$106,073
Control room improvements and repairs			$80	70.0%	100.0%	100.0%	$32,352	$22,647
Enclosures with LEV for grinding equipment			$22,662	100.0%	100.0%	100.0%	$13,136,330	$9,195,431
Purchase additional HEPA vacuums			$252	100.0%	100.0%	100.0%	$146,191	$102,334

Table V-A-3: Total Control Costs by Sector, Job Category, and Control for General Industry and Maritime Employers Affected by the Proposed Silica PEL and an Alternative Silica PEL of 100 μg/m³

Sector/Job Category - Control Requirements/Options	No. of Workers At Risk				% of Overexposed Employees Needing Control to Achieve Control Level		Total Cost	
	50	100	Cost per Worker	Percent Applicability	50	100	50	100
Enhanced housekeeping with HEPA vacuums			$1,772	100.0%	100.0%	100.0%	$1,027,122	$718,985
Cover conveyors in grinding area			$242	100.0%	100.0%	100.0%	$140,130	$98,091
Dust suppression for raw materials			$635	100.0%	100.0%	100.0%	$367,826	$257,478
Tightly sealed storage units			N/A	N/A	N/A	N/A	$0	$0
Forming line operator/pug mill operator	274	229						
Enclosed and ventilated pug mill equipment			$7,998	100.0%	100.0%	100.0%	$2,194,104	$1,828,420
Forming line operator/coatings blender	256	96						
Well-ventilated bag dumping stations			$2,017	50.0%	100.0%	100.0%	$258,197	$96,824
Enclosed and ventilated feed hopper, conveyors, tumble tote charging, and transfer to transfer tote			$11,997	50.0%	100.0%	100.0%	$1,535,873	$575,952
Improved area cleanup with HEPA or central vacuum system			$252	100.0%	100.0%	100.0%	$64,571	$24,214
Enhanced housekeeping with HEPA vacuums			$1,772	100.0%	100.0%	100.0%	$453,670	$170,126
Forming line operator/formers	1,860	1,222						
Improved area cleanup with HEPA or central vacuum system			$252	100.0%	100.0%	100.0%	$468,962	$308,175
Enhanced housekeeping with HEPA vacuums			$1,772	100.0%	100.0%	100.0%	$3,294,881	$2,165,207
Well-ventilated bag dumping stations			$2,017	50.0%	100.0%	100.0%	$1,875,218	$1,232,286
Enclosed and ventilated workstations			$4,732	50.0%	100.0%	100.0%	$4,399,883	$2,891,352
Dental laboratories								
Dental technician	1,324	0						
Improved LEV in grinding, blasting			$97	100.0%	100.0%	100.0%	$128,398	$0
Fine jewelry								
Jewelry workers	4,121	2,944						
Substitution of low-silica modeling/investment materials			N/A	N/A	N/A	N/A	$0	$0

Table V-A-3: Total Control Costs by Sector, Job Category, and Control for General Industry and Maritime Employers Affected by the Proposed Silica PEL and an Alternative Silica PEL of 100 μg/m³

Sector/Job Category - Control Requirements/Options	No. of Workers At Risk				% of Overexposed Employees Needing Control to Achieve Control Level		Total Cost	
	50	100	Cost per Worker	Percent Applicability	50	100	50	100
LEV for abrasive blasting and finishing			$267	100.0%	100.0%	100.0%	$1,098,731	$784,808
Costume Jewelry								
Jewelry workers	459	328						
Substitution of low-silica modeling/investment materials			N/A	N/A	N/A	N/A	$0	$0
LEV for abrasive blasting and finishing			$267	100.0%	100.0%	100.0%	$122,427	$87,448
Refractories								
Material handler	361	180						
Ventilated bag dumping stations with bag compactor			$2,017	100.0%	100.0%	100.0%	$727,591	$363,796
Enclosed and ventilated mixing equipment			$1,400	100.0%	100.0%	100.0%	$504,938	$252,469
Forming Operator	420	210						
Increased LEV maintenance			$344	100.0%	100.0%	100.0%	$144,560	$72,280
Finishing operator	0	0						
No overexposures			N/A	N/A	N/A	N/A	$0	$0
Ceramic fiber furnace operator	0	0						
No overexposures			N/A	N/A	N/A	N/A	$0	$0
Packaging operator	42	42						
LEV for bag filling stations			$2,000	100.0%	100.0%	100.0%	$83,447	$83,447
Bag valves to reduce dust release			$4,728	100.0%	100.0%	100.0%	$197,326	$197,326
Ready-Mix Concrete								
Material handler	1,981	0						
Yard dust suppression			$2,807	50.0%	100.0%	100.0%	$2,779,669	$0
Enclosed cabs			$3,733	50.0%	100.0%	100.0%	$3,697,176	$0
Batch operator	0	0						
No overexposures			N/A	N/A	N/A	N/A	$0	$0
Maintenance operator	603	0						
Wet methods to clean equipment			$917	100.0%	100.0%	100.0%	$552,865	$0
Quality control technician	0	0						
No overexposures			N/A	N/A	N/A	N/A	$0	$0
Truck driver	29,526	29,526						

Table V-A-3: Total Control Costs by Sector, Job Category, and Control for General Industry and Maritime Employers Affected by the Proposed Silica PEL and an Alternative Silica PEL of 100 μg/m³

Sector/Job Category - Control Requirements/Options	No. of Workers At Risk				% of Overexposed Employees Needing Control to Achieve Control Level		Total Cost	
	50	100	Cost per Worker	Percent Applicability	50	100	50	100
Wet methods for drum cleaning			$29	100.0%	100.0%	100.0%	$861,082	$861,082
Ventilation for drum cleaning			$98	100.0%	100.0%	100.0%	$2,890,079	$2,890,079
Iron Foundries								
Sand mixer (muller) operator	660	440						
LEV, mixer & muller hood			$1,400	100.0%	100.0%	100%	$923,114	$615,410
Conveyor enclosures			$6,674	100.0%	100.0%	100%	$4,401,520	$2,934,347
Bin and hopper ventilation			$1,400	100.0%	100.0%	100%	$923,114	$615,410
Bucket elevator ventilation			$2,133	100.0%	100.0%	100%	$1,406,650	$937,767
Screen ventilation			$1,600	100.0%	100.0%	100%	$1,054,988	$703,325
Substitute silica-free materials			N/A	N/A	N/A	N/A	$0	$0
Molder	2,169	897						
Upgraded sand handling equipment - covered elsewhere			N/A	N/A	N/A	N/A	$0	$0
Upgrade or install LEV			$1,400	100.0%	0.0%	100%	$1,255,036	$1,255,036
Rigorous housekeeping- capital			$202	100.0%	0.0%	100%	$180,905	$180,905
Rigorous housekeeping- labor			$1,922	100.0%	0.0%	100%	$1,723,348	$1,723,348
Eliminate compressed air			N/A	N/A	N/A	N/A	$0	$0
Coremaker	1,866	581						
Eliminated compressed air			$961	100.0%	100.0%	100.0%	$1,793,625	$558,017
Enclosed conveyors, covered elsewhere			N/A	N/A	N/A	N/A	$0	$0
Non-silica cores and core coatings			N/A	N/A	N/A	N/A	$0	$0
Professional-level cleaning			N/A	N/A	N/A	N/A	$0	$0
Furnace operator	495	495						
Control dust releases from adjacent processes - covered elsewhere			N/A	N/A	N/A	N/A	$0	$0
Well-maintained furnace emission control system			$115	100.0%	100.0%	100.0%	$57,041	$57,041
Minimize dust generated by sand contamination of scrap			N/A	N/A	N/A	N/A	$0	$0
Pouring operator	660	440						

Table V-A-3: Total Control Costs by Sector, Job Category, and Control for General Industry and Maritime Employers Affected by the Proposed Silica PEL and an Alternative Silica PEL of 100 μg/m^3

Sector/Job Category - Control Requirements/Options	No. of Workers At Risk				% of Overexposed Employees Needing Control to Achieve Control Level		Total Cost	
	50	100	Cost per Worker	Percent Applicability	50	100	50	100
Control dust from adjacent processes - covered elsewhere			N/A	N/A	N/A	N/A	$0	$0
Operator booths or cabs			$3,333	100.0%	0.0%	100.0%	$1,465,261	$1,465,261
Physical isolation of pouring area (create a pouring room)			N/A	N/A	N/A	N/A	$0	$0
Modify ventilation system to reduce airflow from other areas into the pouring area			N/A	N/A	N/A	N/A	$0	$0
Shakeout operator	263	131						
Improve existing ventilation system efficiency (very large castings)			$38,392	10.0%	100.0%	100.0%	$1,009,430	$504,715
Improve existing ventilation system efficiency			$9,385	90.0%	100.0%	100.0%	$2,220,746	$1,110,373
Partially enclose process			$13,330	100.0%	100.0%	100.0%	$3,504,966	$1,752,483
Control emissions from associated operations - covered elsewhere			N/A	N/A	N/A	N/A	$0	$0
Knockout operator	238	154						
Installing and improving LEV			$1,800	50.0%	100.0%	100.0%	$213,875	$139,019
Installing and improving LEV			$6,399	50.0%	100.0%	100.0%	$760,444	$494,288
Installing and improving LEV			$2,000	50.0%	100.0%	100.0%	$237,639	$154,465
Reduce residual sand on castings			N/A	N/A	N/A	N/A	$0	$0
Automate knockout process			N/A	N/A	N/A	N/A	$0	$0
Abrasive blasting operator	1,362	811						
Improved maintenance for blasting cabinet			$674	100.0%	100.0%	100.0%	$918,655	$546,818
Cleaning/finishing operator	2,489	1,728						
LEV for workstations			$4,999	50.0%	100.0%	100.0%	$6,221,948	$4,318,217
LEV on hand tools			$384	50.0%	100.0%	100.0%	$477,412	$331,339
Eliminate compressed air (switch to vacuum)			$376	100.0%	0.0%	100.0%	$649,312	$649,312
Substitution with non-silica materials			N/A	N/A	N/A	N/A	$0	$0
Process automation			N/A	N/A	N/A	N/A	$0	$0
Wet methods			N/A	N/A	N/A	N/A	$0	$0

Table V-A-3: Total Control Costs by Sector, Job Category, and Control for General Industry and Maritime Employers Affected by the Proposed Silica PEL and an Alternative Silica PEL of 100 μg/m³

Sector/Job Category - Control Requirements/Options	No. of Workers At Risk				% of Overexposed Employees Needing Control to Achieve Control Level		Total Cost	
	50	100	Cost per Worker	Percent Applicability	50	100	50	100
Pre-cleaning with automated equipment			N/A	N/A	N/A	N/A	$0	$0
Material handler	817	337						
Enclosed, ventilated cab			$1,867	100.0%	100.0%	100.0%	$1,526,010	$628,357
Maintenance operator	328	211						
Use low silica refractory			N/A	N/A	N/A	N/A	$0	$0
LEV for chipping tools			$248	100.0%	100.0%	100.0%	$81,291	$52,258
Pre-wetting lining to be removed			$416	100.0%	100.0%	100.0%	$136,113	$87,501
Maintaining moisture level in the refractory applied			$208	100.0%	100.0%	100.0%	$68,056	$43,751
Also, use of precast refractories and automated equipment for powdered refractory materials			N/A	N/A	N/A	100%	$0	$0
Housekeeping worker	157	63						
Controls not identified			N/A	N/A	N/A	100%	$0	$0
Professional-level cleaning			N/A	N/A	N/A	100%	$0	$0
Other Ferrous Sand Casting Foundries								
Sand mixer (muller) operator	197	132						
LEV, mixer & muller hood			$1,400	100.0%	100.0%	100.0%	$276,297	$184,198
Conveyor enclosures			$6,674	100.0%	100.0%	100.0%	$1,317,418	$878,279
Bin and hopper ventilation			$1,400	100.0%	100.0%	100.0%	$276,297	$184,198
Bucket elevator ventilation			$2,133	100.0%	100.0%	100.0%	$421,024	$280,683
Screen ventilation			$1,600	100.0%	100.0%	100.0%	$315,768	$210,512
Substitute silica-free materials			N/A	N/A	N/A	N/A	$0	$0
Molder	649	268						
Upgraded sand handling equipment - covered elsewhere			N/A	N/A	N/A	N/A	$0	$0
Upgrade or install LEV			$1,400	100.0%	0.0%	100.0%	$375,645	$375,645
Rigorous housekeeping- capital			$202	100.0%	0.0%	100.0%	$54,147	$54,147
Rigorous housekeeping- labor			$1,922	100.0%	0.0%	100.0%	$515,815	$515,815
Eliminate compressed air			N/A	N/A	N/A	N/A	$0	$0
Coremaker	559	174						

Table V-A-3: Total Control Costs by Sector, Job Category, and Control for General Industry and Maritime Employers Affected by the Proposed Silica PEL and an Alternative Silica PEL of 100 μg/m^3

Sector/Job Category - Control Requirements/Options	No. of Workers At Risk				% of Overexposed Employees Needing Control to Achieve Control Level		Total Cost	
	50	100	Cost per Worker	Percent Applicability	50	100	50	100
Eliminated compressed air			$961	100.0%	100.0%	100.0%	$536,850	$167,020
Enclosed conveyors, covered elsewhere			N/A	N/A	N/A	N/A	$0	$0
Non-silica cores and core coatings			N/A	N/A	N/A	N/A	$0	$0
Professional-level cleaning			N/A	N/A	N/A	N/A	$0	$0
Furnace operator	148	148						
Control dust releases from adjacent processes - covered elsewhere			N/A	N/A	N/A	N/A	$0	$0
Well-maintained furnace emission control system			$115	100.0%	100.0%	100.0%	$17,073	$17,073
Minimize dust generated by sand contamination of scrap			N/A	N/A	N/A	N/A	$0	$0
Pouring operator	197	132						
Control dust from adjacent processes - covered elsewhere			N/A	N/A	N/A	N/A	$0	$0
Operator booths or cabs			$3,333	100.0%	0.0%	100.0%	$438,567	$438,567
Physical isolation of pouring area (create a pouring room)			N/A	N/A	N/A	N/A	$0	$0
Modify ventilation system to reduce airflow from other areas into the pouring area			N/A	N/A	N/A	N/A	$0	$0
Shakeout operator	79	39						
Improve existing ventilation system efficiency (very large castings)			$38,392	10.0%	100.0%	100.0%	$302,132	$151,066
Improve existing ventilation system efficiency			$9,385	90.0%	100.0%	100.0%	$2,220,746	$1,110,373
Partially enclose process			$13,330	100.0%	100.0%	100.0%	$1,049,071	$524,535
Control emissions from associated operations - covered elsewhere			N/A	N/A	N/A	N/A	$0	$0
Knockout operator	71	46						
Installing and improving LEV			$1,800	50.0%	100.0%	100.0%	$213,875	$139,019
Installing and improving LEV			$6,399	50.0%	100.0%	100.0%	$760,444	$494,288
Installing and improving LEV			$2,000	50.0%	100.0%	100.0%	$237,639	$154,465

Table V-A-3: Total Control Costs by Sector, Job Category, and Control for General Industry and Maritime Employers Affected by the Proposed Silica PEL and an Alternative Silica PEL of 100 μg/m³

Sector/Job Category - Control Requirements/Options	No. of Workers At Risk				% of Overexposed Employees Needing Control to Achieve Control Level		Total Cost	
	50	100	Cost per Worker	Percent Applicability	50	100	50	100
Reduce residual sand on castings			N/A	N/A	N/A	N/A	$0	$0
Automate knockout process			N/A	N/A	N/A	N/A	$0	$0
Abrasive blasting operator	408	243						
Improved maintenance for blasting cabinet			$674	100.0%	100.0%	100.0%	$274,962	$163,668
Cleaning/finishing operator	745	517						
LEV for workstations			$4,999	50.0%	100.0%	100.0%	$1,862,290	$1,292,485
LEV on hand tools			$384	50.0%	100.0%	100.0%	$142,894	$99,173
Eliminate compressed air (switch to vacuum)			$376	100.0%	0.0%	100.0%	$194,345	$194,345
Substitution with non-silica materials			N/A	N/A	N/A	N/A	$0	$0
Process automation			N/A	N/A	N/A	N/A	$0	$0
Wet methods			N/A	N/A	N/A	N/A	$0	$0
Pre-cleaning with automated equipment			N/A	N/A	N/A	N/A	$0	$0
Material handler	245	101						
Enclosed, ventilated cab			$1,867	100.0%	100.0%	100.0%	$456,750	$188,074
Maintenance operator	98	63						
Use low silica refractory			N/A	N/A	N/A	N/A	$0	$0
LEV for chipping tools			$248	100.0%	100.0%	100.0%	$24,331	$15,641
Pre-wetting lining to be removed			$416	100.0%	100.0%	100.0%	$40,740	$26,190
Maintaining moisture level in the refractory applied			$208	100.0%	100.0%	100.0%	$20,370	$13,095
Also, use of precast refractories and automated equipment for powdered refractory materials			N/A	N/A	N/A	N/A	$0	$0
Housekeeping worker	47	19						
Controls not identified			N/A	N/A	N/A	N/A	$0	$0
Professional-level cleaning			N/A	N/A	N/A	N/A	$0	$0
Nonferrous Sand Casting Foundries								
Sand mixer (muller) operator	227	151						
LEV, mixer & muller hood			$1,400	100.0%	100.0%	100.0%	$318,030	$212,020

Table V-A-3: Total Control Costs by Sector, Job Category, and Control for General Industry and Maritime Employers Affected by the Proposed Silica PEL and an Alternative Silica PEL of 100 μg/m³

Sector/Job Category - Control Requirements/Options	No. of Workers At Risk				% of Overexposed Employees Needing Control to Achieve Control Level		Total Cost	
	50	100	Cost per Worker	Percent Applicability	50	100	50	100
Conveyor enclosures			$6,674	100.0%	100.0%	100.0%	$1,516,406	$1,010,937
Bin and hopper ventilation			$1,400	100.0%	100.0%	100.0%	$318,030	$212,020
Bucket elevator ventilation			$2,133	100.0%	100.0%	100.0%	$484,617	$323,078
Screen ventilation			$1,600	100.0%	100.0%	100.0%	$363,463	$242,309
Substitute silica-free materials			N/A	N/A	N/A	N/A	$0	$0
Molder	747	309						
Upgraded sand handling equipment - covered elsewhere			N/A	N/A	N/A	N/A	$0	$0
Upgrade or install LEV			$1,400	100.0%	0.0%	100.0%	$432,383	$432,383
Rigorous housekeeping- capital			$202	100.0%	0.0%	100.0%	$62,325	$62,325
Rigorous housekeeping- labor			$1,922	100.0%	0.0%	100.0%	$593,725	$593,725
Eliminate compressed air			N/A	N/A	N/A	N/A	$0	$0
Coremaker	643	200						
Eliminated compressed air			$961	100.0%	100.0%	100.0%	$617,937	$192,247
Enclosed conveyors, covered elsewhere			N/A	N/A	N/A	N/A	$0	$0
Non-silica cores and core coatings			N/A	N/A	N/A	N/A	$0	$0
Professional-level cleaning			N/A	N/A	N/A	N/A	$0	$0
Furnace operator	170	170						
Control dust releases from adjacent processes - covered elsewhere			N/A	N/A	N/A	N/A	$0	$0
Well-maintained furnace emission control system			$115	100.0%	100.0%	100.0%	$19,652	$19,652
Minimize dust generated by sand contamination of scrap			N/A	N/A	N/A	N/A	$0	$0
Control dust from adjacent processes - covered elsewhere			N/A	N/A	N/A	N/A	$0	$0
Pouring operator	227	151						
Operator booths or cabs			$3,333	100.0%	0.0%	100.0%	$504,810	$504,810
Physical isolation of pouring area (create a pouring room)			N/A	N/A	N/A	N/A	$0	$0
Modify ventilation system to reduce airflow			N/A	N/A	N/A	N/A	$0	$0

Table V-A-3: Total Control Costs by Sector, Job Category, and Control for General Industry and Maritime Employers Affected by the Proposed Silica PEL and an Alternative Silica PEL of 100 μg/m³

Sector/Job Category - Control Requirements/Options	No. of Workers At Risk				% of Overexposed Employees Needing Control to Achieve Control Level		Total Cost	
	50	100	Cost per Worker	Percent Applicability	50	100	50	100
from other areas into the pouring area								
Shakeout operator	91	45						
Improve existing ventilation system efficiency (very large castings)			$38,392	10.0%	100.0%	100.0%	$347,767	$173,884
Improve existing ventilation system efficiency			$9,385	90.0%	100.0%	100.0%	$2,220,746	$1,110,373
Partially enclose process			$13,330	100.0%	100.0%	100.0%	$1,207,526	$603,763
Control emissions from associated operations - covered elsewhere			N/A	N/A	N/A	N/A	$0	$0
Knockout operator	82	53						
Installing and improving LEV			$1,800	50.0%	100.0%	100.0%	$213,875	$139,019
Installing and improving LEV			$6,399	50.0%	100.0%	100.0%	$760,444	$494,288
Installing and improving LEV			$2,000	50.0%	100.0%	100.0%	$237,639	$154,465
Reduce residual sand on castings			N/A	N/A	N/A	N/A	$0	$0
Automate knockout process			N/A	N/A	N/A	N/A	$0	$0
Abrasive blasting operator	469	279						
Improved maintenance for blasting cabinet			$674	100.0%	100.0%	100.0%	$316,494	$188,389
Cleaning/finishing operator	858	595						
LEV for workstations			$4,999	50.0%	100.0%	100.0%	$2,143,577	$1,487,706
LEV on hand tools			$384	50.0%	100.0%	100.0%	$164,477	$114,152
Eliminate compressed air (switch to vacuum)			$376	100.0%	0.0%	100.0%	$223,700	$223,700
Substitution with non-silica materials			N/A	N/A	N/A	N/A	$0	$0
Process automation			N/A	N/A	N/A	N/A	$0	$0
Wet methods			N/A	N/A	N/A	N/A	$0	$0
Pre-cleaning with automated equipment			N/A	N/A	N/A	N/A	$0	$0
Material handler	282	116						
Enclosed, ventilated cab			$1,867	100.0%	100.0%	100.0%	$525,739	$216,481
Maintenance operator	92	59						
Use low silica refractory			N/A	N/A	N/A	N/A	$0	$0
LEV for chipping tools			$248	100.0%	100.0%	100.0%	$22,863	$14,698

Table V-A-3: Total Control Costs by Sector, Job Category, and Control for General Industry and Maritime Employers Affected by the Proposed Silica PEL and an Alternative Silica PEL of 100 μg/m³

Sector/Job Category - Control Requirements/Options	No. of Workers At Risk				% of Overexposed Employees Needing Control to Achieve Control Level		Total Cost	
	50	100	Cost per Worker	Percent Applicability	50	100	50	100
Pre-wetting lining to be removed			$416	100.0%	100.0%	100.0%	$38,282	$24,610
Maintaining moisture level in the refractory applied			$208	100.0%	100.0%	100.0%	$19,141	$12,305
Also, use of precast refractories and automated equipment for powdered refractory materials			N/A	N/A	N/A	N/A	$0	$0
Housekeeping worker	54	22						
Controls not identified			N/A	N/A	N/A	N/A	$0	$0
Professional-level cleaning			N/A	N/A	N/A	N/A	$0	$0
Non-Sand Casting Foundries								
Sand mixer (muller) operator	379	253						
LEV, mixer & muller hood			$1,400	100.0%	100.0%	100.0%	$530,499	$353,666
Conveyor enclosures			$6,674	100.0%	100.0%	100.0%	$2,529,483	$1,686,322
Bin and hopper ventilation			$1,400	100.0%	100.0%	100.0%	$530,499	$353,666
Bucket elevator ventilation			$2,133	100.0%	100.0%	100.0%	$808,380	$538,920
Screen ventilation			$1,600	100.0%	100.0%	100.0%	$606,285	$404,190
Substitute silica-free materials			N/A	N/A	N/A	N/A	$0	$0
Molder	1,247	515						
Upgraded sand handling equipment - covered elsewhere			N/A	N/A	N/A	N/A	$0	$0
Upgrade or install LEV			$1,400	100.0%	0.0%	100.0%	$721,249	$721,249
Rigorous housekeeping- capital			$202	100.0%	0.0%	100.0%	$103,963	$103,963
Rigorous housekeeping- labor			$1,922	100.0%	0.0%	100.0%	$990,381	$990,381
Eliminate compressed air			N/A	N/A	N/A	N/A	$0	$0
Coremaker	1,073	334						
Eliminated compressed air			$961	100.0%	100.0%	100.0%	$1,030,768	$320,683
Enclosed conveyors, covered elsewhere			N/A	N/A	N/A	N/A	$0	$0
Non-silica cores and core coatings			N/A	N/A	N/A	N/A	$0	$0
Professional-level cleaning			N/A	N/A	N/A	N/A	$0	$0
Furnace operator	284	284						
Control dust releases from adjacent			N/A	N/A	N/A	N/A	$0	$0

Table V-A-3: Total Control Costs by Sector, Job Category, and Control for General Industry and Maritime Employers Affected by the Proposed Silica PEL and an Alternative Silica PEL of 100 μg/m³

Sector/Job Category - Control Requirements/Options	No. of Workers At Risk				% of Overexposed Employees Needing Control to Achieve Control Level		Total Cost	
	50	100	Cost per Worker	Percent Applicability	50	100	50	100
processes - covered elsewhere								
Well-maintained furnace emission control system			$115	100.0%	100.0%	100.0%	$32,780	$32,780
Minimize dust generated by sand contamination of scrap			N/A	N/A	N/A	N/A	$0	$0
Pouring operator	379	253						
Control dust from adjacent processes - covered elsewhere			N/A	N/A	N/A	N/A	$0	$0
Operator booths or cabs			$3,333	100.0%	0.0%	100.0%	$842,062	$842,062
Physical isolation of pouring area (create a pouring room)			N/A	N/A	N/A	N/A	$0	$0
Modify ventilation system to reduce airflow from other areas into the pouring area			N/A	N/A	N/A	N/A	$0	$0
Shakeout operator	151	76						
Improve existing ventilation system efficiency (very large castings)			$38,392	10.0%	100.0%	100.0%	$580,103	$290,052
Improve existing ventilation system efficiency			$9,385	90.0%	100.0%	100.0%	$2,220,746	$1,110,373
Partially enclose process			$13,330	100.0%	100.0%	100.0%	$2,014,248	$1,007,124
Control emissions from associated operations - covered elsewhere			N/A	N/A	N/A	N/A	$0	$0
Knockout operator	137	89						
Installing and improving LEV			$1,800	50.0%	100.0%	100.0%	$213,875	$139,019
Installing and improving LEV			$6,399	50.0%	100.0%	100.0%	$760,444	$494,288
Installing and improving LEV			$2,000	50.0%	100.0%	100.0%	$237,639	$154,465
Reduce residual sand on castings			N/A	N/A	N/A	N/A	$0	$0
Automate knockout process			N/A	N/A	N/A	N/A	$0	$0
Abrasive blasting operator	783	466						
Improved maintenance for blasting cabinet			$674	100.0%	100.0%	100.0%	$527,936	$314,248
Cleaning/finishing operator	1,431	993						
LEV for workstations			$4,999	50.0%	100.0%	100.0%	$3,575,654	$2,481,611

Table V-A-3: Total Control Costs by Sector, Job Category, and Control for General Industry and Maritime Employers Affected by the Proposed Silica PEL and an Alternative Silica PEL of 100 μg/m³

Sector/Job Category - Control Requirements/Options	No. of Workers At Risk				% of Overexposed Employees Needing Control to Achieve Control Level		Total Cost	
	50	100	Cost per Worker	Percent Applicability	50	100	50	100
LEV on hand tools			$384	50.0%	100.0%	100.0%	$274,361	$190,415
Eliminate compressed air (switch to vacuum)			$376	100.0%	0.0%	100.0%	$373,149	$373,149
Substitution with non-silica materials			N/A	N/A	N/A	N/A	$0	$0
Process automation			N/A	N/A	N/A	N/A	$0	$0
Wet methods			N/A	N/A	N/A	N/A	$0	$0
Pre-cleaning with automated equipment			N/A	N/A	N/A	N/A	$0	$0
Material handler	470	193						
Enclosed, ventilated cab			$1,867	100.0%	100.0%	100.0%	$876,974	$361,107
Maintenance operator	154	99						
Use low silica refractory			N/A	N/A	N/A	N/A	$0	$0
LEV for chipping tools			$248	100.0%	100.0%	100.0%	$38,138	$24,517
Pre-wetting lining to be removed			$416	100.0%	100.0%	100.0%	$63,858	$41,052
Maintaining moisture level in the refractory applied			$208	100.0%	100.0%	100.0%	$31,929	$20,526
Also, use of precast refractories and automated equipment for powdered refractory materials			N/A	N/A	N/A	N/A	$0	$0
Housekeeping worker	90	36						
Controls not identified			N/A	N/A	N/A	N/A	$0	$0
Professional-level cleaning			N/A	N/A	N/A	N/A	$0	$0
Captive Foundries								
Sand mixer (muller) operator	406	270						
LEV, mixer & muller hood			$1400	100.0%	100.0%	100.0%	$567,675	$378,450
Conveyor enclosures			$6,674	100.0%	100.0%	100.0%	$2,706,745	$1,804,497
Bin and hopper ventilation			$1,400	100.0%	100.0%	100.0%	$567,675	$378,450
Bucket elevator ventilation			$2,133	100.0%	100.0%	100.0%	$865,029	$576,686
Screen ventilation			$1,600	100.0%	100.0%	100.0%	$648,772	$432,515
Substitute silica-free materials			N/A	N/A	N/A	N/A	$0	$0
Molder	1,334	551						
Upgraded sand handling equipment - covered			N/A	N/A	N/A	N/A	$0	$0

Table V-A-3: Total Control Costs by Sector, Job Category, and Control for General Industry and Maritime Employers Affected by the Proposed Silica PEL and an Alternative Silica PEL of 100 μg/m³

Sector/Job Category - Control Requirements/Options	No. of Workers At Risk				% of Overexposed Employees Needing Control to Achieve Control Level		Total Cost	
	50	100	Cost per Worker	Percent Applicability	50	100	50	100
elsewhere								
Upgrade or install LEV			$1,400	100.0%	0.0%	100.0%	$771,793	$771,793
Rigorous housekeeping- capital			$202	100.0%	0.0%	100.0%	$111,249	$111,249
Rigorous housekeeping- labor			$1,922	100.0%	0.0%	100.0%	$1,059,785	$1,059,785
Eliminate compressed air			N/A	N/A	N/A	N/A	$0	$0
Coremaker	1,148	357						
Eliminated compressed air			$961	100.0%	100.0%	100.0%	$1,103,002	$343,156
Enclosed conveyors, covered elsewhere			N/A	N/A	N/A	N/A	$0	$0
Non-silica cores and core coatings			N/A	N/A	N/A	N/A	$0	$0
Professional-level cleaning			N/A	N/A	N/A	N/A	$0	$0
Furnace operator	304	304						
Control dust releases from adjacent processes - covered elsewhere			N/A	N/A	N/A	N/A	$0	$0
Well-maintained furnace emission control system			$115	100.0%	100.0%	100.0%	$35,078	$35,078
Minimize dust generated by sand contamination of scrap			N/A	N/A	N/A	N/A	$0	$0
Pouring operator	406	270						
Control dust from adjacent processes - covered elsewhere			N/A	N/A	N/A	N/A	$0	$0
Operator booths or cabs			$3,333	100.0%	0.0%	100.0%	$901,072	$901,072
Physical isolation of pouring area (create a pouring room)			N/A	N/A	N/A	N/A	$0	$0
Modify ventilation system to reduce airflow from other areas into the pouring area			N/A	N/A	N/A	N/A	$0	$0
Shakeout operator	162	81						
Improve existing ventilation system efficiency (very large castings)			$38,392	10.0%	100.0%	100.0%	$620,756	$310,378
Improve existing ventilation system efficiency			$9,385	90.0%	100.0%	100.0%	$2,220,746	$1,110,373
Partially enclose process			$13,330	100.0%	100.0%	100.0%	$2,155,403	$1,077,701

Table V-A-3: Total Control Costs by Sector, Job Category, and Control for General Industry and Maritime Employers Affected by the Proposed Silica PEL and an Alternative Silica PEL of 100 μg/m^3

Sector/Job Category - Control Requirements/Options	No. of Workers At Risk				% of Overexposed Employees Needing Control to Achieve Control Level		Total Cost	
	50	100	Cost per Worker	Percent Applicability	50	100	50	100
Control emissions from associated operations - covered elsewhere			N/A	N/A	N/A	N/A	$0	$0
Knockout operator	146	95						
Installing and improving LEV			$1,800	50.0%	100.0%	100.0%	$213,875	$139,019
Installing and improving LEV			$6,399	50.0%	100.0%	100.0%	$760,444	$494,288
Installing and improving LEV			$2,000	50.0%	100.0%	100.0%	$237,639	$154,465
Reduce residual sand on castings			N/A	N/A	N/A	N/A	$0	$0
Automate knockout process			N/A	N/A	N/A	N/A	$0	$0
Abrasive blasting operator	838	499						
Improved maintenance for blasting cabinet			$674	100.0%	100.0%	100.0%	$564,933	$336,270
Cleaning/finishing operator	1,531	1,062						
LEV for workstations			$4,999	50.0%	100.0%	100.0%	$3,826,230	$2,655,518
LEV on hand tools			$384	50.0%	100.0%	100.0%	$293,588	$203,759
Eliminate compressed air (switch to vacuum)			$376	100.0%	0.0%	100.0%	$399,299	$399,299
Substitution with non-silica materials			N/A	N/A	N/A	N/A	$0	$0
Process automation			N/A	N/A	N/A	N/A	$0	$0
Wet methods			N/A	N/A	N/A	N/A	$0	$0
Pre-cleaning with automated equipment			N/A	N/A	N/A	N/A	$0	$0
Material handler	503	207						
Enclosed, ventilated cab			$1,867	100.0%	100.0%	100.0%	$938,431	$386,413
Maintenance operator	201	129						
Use low silica refractory			N/A	N/A	N/A	N/A	$0	$0
LEV for chipping tools			$248	100.0%	100.0%	100.0%	$49,990	$32,137
Pre-wetting lining to be removed			$416	100.0%	100.0%	100.0%	$83,704	$53,809
Maintaining moisture level in the refractory applied			$208	100.0%	100.0%	100.0%	$41,852	$26,905
Also, use of precast refractories and automated equipment for powdered refractory materials			N/A	N/A	N/A	N/A	$0	$0

Table V-A-3: Total Control Costs by Sector, Job Category, and Control for General Industry and Maritime Employers Affected by the Proposed Silica PEL and an Alternative Silica PEL of 100 μg/m³

Sector/Job Category - Control Requirements/Options	No. of Workers At Risk				% of Overexposed Employees Needing Control to Achieve Control Level		Total Cost	
	50	100	Cost per Worker	Percent Applicability	50	100	50	100
Housekeeping worker	97	39						
Controls not identified			N/A	N/A	N/A	N/A	$0	$0
Professional-level cleaning			N/A	N/A	N/A	N/A	$0	$0
Railroads								
Ballast dumper	1,671	499						
Spray system for right-of-way maintenance vehicles			N/A	N/A	N/A	N/A	$6,686,499	$6,686,499
Machine operator	3,959	95						
Spray system for right-of-way maintenance vehicles			N/A	N/A	N/A	N/A	$8,919,027	$8,919,027
Asphalt Roofing Materials								
Production operator	1,497	749						
Process enclosure			$242	100.0%	100.0%	100.0%	$361,950	$180,975
Enhanced ventilation			$933	100.0%	100.0%	100.0%	$1,397,137	$698,568
Rigorous housekeeping- capital			$252	100.0%	100.0%	100.0%	$377,603	$188,802
Rigorous housekeeping- labor			$1,504	100.0%	100.0%	100.0%	$2,251,610	$1,125,805
Material handler	466	186						
No additional controls required			N/A	N/A	N/A	N/A	$0	$0
Porcelain Enameling								
Preparer	1,877	704						
Well-ventilated bag dumping stations			$2,017	100.0%	100.0%	100.0%	$3,785,026	$1,419,385
Porcelain applicator	1,877	704						
Improved LEV for spray booths and enclosures			$333	100.0%	100.0%	100.0%	$625,417	$234,531
Spray booth maintenance			$58	100.0%	100.0%	100.0%	$108,533	$40,700
Mineral Processing								
Production worker	891	297						
Enclosed ventilation equipment			$242	50.0%	100.0%	100.0%	$107,740	$35,913
Conveyor ventilation			$6,532	50.0%	100.0%	100.0%	$2,911,152	$970,384
Improved maintenance			$1,139	50.0%	100.0%	100.0%	$507,587	$169,196
Professional cleaning			N/A	N/A	N/A	N/A	$0	$0

Table V-A-3: Total Control Costs by Sector, Job Category, and Control for General Industry and Maritime Employers Affected by the Proposed Silica PEL and an Alternative Silica PEL of 100 μg/m^3

Sector/Job Category - Control Requirements/Options	No. of Workers At Risk				% of Overexposed Employees Needing Control to Achieve Control Level		Total Cost	
	50	100	Cost per Worker	Percent Applicability	50	100	50	100
Improved area cleanup with HEPA			$252	100.0%	100.0%	100.0%	$224,799	$74,933
Enhanced housekeeping with HEPA vacuums			$1,825	100.0%	100.0%	100.0%	$1,626,882	$542,294
Dental Equipment and Supplies								
Production operator	274	137						
Ventilated bag dumping stations with bag compactor			$2,017	50.0%	100.0%	100.0%	$276,287	$138,143
Enclosed and ventilated mixing equipment			$1,400	50.0%	100.0%	100.0%	$191,739	$95,870
Increased LEV maintenance			$280	100.0%	100.0%	100.0%	$76,590	$38,295
Asphalt Paving Products								
Plant operator	0	0						
No overexposures			$0	N/A	N/A	N/A	$0	$0
Front-end loader operator	48	0						
Enclosed cabs			$0	100.0%	100.0%	100.0%	$179,111	$0
Maintenance worker	0	0						
No overexposures			$0	N/A	N/A	N/A	$0	$0
Quality control worker	0	0						
No overexposures			$0	N/A	N/A	N/A	$0	$0
Refractory Repair								
Production operator	153	77						
Portable exhaust ventilation			$1,066	33.3%	100.0%	100.0%	$54,387	$27,194
Wet methods for chipping tools			$117	33.3%	100.0%	100.0%	$5,949	$2,975
LEV for chipping tools			$1,600	33.3%	100.0%	100.0%	$81,581	$40,790
Improved maintenance for spay guns			$344	100.0%	100.0%	100.0%	$52,690	$26,345
All Workers [a]	122,317	77,871					$241,498,924	$155,394,667

[a] Excludes abrasive blasters in shipyards (NAICS 336611; 336612)
Source: U.S. Dept. of Labor, OSHA, Directorate of Evaluation and Analysis, Office of Regulatory Analysis, based on ERG (2007b) and ERG (2011).

APPENDIX V-B
Preliminary Compliance Costs for Small Entities (as defined by SBA) and Very Small Entities (fewer than twenty employees) Affected by the Proposed Silica Standard

Table V-B-1: Total Costs for Small Entities Affected by the Proposed Silica Standard (2009 dollars)

NAICS	Industry	Engineering Controls (includes Abrasive Blasting)	Respirators	Exposure Monitoring	Medical Surveillance	Training	Regulated Areas or Access Control	Total
324121	Asphalt paving mixture and block manufacturing	$100,144	$1,563	$5,765	$555	$31,697	$581	**$140,305**
324122	Asphalt shingle and roofing materials	$606,427	$31,487	$200,036	$10,880	$12,040	$11,745	**$872,614**
325510	Paint and coating manufacturing	$0	$10,269	$37,889	$3,644	$16,100	$3,816	**$71,718**
327111	Vitreous china plumbing fixtures & bathroom accessories manufacturing	$157,739	$10,690	$51,628	$3,744	$4,053	$3,990	**$231,845**
327112	Vitreous china, fine earthenware, & other pottery product manufacturing	$1,203,753	$81,945	$475,652	$29,081	$33,593	$30,448	**$1,854,472**
327113	Porcelain electrical supply mfg	$652,017	$44,386	$257,638	$15,752	$18,196	$16,492	**$1,004,480**
327121	Brick and structural clay mfg	$2,657,426	$59,168	$280,688	$20,998	$22,007	$21,985	**$3,062,272**
327122	Ceramic wall and floor tile mfg	$1,899,845	$42,301	$200,669	$15,012	$15,733	$15,718	**$2,189,278**
327123	Other structural clay product mfg	$443,280	$9,870	$46,821	$3,503	$3,671	$3,667	**$510,811**
327124	Clay refractory manufacturing	$127,226	$8,855	$62,720	$3,143	$7,731	$3,290	**$212,965**

Table V-B-1: Total Costs for Small Entities Affected by the Proposed Silica Standard (2009 dollars) (continued)

NAICS	Industry	Engineering Controls (includes Abrasive Blasting)	Respirators	Exposure Monitoring	Medical Surveillance	Training	Regulated Areas or Access Control	Total
327125	Nonclay refractory manufacturing	$133,555	$9,254	$54,536	$3,241	$7,472	$3,454	**$211,512**
327211	Flat glass manufacturing	$227,805	$8,960	$29,108	$3,138	$2,800	$3,344	**$275,155**
327212	Other pressed and blown glass and glassware manufacturing	$202,359	$7,710	$25,085	$2,700	$2,400	$2,878	**$243,132**
327213	Glass container manufacturing	$48,107	$1,833	$5,963	$639	$571	$684	**$57,797**
327320	Ready-mixed concrete manufacturing	$4,148,637	$1,103,956	$4,144,601	$391,774	$291,395	$410,198	**$10,490,561**
327331	Concrete block and brick mfg	$1,834,896	$138,710	$712,642	$49,226	$75,896	$51,541	**$2,862,910**
327332	Concrete pipe mfg	$924,057	$69,855	$358,887	$24,790	$38,221	$25,956	**$1,441,766**
327390	Other concrete product mfg	$5,657,090	$427,652	$2,197,114	$151,766	$233,990	$158,903	**$8,826,516**
327991	Cut stone and stone product manufacturing	$5,286,256	$388,777	$1,949,133	$137,970	$121,837	$144,458	**$8,028,431**
327992	Ground or treated mineral and earth manufacturing	$1,588,541	$23,007	$455,230	$8,165	$25,159	$8,549	**$2,108,649**
327993	Mineral wool manufacturing	$238,858	$9,750	$32,455	$3,419	$3,026	$3,637	**$291,145**
327999	All other misc. nonmetallic mineral product mfg	$724,387	$54,761	$281,339	$19,434	$29,962	$20,347	**$1,130,230**
331111	Iron and steel mills	$315,559	$17,939	$72,403	$6,129	$5,836	$6,691	**$424,557**
331112	Electrometallurgical ferroalloy product manufacturing	$3,707	$211	$851	$72	$69	$79	**$4,987**
331210	Iron and steel pipe and tube manufacturing from purchased steel	$62,639	$3,552	$14,556	$1,239	$1,222	$1,328	**$84,537**

Table V-B-1: Total Costs for Small Entities Affected by the Proposed Silica Standard (2009 dollars) (continued)

NAICS	Industry	Engineering Controls (includes Abrasive Blasting)	Respirators	Exposure Monitoring	Medical Surveillance	Training	Regulated Areas or Access Control	Total
331221	Rolled steel shape manufacturing	$31,618	$1,793	$7,348	$625	$617	$670	**$42,672**
331222	Steel wire drawing	$42,648	$2,419	$9,911	$843	$832	$904	**$57,557**
331314	Secondary smelting and alloying of aluminum	$11,347	$644	$2,607	$222	$215	$241	**$15,277**
331423	Secondary smelting, refining, and alloying of copper	$3,112	$177	$729	$61	$60	$66	**$4,206**
331492	Secondary smelting, refining, and alloying of nonferrous metal (except cu & al)	$13,583	$771	$3,183	$268	$264	$288	**$18,357**
331511	Iron foundries	$3,730,144	$212,862	$1,133,208	$75,541	$81,534	$79,093	**$5,312,382**
331512	Steel investment foundries	$1,199,284	$68,203	$363,147	$24,204	$25,192	$25,342	**$1,705,373**
331513	Steel foundries (except investment)	$1,770,847	$101,054	$537,978	$35,862	$38,708	$37,549	**$2,521,998**
331524	Aluminum foundries (except die-casting)	$3,035,274	$172,615	$919,091	$61,258	$63,759	$64,139	**$4,316,135**
331525	Copper foundries (except die-casting)	$1,122,571	$63,840	$339,918	$22,656	$23,581	$23,721	**$1,596,288**
331528	Other nonferrous foundries (except die-casting)	$436,250	$24,809	$132,098	$8,804	$9,164	$9,218	**$620,344**
332111	Iron and steel forging	$33,266	$1,898	$10,106	$674	$727	$705	**$47,376**
332112	Nonferrous forging	$9,167	$523	$2,785	$186	$200	$194	**$13,056**
332115	Crown and closure manufacturing	$3,567	$204	$1,084	$72	$78	$76	**$5,080**
332116	Metal stamping	$148,935	$8,499	$45,246	$3,016	$3,255	$3,158	**$212,110**
332117	Powder metallurgy part manufacturing	$12,314	$703	$3,741	$249	$269	$261	**$17,537**
332211	Cutlery and flatware (except precious) manufacturing	$7,316	$417	$2,222	$148	$160	$155	**$10,419**

Table V-B-1: Total Costs for Small Entities Affected by the Proposed Silica Standard (2009 dollars) (continued)

NAICS	Industry	Engineering Controls (includes Abrasive Blasting)	Respirators	Exposure Monitoring	Medical Surveillance	Training	Regulated Areas or Access Control	Total
332212	Hand and edge tool manufacturing	$61,509	$3,510	$18,686	$1,246	$1,344	$1,304	**$87,599**
332213	Saw blade and handsaw manufacturing	$6,474	$369	$1,967	$131	$142	$137	**$9,221**
332214	Kitchen utensil, pot, and pan manufacturing	$7,355	$420	$2,234	$149	$161	$156	**$10,475**
332323	Ornamental and architectural metal work	$22,284	$869	$4,342	$308	$482	$323	**$28,608**
332439	Other metal container manufacturing	$30,795	$1,757	$9,355	$624	$673	$653	**$43,857**
332510	Hardware manufacturing	$55,146	$3,147	$16,753	$1,117	$1,205	$1,169	**$78,538**
332611	Spring (heavy gauge) manufacturing	$9,880	$564	$3,002	$200	$216	$209	**$14,071**
332612	Spring (light gauge) manufacturing	$25,858	$1,476	$7,855	$524	$565	$548	**$36,826**
332618	Other fabricated wire product manufacturing	$79,768	$4,552	$24,233	$1,615	$1,744	$1,691	**$113,603**
332710	Machine shops	$724,969	$41,371	$220,243	$14,682	$15,847	$15,372	**$1,032,483**
332812	Metal coating and allied services	$1,939,689	$75,849	$379,617	$26,918	$42,100	$28,183	**$2,492,357**
332911	Industrial valve manufacturing	$37,580	$2,145	$11,417	$761	$821	$797	**$53,520**
332912	Fluid power valve and hose fitting manufacturing	$29,289	$1,671	$8,898	$593	$640	$621	**$41,712**
332913	Plumbing fixture fitting and trim manufacturing	$13,367	$763	$4,061	$271	$292	$283	**$19,037**
332919	Other metal valve and pipe fitting manufacturing	$21,499	$1,227	$6,531	$435	$470	$456	**$30,618**

Table V-B-1: Total Costs for Small Entities Affected by the Proposed Silica Standard (2009 dollars) (continued)

NAICS	Industry	Engineering Controls (includes Abrasive Blasting)	Respirators	Exposure Monitoring	Medical Surveillance	Training	Regulated Areas or Access Control	Total
332991	Ball and roller bearing manufacturing	$10,032	$570	$2,415	$198	$196	$213	**$13,624**
332996	Fabricated pipe and pipe fitting manufacturing	$52,405	$2,990	$15,920	$1,061	$1,145	$1,111	**$74,633**
332997	Industrial pattern manufacturing	$14,582	$832	$4,430	$295	$319	$309	**$20,767**
332998	Enameled iron and metal sanitary ware manufacturing	$10,576	$505	$2,113	$176	$220	$189	**$13,779**
332999	All other miscellaneous fabricated metal product manufacturing	$162,076	$9,249	$49,238	$3,282	$3,543	$3,437	**$230,825**
333319	Other commercial and service industry machinery manufacturing	$86,939	$4,961	$26,412	$1,761	$1,900	$1,843	**$123,816**
333411	Air purification equipment manufacturing	$18,973	$1,083	$5,764	$384	$415	$402	**$27,021**
333412	Industrial and commercial fan and blower manufacturing	$19,063	$1,088	$5,791	$386	$417	$404	**$27,149**
333414	Heating equipment (except warm air furnaces) manufacturing	$31,813	$1,815	$9,665	$644	$695	$675	**$45,308**
333511	Industrial mold manufacturing	$100,560	$5,739	$30,550	$2,036	$2,198	$2,132	**$143,216**
333512	Machine tool (metal cutting types) manufacturing	$31,488	$1,797	$9,566	$638	$688	$668	**$44,845**
333513	Machine tool (metal forming types) manufacturing	$21,321	$1,217	$6,477	$432	$466	$452	**$30,365**

Table V-B-1: Total Costs for Small Entities Affected by the Proposed Silica Standard (2009 dollars) (continued)

NAICS	Industry	Engineering Controls (includes Abrasive Blasting)	Respirators	Exposure Monitoring	Medical Surveillance	Training	Regulated Areas or Access Control	Total
333514	Special die and tool, die set, jig, and fixture manufacturing	$143,060	$8,164	$43,461	$2,897	$3,127	$3,033	**$203,742**
333515	Cutting tool and machine tool accessory manufacturing	$73,244	$4,180	$22,251	$1,483	$1,601	$1,553	**$104,313**
333516	Rolling mill machinery and equipment manufacturing	$6,744	$385	$2,049	$137	$147	$143	**$9,604**
333518	Other metalworking machinery manufacturing	$26,934	$1,537	$8,183	$545	$589	$571	**$38,359**
333612	Speed changer, industrial high-speed drive, and gear manufacturing	$17,615	$1,005	$5,351	$357	$385	$374	**$25,087**
333613	Mechanical power transmission equipment manufacturing	$18,384	$1,049	$5,585	$372	$402	$390	**$26,182**
333911	Pump and pumping equipment manufacturing	$29,042	$1,657	$8,823	$588	$635	$616	**$41,360**
333912	Air and gas compressor manufacturing	$16,815	$960	$5,108	$341	$368	$357	**$23,948**
333991	Power-driven handtool manufacturing	$6,928	$395	$2,105	$140	$151	$147	**$9,867**
333992	Welding and soldering equipment manufacturing	$16,251	$927	$4,937	$329	$355	$345	**$23,144**
333993	Packaging machinery manufacturing	$38,529	$2,199	$11,705	$780	$842	$817	**$54,872**

Table V-B-1: Total Costs for Small Entities Affected by the Proposed Silica Standard (2009 dollars) (continued)

NAICS	Industry	Engineering Controls (includes Abrasive Blasting)	Respirators	Exposure Monitoring	Medical Surveillance	Training	Regulated Areas or Access Control	Total
333994	Industrial process furnace and oven manufacturing	$24,167	$1,379	$7,342	$489	$528	$512	**$34,418**
333995	Fluid power cylinder and actuator manufacturing	$22,644	$1,292	$6,879	$459	$495	$480	**$32,249**
333996	Fluid power pump and motor manufacturing	$10,714	$611	$3,255	$217	$234	$227	**$15,258**
333997	Scale and balance (except laboratory) manufacturing	$8,516	$486	$2,587	$172	$186	$181	**$12,129**
333999	All other miscellaneous general purpose machinery manufacturing	$86,635	$4,944	$26,320	$1,754	$1,894	$1,837	**$123,384**
334518	Watch, clock, and part manufacturing	$4,667	$266	$1,418	$95	$102	$99	**$6,646**
335211	Electric housewares and household fans	$2,707	$104	$392	$35	$48	$39	**$3,326**
335221	Household cooking appliance manufacturing	$5,307	$205	$768	$70	$95	$76	**$6,521**
335222	Household refrigerator and home freezer manufacturing	$26,139	$1,009	$3,784	$343	$468	$376	**$32,118**
335224	Household laundry equipment manufacturing	$24,839	$958	$3,596	$326	$444	$357	**$30,521**
335228	Other major household appliance manufacturing	$1,496	$58	$289	$21	$32	$22	**$1,917**
336111	Automobile manufacturing	$218,635	$12,444	$49,525	$4,203	$3,914	$4,636	**$293,357**
336112	Light truck and utility vehicle manufacturing	$301,676	$17,170	$68,335	$5,799	$5,400	$6,397	**$404,778**

Table V-B-1: Total Costs for Small Entities Affected by the Proposed Silica Standard (2009 dollars) (continued)

NAICS	Industry	Engineering Controls (includes Abrasive Blasting)	Respirators	Exposure Monitoring	Medical Surveillance	Training	Regulated Areas or Access Control	Total
336120	Heavy duty truck manufacturing	$93,229	$5,303	$21,179	$1,800	$1,692	$1,977	**$125,181**
336211	Motor vehicle body manufacturing	$138,218	$7,849	$32,738	$2,722	$2,674	$2,931	**$187,131**
336212	Truck trailer manufacturing	$38,013	$2,169	$11,548	$770	$831	$806	**$54,137**
336213	Motor home manufacturing	$62,548	$3,557	$14,284	$1,212	$1,147	$1,326	**$84,073**
336311	Carburetor, piston, piston ring, and valve manufacturing	$7,211	$411	$2,191	$146	$158	$153	**$10,269**
336312	Gasoline engine and engine parts manufacturing	$48,844	$2,774	$11,239	$954	$919	$1,036	**$65,767**
336322	Other motor vehicle electrical and electronic equipment manufacturing	$53,045	$3,013	$12,206	$1,036	$999	$1,125	**$71,423**
336330	Motor vehicle steering and suspension components (except spring) manufacturing	$18,951	$1,077	$4,341	$369	$352	$402	**$25,492**
336340	Motor vehicle brake system manufacturing	$24,424	$1,387	$5,620	$477	$460	$518	**$32,886**
336350	Motor vehicle transmission and power train parts manufacturing	$34,839	$1,980	$7,988	$677	$646	$739	**$46,869**
336370	Motor vehicle metal stamping	$111,753	$6,377	$33,950	$2,263	$2,443	$2,370	**$159,156**
336399	All other motor vehicle parts manufacturing	$125,811	$7,146	$28,950	$2,458	$2,368	$2,668	**$169,401**

Table V-B-1: Total Costs for Small Entities Affected by the Proposed Silica Standard (2009 dollars) (continued)

NAICS	Industry	Engineering Controls (includes Abrasive Blasting)	Respirators	Exposure Monitoring	Medical Surveillance	Training	Regulated Areas or Access Control	Total
336611	Ship building and repair	$7,868,944	$0	$412,708	$397,735	$26,973	$43,259	**$8,749,619**
336612	Boat building	$2,304,547	$0	$164,659	$121,002	$9,212	$12,669	**$2,612,088**
336992	Military armored vehicle, tank, and tank component manufacturing	$20,097	$1,142	$4,786	$394	$383	$426	**$27,227**
337215	Showcase, partition, shelving, and locker manufacturing	$124,142	$7,084	$37,714	$2,514	$2,714	$2,632	**$176,800**
339114	Dental equipment and supplies manufacturing	$195,887	$11,481	$42,361	$4,075	$3,323	$4,266	**$261,393**
339116	Dental laboratories	$86,572	$52,020	$909,690	$18,461	$311,198	$19,329	**$1,397,271**
339911	Jewelry (except costume) manufacturing	$210,599	$161,062	$832,346	$57,158	$71,043	$59,846	**$1,392,054**
339913	Jewelers' materials and lapidary work manufacturing	$38,924	$29,768	$153,837	$10,564	$13,130	$11,061	**$257,285**
339914	Costume jewelry and novelty manufacturing	$51,107	$26,031	$134,689	$9,238	$11,421	$9,672	**$242,158**
339950	Sign manufacturing	$199,057	$8,741	$45,788	$3,102	$4,874	$3,248	**$264,810**
423840	Industrial supplies, wholesalers	$70,777	$6,536	$58,061	$2,355	$3,472	$2,411	**$143,614**
482110	Rail transportation	$0	$0	$0	$0	$0	$0	**$0**
621210	Dental offices	$23,734	$14,251	$238,739	$5,027	$83,123	$5,299	**$370,174**
Total – General Industry and Maritime		**$57,563,800**	**$3,823,972**	**$19,871,006**	**$1,874,031**	**$1,910,195**	**$1,477,054**	**$86,520,059**
236100	Residential Building Construction	$11,679,003	$1,883,739	$1,497,930	$1,617,853	$1,189,401	$660,009	**$18,527,934**
236200	Nonresidential Building Construction	$9,960,350	$4,404,548	$2,858,810	$3,799,420	$2,806,661	$613,396	**$24,443,185**
237100	Utility System Construction	$19,630,172	$1,785,513	$3,443,515	$1,565,272	$3,710,478	$598,251	**$30,733,201**

Table V-B-1: Total Costs for Small Entities Affected by the Proposed Silica Standard (2009 dollars) (continued)

NAICS	Industry	Engineering Controls (includes Abrasive Blasting)	Respirators	Exposure Monitoring	Medical Surveillance	Training	Regulated Areas or Access Control	Total
237200	Land Subdivision	$315,507	$27,818	$75,890	$24,809	$91,833	$10,474	**$546,331**
237300	Highway, Street, and Bridge Construction	$7,157,915	$1,133,037	$1,857,199	$985,682	$2,351,262	$271,898	**$13,756,992**
237900	Other Heavy and Civil Engineering Construction	$3,111,938	$315,143	$706,418	$275,186	$922,202	$96,598	**$5,427,484**
238100	Foundation, Structure, and Building Exterior Contractors	$46,297,621	$41,383,516	$13,035,158	$35,368,755	$10,480,139	$5,594,969	**$152,160,159**
238200	Building Equipment Contractors	$2,170,740	$251,217	$291,091	$219,518	$375,396	$91,290	**$3,399,252**
238300	Building Finishing Contractors	$25,230,918	$2,094,721	$1,989,238	$4,364,535	$2,351,132	$747,130	**$36,777,673**
238900	Other Specialty Trade Contractors	$33,741,853	$3,162,113	$4,744,348	$3,814,256	$5,768,874	$2,200,768	**$53,432,213**
999000	State and Local Governments [a]	$1,458,463	$210,748	$418,122	$183,147	$576,896	$148,580	**$2,995,955**
Total -- Construction		**$160,754,480**	**$56,652,114**	**$30,917,719**	**$52,218,432**	**$30,624,274**	**$11,033,362**	**$342,200,381**

[a] Applies to state and local governments in State-Plan States.
Source: U.S. Dept. of Labor, OSHA, Directorate of Evaluation and Analysis, Office of Regulatory Analysis, based on ERG (2011).

Table V-B-2: Total Costs for Very Small Entities (<20 employees) Affected by the Proposed Silica Standard (2009 dollars)

NAICS	Industry	Engineering Controls (includes Abrasive Blasting)	Respirators	Exposure Monitoring	Medical Surveillance	Training	Regulated Areas or Access Control	Total
324121	Asphalt paving mixture and block manufacturing	$19,148	$301	$1,381	$108	$6,721	$111	**$27,770**
324122	Asphalt shingle and roofing materials	$52,113	$2,736	$27,108	$986	$1,302	$1,009	**$85,253**
325510	Paint and coating manufacturing	$0	$2,350	$10,789	$847	$4,057	$867	**$18,910**
327111	Vitreous china plumbing fixtures & bathroom accessories manufacturing	$16,177	$1,109	$8,011	$400	$501	$409	**$26,606**
327112	Vitreous china, fine earthenware, & other pottery product manufacturing	$454,734	$31,176	$225,182	$11,235	$14,073	$11,502	**$747,902**
327113	Porcelain electrical supply mfg	$48,534	$3,327	$24,034	$1,199	$1,502	$1,228	**$79,824**
327121	Brick and structural clay mfg	$64,979	$1,457	$8,601	$525	$597	$538	**$76,696**
327122	Ceramic wall and floor tile mfg	$324,376	$7,274	$42,937	$2,621	$2,979	$2,684	**$382,871**
327123	Other structural clay product mfg	$56,913	$1,276	$7,534	$460	$523	$471	**$67,176**
327124	Clay refractory manufacturing	$16,531	$1,159	$10,213	$418	$1,114	$428	**$29,861**

Table V-B-2: Total Costs for Very Small Entities (<20 employees) Affected by the Proposed Silica Standard (2009 dollars) (continued)

NAICS	Industry	Engineering Controls (includes Abrasive Blasting)	Respirators	Exposure Monitoring	Medical Surveillance	Training	Regulated Areas or Access Control	Total
327125	Nonclay refractory manufacturing	$18,856	$1,322	$11,649	$476	$1,271	$488	**$34,061**
327211	Flat glass manufacturing	$3,485	$139	$674	$50	$52	$51	**$4,450**
327212	Other pressed and blown glass and glassware manufacturing	$69,291	$2,671	$12,995	$962	$990	$985	**$87,895**
327213	Glass container manufacturing	$3,784	$146	$710	$51	$54	$54	**$4,798**
327320	Ready-mixed concrete manufacturing	$679,165	$182,012	$850,308	$65,591	$52,902	$67,153	**$1,897,131**
327331	Concrete block and brick mfg	$327,459	$24,931	$159,382	$8,984	$15,021	$9,198	**$544,975**
327332	Concrete pipe mfg	$70,104	$5,337	$34,121	$1,923	$3,216	$1,969	**$116,670**
327390	Other concrete product mfg	$1,132,938	$86,255	$551,429	$31,083	$51,968	$31,823	**$1,885,496**
327991	Cut stone and stone product manufacturing	$1,703,909	$126,205	$787,342	$45,480	$43,551	$46,563	**$2,753,051**
327992	Ground or treated mineral and earth manufacturing	$278,008	$4,055	$99,842	$1,461	$4,883	$1,496	**$389,745**
327993	Mineral wool manufacturing	$37,709	$1,556	$7,603	$561	$571	$574	**$48,575**
327999	All other misc. nonmetallic mineral product mfg	$187,387	$14,266	$91,206	$5,141	$8,595	$5,264	**$311,859**
331111	Iron and steel mills	$6,210	$357	$2,364	$129	$151	$132	**$9,342**
331112	Electrometallurgical ferroalloy product manufacturing	$0	$0	$0	$0	$0	$0	**$0**

Table V-B-2: Total Costs for Very Small Entities (<20 employees) Affected by the Proposed Silica Standard (2009 dollars) (continued)

NAICS	Industry	Engineering Controls (includes Abrasive Blasting)	Respirators	Exposure Monitoring	Medical Surveillance	Training	Regulated Areas or Access Control	Total
331210	Iron and steel pipe and tube manufacturing from purchased steel	$1,134	$65	$432	$23	$27	$24	**$1,706**
331221	Rolled steel shape manufacturing	$1,072	$62	$408	$22	$26	$23	**$1,612**
331222	Steel wire drawing	$1,954	$112	$744	$40	$47	$41	**$2,939**
331314	Secondary smelting and alloying of aluminum	$833	$48	$317	$17	$20	$18	**$1,254**
331423	Secondary smelting, refining, and alloying of copper	$0	$0	$0	$0	$0	$0	**$0**
331492	Secondary smelting, refining, and alloying of nonferrous metal (except cu & al)	$1,926	$111	$733	$40	$47	$41	**$2,897**
331511	Iron foundries	$219,725	$12,628	$83,654	$4,551	$5,326	$4,659	**$330,543**
331512	Steel investment foundries	$31,896	$1,827	$12,104	$658	$743	$674	**$47,902**
331513	Steel foundries (except investment)	$108,133	$6,215	$41,169	$2,240	$2,621	$2,293	**$162,670**
331524	Aluminum foundries (except die-casting)	$334,945	$19,184	$127,104	$6,913	$7,803	$7,078	**$503,027**
331525	Copper foundries (except die-casting)	$246,442	$14,115	$93,519	$5,087	$5,741	$5,208	**$370,110**
331528	Other nonferrous foundries (except die-casting)	$107,898	$6,180	$40,945	$2,227	$2,514	$2,280	**$162,043**
332111	Iron and steel forging	$2,718	$156	$1,035	$56	$66	$58	**$4,089**

Table V-B-2: Total Costs for Very Small Entities (<20 employees) Affected by the Proposed Silica Standard (2009 dollars) (continued)

NAICS	Industry	Engineering Controls (includes Abrasive Blasting)	Respirators	Exposure Monitoring	Medical Surveillance	Training	Regulated Areas or Access Control	Total
332112	Nonferrous forging	$521	$30	$198	$11	$13	$11	**$784**
332115	Crown and closure manufacturing	$660	$38	$251	$14	$16	$14	**$992**
332116	Metal stamping	$18,051	$1,037	$6,872	$374	$438	$383	**$27,154**
332117	Powder metallurgy part manufacturing	$1,378	$79	$524	$29	$33	$29	**$2,072**
332211	Cutlery and flatware (except precious) manufacturing	$1,474	$85	$561	$31	$36	$31	**$2,217**
332212	Hand and edge tool manufacturing	$12,986	$746	$4,944	$269	$315	$275	**$19,535**
332213	Saw blade and handsaw manufacturing	$1,526	$88	$581	$32	$37	$32	**$2,296**
332214	Kitchen utensil, pot, and pan manufacturing	$0	$0	$0	$0	$0	$0	**$0**
332323	Ornamental and architectural metal work	$7,130	$280	$1,741	$101	$171	$103	**$9,527**
332439	Other metal container manufacturing	$3,509	$202	$1,336	$73	$85	$74	**$5,279**
332510	Hardware manufacturing	$7,886	$453	$3,002	$163	$191	$167	**$11,863**
332611	Spring (heavy gauge) manufacturing	$1,281	$74	$488	$27	$31	$27	**$1,927**
332612	Spring (light gauge) manufacturing	$3,297	$189	$1,255	$68	$80	$70	**$4,960**
332618	Other fabricated wire product manufacturing	$13,259	$762	$5,048	$275	$321	$281	**$19,946**

Table V-B-2: Total Costs for Very Small Entities (<20 employees) Affected by the Proposed Silica Standard (2009 dollars) (continued)

NAICS	Industry	Engineering Controls (includes Abrasive Blasting)	Respirators	Exposure Monitoring	Medical Surveillance	Training	Regulated Areas or Access Control	Total
332710	Machine shops	$276,608	$15,897	$105,311	$5,729	$6,705	$5,865	**$416,115**
332812	Metal coating and allied services	$459,014	$18,077	$112,580	$6,514	$11,049	$6,669	**$613,903**
332911	Industrial valve manufacturing	$3,913	$225	$1,490	$81	$95	$83	**$5,886**
332912	Fluid power valve and hose fitting manufacturing	$2,985	$172	$1,137	$62	$72	$63	**$4,491**
332913	Plumbing fixture fitting and trim manufacturing	$1,000	$57	$381	$21	$24	$21	**$1,505**
332919	Other metal valve and pipe fitting manufacturing	$1,801	$104	$686	$37	$44	$38	**$2,710**
332991	Ball and roller bearing manufacturing	$753	$43	$287	$16	$18	$16	**$1,132**
332996	Fabricated pipe and pipe fitting manufacturing	$8,278	$476	$3,152	$171	$201	$176	**$12,453**
332997	Industrial pattern manufacturing	$5,928	$341	$2,257	$123	$144	$126	**$8,917**
332998	Enameled iron and metal sanitary ware manufacturing	$2,306	$111	$729	$40	$59	$41	**$3,287**
332999	All other miscellaneous fabricated metal product manufacturing	$37,213	$2,139	$14,168	$771	$902	$789	**$55,981**
333319	Other commercial and service industry machinery manufacturing	$13,146	$756	$5,005	$272	$319	$279	**$19,776**
333411	Air purification equipment manufacturing	$3,154	$181	$1,201	$65	$76	$67	**$4,745**

Table V-B-2: Total Costs for Very Small Entities (<20 employees) Affected by the Proposed Silica Standard (2009 dollars) (continued)

NAICS	Industry	Engineering Controls (includes Abrasive Blasting)	Respirators	Exposure Monitoring	Medical Surveillance	Training	Regulated Areas or Access Control	Total
333412	Industrial and commercial fan and blower manufacturing	$1,114	$64	$424	$23	$27	$24	**$1,675**
333414	Heating equipment (except warm air furnaces) manufacturing	$4,046	$233	$1,541	$84	$98	$86	**$6,087**
333511	Industrial mold manufacturing	$29,075	$1,671	$11,069	$602	$705	$616	**$43,738**
333512	Machine tool (metal cutting types) manufacturing	$5,821	$335	$2,216	$121	$141	$123	**$8,756**
333513	Machine tool (metal forming types) manufacturing	$3,102	$178	$1,181	$64	$75	$66	**$4,666**
333514	Special die and tool, die set, jig, and fixture manufacturing	$43,784	$2,516	$16,670	$907	$1,061	$928	**$65,867**
333515	Cutting tool and machine tool accessory manufacturing	$20,877	$1,200	$7,948	$432	$506	$443	**$31,406**
333516	Rolling mill machinery and equipment manufacturing	$904	$52	$344	$19	$22	$19	**$1,361**
333518	Other metalworking machinery manufacturing	$4,498	$258	$1,712	$93	$109	$95	**$6,766**

Table V-B-2: Total Costs for Very Small Entities (<20 employees) Affected by the Proposed Silica Standard (2009 dollars) (continued)

NAICS	Industry	Engineering Controls (includes Abrasive Blasting)	Respirators	Exposure Monitoring	Medical Surveillance	Training	Regulated Areas or Access Control	Total
333612	Speed changer, industrial high-speed drive, and gear manufacturing	$2,206	$127	$840	$46	$53	$47	**$3,318**
333613	Mechanical power transmission equipment manufacturing	$2,070	$119	$788	$43	$50	$44	**$3,114**
333911	Pump and pumping equipment manufacturing	$4,792	$275	$1,825	$99	$116	$102	**$7,209**
333912	Air and gas compressor manufacturing	$2,810	$162	$1,070	$58	$68	$60	**$4,228**
333991	Power-driven handtool manufacturing	$1,471	$85	$560	$30	$36	$31	**$2,212**
333992	Welding and soldering equipment manufacturing	$2,549	$147	$971	$53	$62	$54	**$3,835**
333993	Packaging machinery manufacturing	$6,476	$372	$2,466	$134	$157	$137	**$9,742**
333994	Industrial process furnace and oven manufacturing	$3,743	$215	$1,425	$78	$91	$79	**$5,631**
333995	Fluid power cylinder and actuator manufacturing	$2,629	$151	$1,001	$54	$64	$56	**$3,955**
333996	Fluid power pump and motor manufacturing	$1,775	$102	$676	$37	$43	$38	**$2,670**

Table V-B-2: Total Costs for Very Small Entities (<20 employees) Affected by the Proposed Silica Standard (2009 dollars) (continued)

NAICS	Industry	Engineering Controls (includes Abrasive Blasting)	Respirators	Exposure Monitoring	Medical Surveillance	Training	Regulated Areas or Access Control	Total
333997	Scale and balance (except laboratory) manufacturing	$1,294	$74	$493	$27	$31	$27	**$1,947**
333999	All other miscellaneous general purpose machinery manufacturing	$21,695	$1,247	$8,260	$449	$526	$460	**$32,637**
334518	Watch, clock, and part manufacturing	$879	$51	$335	$18	$21	$19	**$1,322**
335211	Electric housewares and household fans	$0	$0	$0	$0	$0	$0	**$0**
335221	Household cooking appliance manufacturing	$542	$21	$131	$8	$13	$8	**$722**
335222	Household refrigerator and home freezer manufacturing	$0	$0	$0	$0	$0	$0	**$0**
335224	Household laundry equipment manufacturing	$0	$0	$0	$0	$0	$0	**$0**
335228	Other major household appliance manufacturing	$0	$0	$0	$0	$0	$0	**$0**
336111	Automobile manufacturing	$1,427	$82	$543	$30	$35	$30	**$2,147**
336112	Light truck and utility vehicle manufacturing	$529	$30	$201	$11	$13	$11	**$795**
336120	Heavy duty truck manufacturing	$627	$36	$239	$13	$15	$13	**$943**

Table V-B-2: Total Costs for Very Small Entities (<20 employees) Affected by the Proposed Silica Standard (2009 dollars) (continued)

NAICS	Industry	Engineering Controls (includes Abrasive Blasting)	Respirators	Exposure Monitoring	Medical Surveillance	Training	Regulated Areas or Access Control	Total
336211	Motor vehicle body manufacturing	$8,223	$473	$3,131	$170	$199	$174	**$12,371**
336212	Truck trailer manufacturing	$3,422	$197	$1,303	$71	$83	$73	**$5,147**
336213	Motor home manufacturing	$793	$46	$302	$16	$19	$17	**$1,193**
336311	Carburetor, piston, piston ring, and valve manufacturing	$883	$51	$336	$18	$21	$19	**$1,329**
336312	Gasoline engine and engine parts manufacturing	$7,766	$446	$2,957	$161	$188	$165	**$11,683**
336322	Other motor vehicle electrical and electronic equipment manufacturing	$5,729	$329	$2,181	$119	$139	$121	**$8,618**
336330	Motor vehicle steering and suspension components (except spring) manufacturing	$1,912	$110	$728	$40	$46	$41	**$2,876**
336340	Motor vehicle brake system manufacturing	$1,586	$91	$604	$33	$38	$34	**$2,386**
336350	Motor vehicle transmission and power train parts manufacturing	$4,248	$244	$1,617	$88	$103	$90	**$6,390**
336370	Motor vehicle metal stamping	$3,828	$220	$1,458	$79	$93	$81	**$5,759**
336399	All other motor vehicle parts manufacturing	$10,650	$612	$4,055	$221	$258	$226	**$16,021**
336611	Ship building and repair	$183,860	$0	$16,463	$9,873	$815	$1,011	**$212,021**

Table V-B-2: Total Costs for Very Small Entities (<20 employees) Affected by the Proposed Silica Standard (2009 dollars) (continued)

NAICS	Industry	Engineering Controls (includes Abrasive Blasting)	Respirators	Exposure Monitoring	Medical Surveillance	Training	Regulated Areas or Access Control	Total
336612	Boat building	$339,890	$0	$30,434	$18,251	$1,507	$1,869	**$391,950**
336992	Military armored vehicle, tank, and tank component manufacturing	$0	$0	$0	$0	$0	$0	**$0**
337215	Showcase, partition, shelving, and locker manufacturing	$18,756	$1,078	$7,141	$388	$455	$398	**$28,216**
339114	Dental equipment and supplies manufacturing	$57,386	$3,387	$15,552	$1,221	$1,080	$1,250	**$79,876**
339116	Dental laboratories	$54,168	$32,781	$713,319	$11,813	$215,937	$12,094	**$1,040,112**
339911	Jewelry (except costume) manufacturing	$69,637	$53,636	$344,913	$19,328	$26,051	$19,789	**$533,353**
339913	Jewelers' materials and lapidary work manufacturing	$11,289	$8,695	$55,916	$3,133	$4,223	$3,208	**$86,465**
339914	Costume jewelry and novelty manufacturing	$18,493	$9,486	$61,076	$3,418	$4,583	$3,500	**$100,556**
339950	Sign manufacturing	$64,362	$2,846	$18,554	$1,026	$1,748	$1,050	**$89,586**
423840	Industrial supplies, wholesalers	$24,943	$2,303	$20,462	$830	$1,224	$850	**$50,612**
482110	Rail transportation	$0	$0	$0	$0	$0	$0	**$0**
621210	Dental offices	$20,580	$12,357	$207,016	$4,359	$72,078	$4,595	**$320,986**
Total – General Industry and Maritime		**$8,602,681**	**$743,951**	**$5,227,203**	**$296,124**	**$598,074**	**$277,393**	**$15,745,425**

Table V-B-2: Total Costs for Very Small Entities (<20 employees) Affected by the Proposed Silica Standard (2009 dollars) (continued)

NAICS	Industry	Engineering Controls (includes Abrasive Blasting)	Respirators	Exposure Monitoring	Medical Surveillance	Training	Regulated Areas or Access Control	Total
236100	Residential Building Construction	$8,460,143	$1,364,560	$1,357,327	$1,208,711	$968,449	$478,104	**$13,837,293**
236200	Nonresidential Building Construction	$4,188,645	$1,852,253	$1,503,853	$1,647,889	$1,326,678	$257,953	**$10,777,269**
237100	Utility System Construction	$5,245,137	$477,085	$1,150,949	$431,354	$1,114,395	$159,851	**$8,578,771**
237200	Land Subdivision	$315,507	$27,818	$75,890	$24,809	$91,833	$10,474	**$546,331**
237300	Highway, Street, and Bridge Construction	$2,223,352	$351,938	$721,608	$315,769	$820,917	$84,455	**$4,518,038**
237900	Other Heavy and Civil Engineering Construction	$896,467	$90,784	$254,558	$81,760	$298,611	$27,827	**$1,650,007**
238100	Foundation, Structure, and Building Exterior Contractors	$24,000,229	$21,452,805	$8,452,674	$18,909,854	$6,106,611	$2,900,376	**$81,822,550**
238200	Building Equipment Contractors	$1,132,607	$131,075	$189,986	$118,128	$220,160	$47,631	**$1,839,588**
238300	Building Finishing Contractors	$14,644,589	$1,215,823	$1,444,282	$2,612,725	$1,533,902	$433,651	**$21,884,973**
238900	Other Specialty Trade Contractors	$18,822,294	$1,763,929	$3,310,559	$2,194,447	$3,617,189	$1,227,660	**$30,936,078**
999000	State and Local Governments [a]	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Total - Construction		**$79,928,970**	**$28,728,070**	**$18,461,685**	**$27,545,448**	**$16,098,744**	**$5,627,982**	**$176,390,899**

[a] Applies to state and local governments in State-Plan States.
Source: U.S. Dept. of Labor, OSHA, Directorate of Evaluation and Analysis, Office of Regulatory Analysis, based on ERG (2011).

APPENDIX V-C
Preliminary Compliance Costs for Entities in General Industry, Maritime, and Construction Affected by the Alternative Permissible Exposure Limit of 100 μg/m^3

Table V-C-1: Annualized Compliance Costs for Employers in General Industry, Maritime, and Construction Affected by OSHA's Alternative Silica PEL of 100 μg/m³ (2009 dollars)

Industry	Engineering Controls (includes Abrasive Blasting)	Respirators	Exposure Assessment	Medical Surveillance	Training	Regulated Areas or Access Control	Total
General Industry	$0	$0	$20,435,555	$0	$2,952,035	$0	**$23,387,590**
Maritime	$12,797,027	NA	$479,411	$0	$43,865	$56,281	**$13,376,584**
Construction	$134,040,811	$2,534,770	$27,158,378	$49,666,041	$47,270,844	$9,516,996	**$270,187,841**
Total	**$146,837,838**	**$2,534,770**	**$48,073,344**	**$49,666,041**	**$50,266,744**	**$9,573,277**	**$306,952,015**

Source: U.S. Dept. of Labor, OSHA, Directorate of Standards and Guidance, Office of Regulatory Analysis, based on ERG (2013).

Table V-C-2: Annualized Costs, by Industry, for All General Industry and Maritime Entities Affected by the Alternative Silica PEL of 100 μg/m^3 (2009 dollars)

NAICS	Industry	All Establishments	Small Firms (SBA-defined)	Very Small Establishments (<20 Employees)
324121	Asphalt paving mixture and block manufacturing	$58,174	$37,462	$8,102
324122	Asphalt shingle and roofing materials	$366,823	$101,384	$13,409
325510	Paint and coating manufacturing	$103,905	$53,988	$14,846
327111	Vitreous china plumbing fixtures & bathroom accessories manufacturing	$258,048	$36,058	$5,467
327112	Vitreous china, fine earthenware, & other pottery product manufacturing	$404,597	$328,453	$153,665
327113	Porcelain electrical supply mfg	$271,906	$177,908	$16,401
327121	Brick and structural clay mfg	$476,122	$236,985	$7,184
327122	Ceramic wall and floor tile mfg	$262,347	$169,425	$35,865
327123	Other structural clay product mfg	$61,686	$39,531	$6,293
327124	Clay refractory manufacturing	$79,750	$39,349	$6,262
327125	Nonclay refractory manufacturing	$100,510	$34,964	$7,143
327211	Flat glass manufacturing	$30,202	$30,202	$686
327212	Other pressed and blown glass and glassware manufacturing	$115,893	$25,977	$13,204
327213	Glass container manufacturing	$80,871	$6,175	$721
327320	Ready-mixed concrete manufacturing	$6,164,602	$4,359,595	$887,536
327331	Concrete block and brick mfg	$788,578	$577,826	$127,277
327332	Concrete pipe mfg	$488,201	$290,994	$27,248
327390	Other concrete product mfg	$2,292,248	$1,781,469	$440,352
327991	Cut stone and stone product manufacturing	$1,452,462	$1,530,352	$612,514
327992	Ground or treated mineral and earth manufacturing	$205,820	$105,493	$22,502
327993	Mineral wool manufacturing	$125,572	$33,401	$7,687
327999	All other misc. nonmetallic mineral product mfg	$354,007	$228,116	$72,834
331111	Iron and steel mills	$54,965	$54,965	$1,755
331112	Electrometallurgical ferroalloy product manufacturing	$1,110	$646	$0

Table V-C-2: Annualized Costs, by Industry, for All General Industry and Maritime Entities Affected by the Alternative Silica PEL of 100 μg/m^3 (2009 dollars) (continued)

NAICS	Industry	All Establishments	Small Firms (SBA-defined)	Very Small Establishments (<20 Employees)
331210	Iron and steel pipe and tube manufacturing from purchased steel	$11,099	$11,099	$320
331221	Rolled steel shape manufacturing	$5,603	$5,603	$303
331222	Steel wire drawing	$7,557	$7,557	$552
331314	Secondary smelting and alloying of aluminum	$3,736	$1,985	$236
331423	Secondary smelting, refining, and alloying of copper	$652	$555	$0
331492	Secondary smelting, refining, and alloying of nonferrous metal (except cu & al)	$4,878	$2,424	$544
331511	Iron foundries	$1,989,119	$850,469	$62,089
331512	Steel investment foundries	$560,466	$271,564	$8,955
331513	Steel foundries (except investment)	$605,105	$403,751	$30,556
331524	Aluminum foundries (except die-casting)	$925,292	$687,302	$94,034
331525	Copper foundries (except die-casting)	$233,357	$254,193	$69,187
331528	Other nonferrous foundries (except die-casting)	$161,305	$98,784	$30,292
332111	Iron and steel forging	$14,790	$7,585	$768
332112	Nonferrous forging	$4,883	$2,090	$147
332115	Crown and closure manufacturing	$1,703	$813	$186
332116	Metal stamping	$34,674	$33,957	$5,101
332117	Powder metallurgy part manufacturing	$4,366	$2,807	$389
332211	Cutlery and flatware (except precious) manufacturing	$3,206	$1,668	$416
332212	Hand and edge tool manufacturing	$20,001	$14,024	$3,670
332213	Saw blade and handsaw manufacturing	$3,865	$1,476	$431
332214	Kitchen utensil, pot, and pan manufacturing	$2,188	$1,677	$0
332323	Ornamental and architectural metal work	$4,058	$3,630	$1,433
332439	Other metal container manufacturing	$8,421	$7,021	$992
332510	Hardware manufacturing	$25,167	$12,573	$2,228
332611	Spring (heavy gauge) manufacturing	$2,255	$2,253	$362
332612	Spring (light gauge) manufacturing	$8,514	$5,895	$932
332618	Other fabricated wire product manufacturing	$20,215	$18,187	$3,747
332710	Machine shops	$159,359	$165,292	$78,163
332812	Metal coating and allied services	$334,671	$316,923	$92,551
332911	Industrial valve manufacturing	$19,730	$8,568	$1,106

Table V-C-2: Annualized Costs, by Industry, for All General Industry and Maritime Entities Affected by the Alternative Silica PEL of 100 μg/m^3 (2009 dollars) (continued)

NAICS	Industry	All Establishments	Small Firms (SBA-defined)	Very Small Establishments (<20 Employees)
332912	Fluid power valve and hose fitting manufacturing	$18,885	$6,678	$844
332913	Plumbing fixture fitting and trim manufacturing	$6,125	$3,048	$283
332919	Other metal valve and pipe fitting manufacturing	$9,611	$4,902	$509
332991	Ball and roller bearing manufacturing	$14,458	$1,835	$213
332996	Fabricated pipe and pipe fitting manufacturing	$14,441	$11,948	$2,339
332997	Industrial pattern manufacturing	$2,814	$3,325	$1,675
332998	Enameled iron and metal sanitary ware manufacturing	$7,373	$1,674	$561
332999	All other miscellaneous fabricated metal product manufacturing	$40,627	$36,953	$10,515
333319	Other commercial and service industry machinery manufacturing	$28,261	$19,822	$3,715
333411	Air purification equipment manufacturing	$7,634	$4,326	$891
333412	Industrial and commercial fan and blower manufacturing	$5,400	$4,346	$315
333414	Heating equipment (except warm air furnaces) manufacturing	$10,580	$7,253	$1,143
333511	Industrial mold manufacturing	$22,968	$22,928	$8,216
333512	Machine tool (metal cutting types) manufacturing	$9,340	$7,179	$1,645
333513	Machine tool (metal forming types) manufacturing	$4,678	$4,861	$877
333514	Special die and tool, die set, jig, and fixture manufacturing	$33,940	$32,617	$12,373
333515	Cutting tool and machine tool accessory manufacturing	$20,068	$16,700	$5,899
333516	Rolling mill machinery and equipment manufacturing	$1,761	$1,538	$256
333518	Other metalworking machinery manufacturing	$7,172	$6,141	$1,271
333612	Speed changer, industrial high-speed drive, and gear manufacturing	$6,311	$4,016	$623
333613	Mechanical power transmission equipment manufacturing	$7,971	$4,191	$585
333911	Pump and pumping equipment manufacturing	$16,090	$6,621	$1,354
333912	Air and gas compressor manufacturing	$11,380	$3,834	$794
333991	Power-driven handtool manufacturing	$4,640	$1,580	$416
333992	Welding and soldering equipment manufacturing	$8,263	$3,705	$720
333993	Packaging machinery manufacturing	$11,399	$8,785	$1,830

Table V-C-2: Annualized Costs, by Industry, for All General Industry and Maritime Entities Affected by the Alternative Silica PEL of 100 μg/m^3 (2009 dollars) (continued)

NAICS	Industry	All Establishments	Small Firms (SBA-defined)	Very Small Establishments (<20 Employees)
333994	Industrial process furnace and oven manufacturing	$5,847	$5,510	$1,058
333995	Fluid power cylinder and actuator manufacturing	$10,295	$5,163	$743
333996	Fluid power pump and motor manufacturing	$7,079	$2,443	$502
333997	Scale and balance (except laboratory) manufacturing	$2,042	$1,942	$366
333999	All other miscellaneous general purpose machinery manufacturing	$27,871	$19,753	$6,131
334518	Watch, clock, and part manufacturing	$1,212	$1,064	$248
335211	Electric housewares and household fans	$1,396	$333	$0
335221	Household cooking appliance manufacturing	$3,015	$654	$108
335222	Household refrigerator and home freezer manufacturing	$3,219	$3,219	$0
335224	Household laundry equipment manufacturing	$3,059	$3,059	$0
335228	Other major household appliance manufacturing	$2,408	$242	$0
336111	Automobile manufacturing	$37,519	$37,519	$403
336112	Light truck and utility vehicle manufacturing	$51,769	$51,769	$149
336120	Heavy duty truck manufacturing	$16,064	$16,064	$177
336211	Motor vehicle body manufacturing	$24,888	$24,888	$2,324
336212	Truck trailer manufacturing	$16,573	$8,667	$967
336213	Motor home manufacturing	$10,839	$10,839	$224
336311	Carburetor, piston, piston ring, and valve manufacturing	$5,356	$1,644	$250
336312	Gasoline engine and engine parts manufacturing	$33,606	$8,546	$2,194
336322	Other motor vehicle electrical and electronic equipment manufacturing	$31,522	$9,281	$1,619
336330	Motor vehicle steering and suspension components (except spring) manufacturing	$19,917	$3,298	$540
336340	Motor vehicle brake system manufacturing	$17,167	$4,273	$448
336350	Motor vehicle transmission and power train parts manufacturing	$42,371	$6,066	$1,200
336370	Motor vehicle metal stamping	$55,868	$25,480	$1,082
336399	All other motor vehicle parts manufacturing	$75,860	$22,012	$3,009
336611	Ship building and repair	$8,225,316	$8,225,316	$197,243
336612	Boat building	$5,151,268	$2,441,507	$364,630

Table V-C-2: Annualized Costs, by Industry, for All General Industry and Maritime Entities Affected by the Alternative Silica PEL of 100 μg/m^3 (2009 dollars) (continued)

NAICS	Industry	All Establishments	Small Firms (SBA-defined)	Very Small Establishments (<20 Employees)
336992	Military armored vehicle, tank, and tank component manufacturing	$3,630	$3,630	$0
337215	Showcase, partition, shelving, and locker manufacturing	$31,885	$28,304	$5,300
339114	Dental equipment and supplies manufacturing	$52,293	$45,684	$16,632
339116	Dental laboratories	$514,417	$493,136	$358,601
339911	Jewelry (except costume) manufacturing	$695,088	$653,685	$267,490
339913	Jewelers' materials and lapidary work manufacturing	$142,941	$120,817	$43,364
339914	Costume jewelry and novelty manufacturing	$97,247	$105,583	$47,282
339950	Sign manufacturing	$35,993	$36,473	$14,552
423840	Industrial supplies, wholesalers	$34,410	$32,503	$11,455
482110	Rail transportation	$1,024,480	$0	$0
621210	Dental offices	$137,617	$130,871	$113,481
Total – General Industry and Maritime		**$36,764,174**	**$26,304,485**	**$4,502,274**

Source: U.S. Dept. of Labor, OSHA, Directorate of Standards and Guidance, Office of Regulatory Analysis,
based on ERG (2013).

Table V-C-3: Annualized Costs, by Industry, for All Construction Entities Affected by the Alternative Silica PEL of 100 μg/m^3 (2009 dollars)

NAICS	Industry	All Establishments	Small Firms (SBA-defined)	Very Small Establishments (<20 Employees)
236100	Residential Building Construction	$10,741,343	$8,208,322	$6,211,939
236200	Nonresidential Building Construction	$18,789,733	$11,354,627	$5,124,677
237100	Utility System Construction	$23,470,434	$15,209,315	$4,314,981
237200	Land Subdivision	$626,145	$314,066	$314,066
237300	Highway, Street, and Bridge Construction	$15,068,032	$6,725,116	$2,265,299
237900	Other Heavy and Civil Engineering Construction	$3,743,359	$2,813,548	$878,318
238100	Foundation, Structure, and Building Exterior Contractors	$104,393,749	$73,786,241	$40,460,844
238200	Building Equipment Contractors	$2,428,769	$1,670,868	$918,743
238300	Building Finishing Contractors	$39,527,187	$27,017,780	$16,080,277
238900	Other Specialty Trade Contractors	$39,775,549	$30,843,795	$18,041,684
999000	State and local governments [d]	$11,623,542	$1,494,283	$0
Total -- Construction		**$270,187,841**	**$179,437,961**	**$94,610,827**

Source: U.S. Dept. of Labor, OSHA, Directorate of Standards and Guidance, Office of Regulatory Analysis, based on ERG (2013).

APPENDIX V-D
Preliminary Compliance Costs at the Alternative Discount Rates of 3 Percent and 0 Percent for Entities in General Industry, Maritime, and Construction Affected by the Proposed Silica Standard

Table V-D-1: Annualized Compliance Costs for Employers in General Industry, Maritime, and Construction Affected by OSHA's Proposed Silica Standard (3% discount rate; 2009 dollars)

Industry	Engineering Controls (includes Abrasive Blasting)	Respirators	Exposure Assessment	Medical Surveillance	Training	Regulated Areas or Access Control	Total
General Industry	$84,804,435	$6,902,081	$28,915,118	$2,325,230	$2,787,182	$2,571,785	**$128,305,832**
Maritime	$12,797,027	N/A	$664,265	$624,090	$41,359	$70,108	**$14,196,849**
Construction	$232,392,606	$83,671,367	$42,925,615	$73,284,611	$45,950,892	$16,601,607	**$494,826,699**
Total	**$329,994,068**	**$90,573,449**	**$72,504,999**	**$76,233,932**	**$48,779,433**	**$19,243,500**	**$637,329,380**

Source: U.S. Dept. of Labor, OSHA, Directorate of Evaluation and Analysis, Office of Regulatory Analysis, based on ERG (2011).

Table V-D-2: Annualized Costs, by Industry, for All General Industry, Maritime, and Construction Entities Affected by the Proposed Silica Standard (3% discount rate; 2009 dollars)

NAICS	Industry	All Establishments	Small Firms (SBA-defined)	Very Small Establishments (<20 Employees)
324121	Asphalt paving mixture and block manufacturing	$229,983	$133,424	$26,434
324122	Asphalt shingle and roofing materials	$3,068,544	$848,095	$83,029
325510	Paint and coating manufacturing	$141,382	$70,331	$18,561
327111	Vitreous china plumbing fixtures & bathroom accessories manufacturing	$1,586,219	$221,648	$25,529
327112	Vitreous china, fine earthenware, & other pottery product manufacturing	$2,487,054	$1,775,692	$717,619
327113	Porcelain electrical supply mfg	$1,671,403	$961,809	$76,592
327121	Brick and structural clay mfg	$7,447,031	$2,912,311	$73,009
327122	Ceramic wall and floor tile mfg	$3,926,593	$2,082,067	$364,465
327123	Other structural clay product mfg	$890,238	$485,796	$63,947
327124	Clay refractory manufacturing	$463,437	$204,896	$28,788
327125	Nonclay refractory manufacturing	$584,070	$203,182	$32,837
327211	Flat glass manufacturing	$264,391	$264,391	$4,283
327212	Other pressed and blown glass and glassware manufacturing	$1,041,861	$233,528	$84,554
327213	Glass container manufacturing	$726,990	$55,514	$4,616
327320	Ready-mixed concrete manufacturing	$16,209,472	$10,304,023	$1,864,583
327331	Concrete block and brick mfg	$4,393,887	$2,834,276	$539,480
327332	Concrete pipe mfg	$2,720,211	$1,427,346	$115,494
327390	Other concrete product mfg	$12,772,198	$8,738,235	$1,866,485
327991	Cut stone and stone product manufacturing	$8,387,200	$7,833,752	$2,688,478
327992	Ground or treated mineral and earth manufacturing	$4,444,557	$2,041,188	$377,716
327993	Mineral wool manufacturing	$1,051,414	$279,670	$46,734
327999	All other misc. nonmetallic mineral product mfg	$1,946,523	$1,118,926	$308,715
331111	Iron and steel mills	$406,888	$406,888	$8,982
331112	Electrometallurgical ferroalloy product manufacturing	$8,220	$4,780	$0
331210	Iron and steel pipe and tube manufacturing from purchased steel	$81,019	$81,019	$1,640
331221	Rolled steel shape manufacturing	$40,896	$40,896	$1,550

Table V-D-2: Annualized Costs, by Industry, for All General Industry, Maritime, and Construction Entities Affected by the Proposed Silica Standard (3% discount rate; 2009 dollars) (continued)

NAICS	Industry	All Establishments	Small Firms (SBA-defined)	Very Small Establishments (<20 Employees)
331222	Steel wire drawing	$55,162	$55,162	$2,826
331314	Secondary smelting and alloying of aluminum	$27,560	$14,640	$1,205
331423	Secondary smelting, refining, and alloying of copper	$4,735	$4,031	$0
331492	Secondary smelting, refining, and alloying of nonferrous metal (except cu & al)	$35,411	$17,594	$2,786
331511	Iron foundries	$14,673,210	$5,099,768	$317,824
331512	Steel investment foundries	$4,104,782	$1,636,991	$46,055
331513	Steel foundries (except investment)	$4,405,767	$2,421,061	$156,410
331524	Aluminum foundries (except die-casting)	$6,685,283	$4,143,066	$483,633
331525	Copper foundries (except die-casting)	$1,569,326	$1,532,279	$355,841
331528	Other nonferrous foundries (except die-casting)	$1,181,376	$595,469	$155,796
332111	Iron and steel forging	$101,595	$45,480	$3,932
332112	Nonferrous forging	$33,543	$12,533	$754
332115	Crown and closure manufacturing	$12,192	$4,876	$954
332116	Metal stamping	$245,246	$203,621	$26,109
332117	Powder metallurgy part manufacturing	$31,464	$16,835	$1,993
332211	Cutlery and flatware (except precious) manufacturing	$22,025	$10,002	$2,131
332212	Hand and edge tool manufacturing	$139,234	$84,093	$18,784
332213	Saw blade and handsaw manufacturing	$27,656	$8,852	$2,207
332214	Kitchen utensil, pot, and pan manufacturing	$15,033	$10,055	$0
332323	Ornamental and architectural metal work	$33,518	$27,210	$9,075
332439	Other metal container manufacturing	$57,847	$42,102	$5,075
332510	Hardware manufacturing	$172,873	$75,395	$11,407
332611	Spring (heavy gauge) manufacturing	$15,493	$13,508	$1,853
332612	Spring (light gauge) manufacturing	$58,483	$35,352	$4,769
332618	Other fabricated wire product manufacturing	$138,860	$109,056	$19,178
332710	Machine shops	$1,033,894	$991,161	$400,103
332812	Metal coating and allied services	$2,887,294	$2,370,609	$584,819
332911	Industrial valve manufacturing	$144,010	$51,378	$5,659
332912	Fluid power valve and hose fitting manufacturing	$134,408	$40,043	$4,318
332913	Plumbing fixture fitting and trim manufacturing	$43,590	$18,275	$1,447
332919	Other metal valve and pipe fitting manufacturing	$68,400	$29,393	$2,606
332991	Ball and roller bearing manufacturing	$102,894	$13,060	$1,089

Table V-D-2: Annualized Costs, by Industry, for All General Industry, Maritime, and Construction Entities Affected by the Proposed Silica Standard (3% discount rate; 2009 dollars) (continued)

NAICS	Industry	All Establishments	Small Firms (SBA-defined)	Very Small Establishments (<20 Employees)
332996	Fabricated pipe and pipe fitting manufacturing	$102,780	$71,646	$11,974
332997	Industrial pattern manufacturing	$20,026	$19,936	$8,574
332998	Enameled iron and metal sanitary ware manufacturing	$57,872	$13,140	$3,145
332999	All other miscellaneous fabricated metal product manufacturing	$276,259	$221,587	$53,827
333319	Other commercial and service industry machinery manufacturing	$200,609	$118,860	$19,015
333411	Air purification equipment manufacturing	$55,843	$25,939	$4,563
333412	Industrial and commercial fan and blower manufacturing	$39,499	$26,063	$1,611
333414	Heating equipment (except warm air furnaces) manufacturing	$77,396	$43,495	$5,853
333511	Industrial mold manufacturing	$153,575	$137,484	$42,055
333512	Machine tool (metal cutting types) manufacturing	$65,338	$43,050	$8,419
333513	Machine tool (metal forming types) manufacturing	$32,539	$29,150	$4,487
333514	Special die and tool, die set, jig, and fixture manufacturing	$222,527	$195,588	$63,333
333515	Cutting tool and machine tool accessory manufacturing	$134,187	$100,138	$30,197
333516	Rolling mill machinery and equipment manufacturing	$11,776	$9,220	$1,308
333518	Other metalworking machinery manufacturing	$47,954	$36,824	$6,506
333612	Speed changer, industrial high-speed drive, and gear manufacturing	$46,437	$24,083	$3,191
333613	Mechanical power transmission equipment manufacturing	$58,651	$25,134	$2,994
333911	Pump and pumping equipment manufacturing	$116,060	$39,705	$6,932
333912	Air and gas compressor manufacturing	$81,019	$22,989	$4,065
333991	Power-driven handtool manufacturing	$33,032	$9,472	$2,127
333992	Welding and soldering equipment manufacturing	$59,812	$22,218	$3,688
333993	Packaging machinery manufacturing	$80,254	$52,676	$9,368
333994	Industrial process furnace and oven manufacturing	$40,768	$33,041	$5,414
333995	Fluid power cylinder and actuator manufacturing	$74,814	$30,959	$3,803
333996	Fluid power pump and motor manufacturing	$51,310	$14,647	$2,567
333997	Scale and balance (except laboratory) manufacturing	$14,210	$11,644	$1,872
333999	All other miscellaneous general purpose machinery manufacturing	$198,435	$118,446	$31,381
334518	Watch, clock, and part manufacturing	$8,379	$6,380	$1,271
335211	Electric housewares and household fans	$13,225	$3,158	$0

Table V-D-2: Annualized Costs, by Industry, for All General Industry, Maritime, and Construction Entities Affected by the Proposed Silica Standard (3% discount rate; 2009 dollars) (continued)

NAICS	Industry	All Establishments	Small Firms (SBA-defined)	Very Small Establishments (<20 Employees)
335221	Household cooking appliance manufacturing	$28,559	$6,192	$688
335222	Household refrigerator and home freezer manufacturing	$30,497	$30,497	$0
335224	Household laundry equipment manufacturing	$28,980	$28,980	$0
335228	Other major household appliance manufacturing	$22,811	$1,823	$0
336111	Automobile manufacturing	$281,138	$281,138	$2,064
336112	Light truck and utility vehicle manufacturing	$387,918	$387,918	$764
336120	Heavy duty truck manufacturing	$119,966	$119,966	$907
336211	Motor vehicle body manufacturing	$179,368	$179,368	$11,895
336212	Truck trailer manufacturing	$121,251	$51,970	$4,949
336213	Motor home manufacturing	$80,573	$80,573	$1,147
336311	Carburetor, piston, piston ring, and valve manufacturing	$39,503	$9,858	$1,277
336312	Gasoline engine and engine parts manufacturing	$247,860	$63,030	$11,233
336322	Other motor vehicle electrical and electronic equipment manufacturing	$232,489	$68,450	$8,287
336330	Motor vehicle steering and suspension components (except spring) manufacturing	$147,550	$24,431	$2,766
336340	Motor vehicle brake system manufacturing	$126,615	$31,517	$2,294
336350	Motor vehicle transmission and power train parts manufacturing	$313,751	$44,918	$6,144
336370	Motor vehicle metal stamping	$413,986	$152,787	$5,538
336399	All other motor vehicle parts manufacturing	$559,504	$162,351	$15,405
336611	Ship building and repair	$8,729,700	$8,729,700	$211,450
336612	Boat building	$5,467,149	$2,605,542	$390,894
336992	Military armored vehicle, tank, and tank component manufacturing	$26,099	$26,099	$0
337215	Showcase, partition, shelving, and locker manufacturing	$224,062	$169,724	$27,130
339114	Dental equipment and supplies manufacturing	$336,863	$250,436	$76,629
339116	Dental laboratories	$1,399,608	$1,361,661	$1,015,772
339911	Jewelry (except costume) manufacturing	$1,528,488	$1,364,756	$523,511
339913	Jewelers' materials and lapidary work manufacturing	$314,326	$252,239	$84,870
339914	Costume jewelry and novelty manufacturing	$231,425	$236,873	$98,499
339950	Sign manufacturing	$280,583	$252,203	$85,465
423840	Industrial supplies, wholesalers	$172,217	$139,755	$49,252
482110	Rail transportation	$2,422,222	N/A	N/A
621210	Dental offices	$379,189	$445,062	$385,923

Table V-D-2: Annualized Costs, by Industry, for All General Industry, Maritime, and Construction Entities Affected by the Proposed Silica Standard (3% discount rate; 2009 dollars) (continued)

NAICS	Industry	All Establishments	Small Firms (SBA-defined)	Very Small Establishments (<20 Employees)
Total – General Industry and Maritime		**$142,502,681**	**$84,363,118**	**$15,423,052**
236100	Residential Building Construction	$22,765,847	$24,902,719	$18,442,077
236200	Nonresidential Building Construction	$38,521,866	$30,318,568	$13,232,635
237100	Utility System Construction	$44,446,699	$34,960,192	$9,699,193
237200	Land Subdivision	$1,029,351	$615,429	$615,429
237300	Highway, Street, and Bridge Construction	$28,811,046	$15,727,142	$5,124,322
237900	Other Heavy and Civil Engineering Construction	$6,652,584	$6,019,608	$1,818,622
238100	Foundation, Structure, and Building Exterior Contractors	$211,905,643	$194,092,044	$103,445,878
238200	Building Equipment Contractors	$4,627,413	$4,186,291	$2,248,482
238300	Building Finishing Contractors	$49,756,684	$42,793,132	$25,359,297
238900	Other Specialty Trade Contractors	$64,516,874	$61,124,025	$35,198,471
999000	State and local governments [d]	$21,792,693	$3,229,625	$0
Total -- Construction		**$494,826,699**	**$417,968,775**	**$215,184,405**

Source: U.S. Dept. of Labor, OSHA, Directorate of Evaluation and Analysis, Office of Regulatory Analysis, based on ERG (2011).

Table V-D-3: Annualized Compliance Costs for Employers in General Industry, Maritime, and Construction Affected by OSHA's Proposed Silica Standard (0% discount rate; 2009 dollars)

Industry	Engineering Controls (includes Abrasive Blasting)	Respirators	Exposure Assessment	Medical Surveillance	Training	Regulated Areas or Access Control	Total
General Industry	$82,310,208	$6,893,761	$28,721,542	$2,269,161	$2,674,227	$2,565,657	**$125,434,555**
Maritime	$12,797,027	N/A	$659,530	$609,104	$39,642	$69,941	**$14,175,243**
Construction	$225,360,925	$83,443,096	$41,810,581	$71,468,453	$45,046,471	$16,502,901	**$483,632,427**
Total	**$320,468,159**	**$90,336,857**	**$71,191,652**	**$74,346,717**	**$47,760,340**	**$19,138,499**	**$623,242,225**

Source: U.S. Dept. of Labor, OSHA, Directorate of Evaluation and Analysis, Office of Regulatory Analysis, based on ERG (2011).

Table V-D-4: Annualized Costs, by Industry, for All General Industry, Maritime, and Construction Entities Affected by the Proposed Silica Standard (0% discount rate; 2009 dollars)

NAICS	Industry	All Establishments	Small Firms (SBA-defined)	Very Small Establishments (<20 Employees)
324121	Asphalt paving mixture and block manufacturing	$221,701	$128,709	$25,519
324122	Asphalt shingle and roofing materials	$3,007,795	$831,305	$81,506
325510	Paint and coating manufacturing	$139,404	$69,384	$18,322
327111	Vitreous china plumbing fixtures & bathroom accessories manufacturing	$1,536,242	$214,664	$24,791
327112	Vitreous china, fine earthenware, & other pottery product manufacturing	$2,408,693	$1,721,739	$696,880
327113	Porcelain electrical supply mfg	$1,618,742	$932,585	$74,378
327121	Brick and structural clay mfg	$7,179,158	$2,809,577	$70,483
327122	Ceramic wall and floor tile mfg	$3,785,802	$2,008,621	$351,856
327123	Other structural clay product mfg	$858,409	$468,660	$61,734
327124	Clay refractory manufacturing	$450,424	$199,370	$28,053
327125	Nonclay refractory manufacturing	$567,671	$197,477	$31,998
327211	Flat glass manufacturing	$257,017	$257,017	$4,168
327212	Other pressed and blown glass and glassware manufacturing	$1,012,515	$226,951	$82,266
327213	Glass container manufacturing	$706,512	$53,951	$4,491
327320	Ready-mixed concrete manufacturing	$16,003,229	$10,176,459	$1,842,324
327331	Concrete block and brick mfg	$4,363,652	$2,814,626	$535,710
327332	Concrete pipe mfg	$2,701,493	$1,417,450	$114,687
327390	Other concrete product mfg	$12,684,312	$8,677,653	$1,853,441
327991	Cut stone and stone product manufacturing	$8,240,763	$7,699,981	$2,644,112
327992	Ground or treated mineral and earth manufacturing	$4,341,486	$1,994,971	$369,476
327993	Mineral wool manufacturing	$1,021,868	$271,811	$45,473
327999	All other misc. nonmetallic mineral product mfg	$1,933,120	$1,111,169	$306,557
331111	Iron and steel mills	$394,786	$394,786	$8,736
331112	Electrometallurgical ferroalloy product manufacturing	$7,976	$4,637	$0
331210	Iron and steel pipe and tube manufacturing from purchased steel	$78,610	$78,610	$1,595
331221	Rolled steel shape manufacturing	$39,680	$39,680	$1,508

Table V-D-4: Annualized Costs, by Industry, for All General Industry, Maritime, and Construction Entities Affected by the Proposed Silica Standard (0% discount rate; 2009 dollars) (continued)

NAICS	Industry	All Establishments	Small Firms (SBA-defined)	Very Small Establishments (<20 Employees)
331222	Steel wire drawing	$53,522	$53,522	$2,749
331314	Secondary smelting and alloying of aluminum	$26,739	$14,205	$1,172
331423	Secondary smelting, refining, and alloying of copper	$4,594	$3,911	$0
331492	Secondary smelting, refining, and alloying of nonferrous metal (except cu & al)	$34,360	$17,072	$2,709
331511	Iron foundries	$14,236,481	$4,954,137	$309,112
331512	Steel investment foundries	$3,982,618	$1,590,153	$44,790
331513	Steel foundries (except investment)	$4,274,894	$2,351,925	$152,123
331524	Aluminum foundries (except die-casting)	$6,486,741	$4,024,524	$470,349
331525	Copper foundries (except die-casting)	$1,523,341	$1,488,438	$346,067
331528	Other nonferrous foundries (except die-casting)	$1,146,217	$578,431	$151,516
332111	Iron and steel forging	$98,609	$44,182	$3,824
332112	Nonferrous forging	$32,557	$12,175	$733
332115	Crown and closure manufacturing	$11,831	$4,737	$928
332116	Metal stamping	$237,995	$197,806	$25,394
332117	Powder metallurgy part manufacturing	$30,531	$16,354	$1,938
332211	Cutlery and flatware (except precious) manufacturing	$21,378	$9,716	$2,073
332212	Hand and edge tool manufacturing	$135,131	$81,692	$18,269
332213	Saw blade and handsaw manufacturing	$26,838	$8,599	$2,147
332214	Kitchen utensil, pot, and pan manufacturing	$14,591	$9,768	$0
332323	Ornamental and architectural metal work	$32,319	$26,252	$8,766
332439	Other metal container manufacturing	$56,147	$40,900	$4,936
332510	Hardware manufacturing	$167,792	$73,242	$11,094
332611	Spring (heavy gauge) manufacturing	$15,037	$13,122	$1,802
332612	Spring (light gauge) manufacturing	$56,764	$34,342	$4,638
332618	Other fabricated wire product manufacturing	$134,778	$105,942	$18,653
332710	Machine shops	$1,003,849	$962,857	$389,136
332812	Metal coating and allied services	$2,783,421	$2,287,212	$564,897
332911	Industrial valve manufacturing	$139,729	$49,911	$5,504
332912	Fluid power valve and hose fitting manufacturing	$130,431	$38,899	$4,200
332913	Plumbing fixture fitting and trim manufacturing	$42,300	$17,753	$1,407
332919	Other metal valve and pipe fitting manufacturing	$66,377	$28,553	$2,534
332991	Ball and roller bearing manufacturing	$99,850	$12,674	$1,059
332996	Fabricated pipe and pipe fitting manufacturing	$99,739	$69,600	$11,645

Table V-D-4: Annualized Costs, by Industry, for All General Industry, Maritime, and Construction Entities Affected by the Proposed Silica Standard (0% discount rate; 2009 dollars) (continued)

NAICS	Industry	All Establishments	Small Firms (SBA-defined)	Very Small Establishments (<20 Employees)
332997	Industrial pattern manufacturing	$19,433	$19,367	$8,339
332998	Enameled iron and metal sanitary ware manufacturing	$55,945	$12,703	$3,047
332999	All other miscellaneous fabricated metal product manufacturing	$268,154	$215,259	$52,351
333319	Other commercial and service industry machinery manufacturing	$194,675	$115,466	$18,493
333411	Air purification equipment manufacturing	$54,183	$25,199	$4,438
333412	Industrial and commercial fan and blower manufacturing	$38,325	$25,319	$1,567
333414	Heating equipment (except warm air furnaces) manufacturing	$75,096	$42,252	$5,693
333511	Industrial mold manufacturing	$149,085	$133,558	$40,902
333512	Machine tool (metal cutting types) manufacturing	$63,412	$41,820	$8,188
333513	Machine tool (metal forming types) manufacturing	$31,580	$28,317	$4,364
333514	Special die and tool, die set, jig, and fixture manufacturing	$216,047	$190,003	$61,596
333515	Cutting tool and machine tool accessory manufacturing	$130,264	$97,279	$29,370
333516	Rolling mill machinery and equipment manufacturing	$11,432	$8,957	$1,272
333518	Other metalworking machinery manufacturing	$46,552	$35,772	$6,327
333612	Speed changer, industrial high-speed drive, and gear manufacturing	$45,056	$23,395	$3,103
333613	Mechanical power transmission equipment manufacturing	$56,908	$24,416	$2,912
333911	Pump and pumping equipment manufacturing	$112,617	$38,571	$6,742
333912	Air and gas compressor manufacturing	$78,622	$22,333	$3,953
333991	Power-driven handtool manufacturing	$32,055	$9,201	$2,069
333992	Welding and soldering equipment manufacturing	$58,039	$21,583	$3,586
333993	Packaging machinery manufacturing	$77,884	$51,172	$9,111
333994	Industrial process furnace and oven manufacturing	$39,566	$32,097	$5,266
333995	Fluid power cylinder and actuator manufacturing	$72,593	$30,075	$3,699
333996	Fluid power pump and motor manufacturing	$49,787	$14,229	$2,497
333997	Scale and balance (except laboratory) manufacturing	$13,791	$11,311	$1,821
333999	All other miscellaneous general purpose machinery manufacturing	$192,565	$115,063	$30,521
334518	Watch, clock, and part manufacturing	$8,133	$6,198	$1,237
335211	Electric housewares and household fans	$12,744	$3,043	$0
335221	Household cooking appliance manufacturing	$27,519	$5,966	$665

Table V-D-4: Annualized Costs, by Industry, for All General Industry, Maritime, and Construction Entities Affected by the Proposed Silica Standard (0% discount rate; 2009 dollars) (continued)

NAICS	Industry	All Establishments	Small Firms (SBA-defined)	Very Small Establishments (<20 Employees)
335222	Household refrigerator and home freezer manufacturing	$29,387	$29,387	$0
335224	Household laundry equipment manufacturing	$27,925	$27,925	$0
335228	Other major household appliance manufacturing	$21,980	$1,759	$0
336111	Automobile manufacturing	$272,768	$272,768	$2,008
336112	Light truck and utility vehicle manufacturing	$376,369	$376,369	$744
336120	Heavy duty truck manufacturing	$116,395	$116,395	$882
336211	Motor vehicle body manufacturing	$174,051	$174,051	$11,569
336212	Truck trailer manufacturing	$117,647	$50,486	$4,814
336213	Motor home manufacturing	$78,175	$78,175	$1,116
336311	Carburetor, piston, piston ring, and valve manufacturing	$38,328	$9,577	$1,242
336312	Gasoline engine and engine parts manufacturing	$240,487	$61,155	$10,925
336322	Other motor vehicle electrical and electronic equipment manufacturing	$225,573	$66,414	$8,059
336330	Motor vehicle steering and suspension components (except spring) manufacturing	$143,159	$23,704	$2,690
336340	Motor vehicle brake system manufacturing	$122,848	$30,579	$2,231
336350	Motor vehicle transmission and power train parts manufacturing	$304,417	$43,582	$5,976
336370	Motor vehicle metal stamping	$401,658	$148,424	$5,386
336399	All other motor vehicle parts manufacturing	$542,860	$157,521	$14,982
336611	Ship building and repair	$8,716,414	$8,716,414	$211,067
336612	Boat building	$5,458,828	$2,601,166	$390,186
336992	Military armored vehicle, tank, and tank component manufacturing	$25,327	$25,327	$0
337215	Showcase, partition, shelving, and locker manufacturing	$217,446	$164,877	$26,387
339114	Dental equipment and supplies manufacturing	$326,527	$242,932	$74,405
339116	Dental laboratories	$1,372,634	$1,337,279	$999,105
339911	Jewelry (except costume) manufacturing	$1,506,718	$1,346,104	$516,785
339913	Jewelers' materials and lapidary work manufacturing	$309,849	$248,792	$83,779
339914	Costume jewelry and novelty manufacturing	$227,737	$233,260	$97,093
339950	Sign manufacturing	$270,763	$243,567	$82,642
423840	Industrial supplies, wholesalers	$168,737	$137,113	$48,321
482110	Rail transportation	$2,401,869	N/A	N/A
621210	Dental offices	$372,297	$437,759	$379,590
Total – General Industry and Maritime		**$139,609,798**	**$82,827,234**	**$15,151,345**

Table V-D-4: Annualized Costs, by Industry, for All General Industry, Maritime, and Construction Entities Affected by the Proposed Silica Standard (0% discount rate; 2009 dollars) (continued)

NAICS	Industry	All Establishments	Small Firms (SBA-defined)	Very Small Establishments (<20 Employees)
236100	Residential Building Construction	$22,403,463	$24,590,721	$18,207,159
236200	Nonresidential Building Construction	$37,738,001	$29,809,995	$13,008,234
237100	Utility System Construction	$42,887,782	$33,937,369	$9,419,726
237200	Land Subdivision	$973,501	$588,621	$588,621
237300	Highway, Street, and Bridge Construction	$27,441,259	$15,120,845	$4,932,117
237900	Other Heavy and Civil Engineering Construction	$6,301,839	$5,755,929	$1,741,321
238100	Foundation, Structure, and Building Exterior Contractors	$209,175,716	$191,939,862	$102,252,677
238200	Building Equipment Contractors	$4,439,081	$4,054,757	$2,178,654
238300	Building Finishing Contractors	$49,412,982	$42,495,544	$25,174,853
238900	Other Specialty Trade Contractors	$62,124,921	$59,207,894	$34,110,215
999000	State and local governments [d]	$20,733,881	$3,092,867	$0
Total -- Construction		**$483,632,427**	**$410,594,402**	**$211,613,577**

Source: U.S. Dept. of Labor, OSHA, Directorate of Evaluation and Analysis, Office of Regulatory Analysis, based on ERG (2011).