Before the
Occupational Safety and Health Administration
U.S. Department of Labor

Occupational Exposure to Crystalline Silica; Notice of Proposed Rulemaking, 78 Fed. Reg. 56274 (September 12, 2013); 78 Fed. Reg. 65242 (October 31, 2013); 79 Fed. Reg. 4641 (January 29, 2014)	))))))	Docket No. OSHA-2010-0034

Post-Hearing Brief of Stuart L. Sessions

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Introduction

In this Post-Hearing Brief, I will address three issues relating to OSHA's Proposed Standard for Occupational Exposure to Crystalline Silica: (1) OSHA's Regulatory Flexibility Screening Analysis for General Industry; (2) OSHA's projection of employment impacts of the Proposed Standard; and (3) an appropriate approach to using data sources to identify general industry profitability. In each of these areas, I believe OSHA's analysis is characterized by serious flaws and limitations.

I. Review of Methodological Issues in OSHA's Regulatory Flexibility Screening Analysis for General Industry

For each general industry affected by the Proposed Standard, OSHA conducts parallel screening analyses to assess the economic impact of the proposed rule on all entities in the industry, on small entities in the industry, and on very small entities in the industry. The analyses for small entities and for very small entities are referred to collectively as the Agency's Regulatory Flexibility Screening Analysis. In this paper, I discuss several methodological shortcomings in OSHA's analysis which, in my view, make the analysis entirely inadequate for investigating whether small entities will bear disproportionate impacts relative to large entities.

In estimating each of the three quantities that OSHA compares in the Agency's regulatory flexibility screening analysis -- i) an industry's compliance costs; ii) the industry's revenues; and iii) the industry's profits -- OSHA fails to recognize important distinctions between small and large entities. Failing to recognize these distinctions, OSHA analyzes small entities in essence simply as scaled-down versions of large entities. This approach misses important factors that will make compliance much more economically infeasible for affected small businesses than for affected large businesses.

In this paper, I do not repeat the concerns expressed in previous communications with OSHA about problems in the Agency's Preliminary Economic Analysis ("PEA") that apply equally to small and large businesses. As stated in earlier submissions and testimony, I believe that for each of the general industry sectors affected by the Proposed Standard, OSHA has greatly underestimated costs, overestimated profits, and developed no credible means for estimating revenues. These objections involve the analytical methods that OSHA applied identically for both small and large businesses. The issues discussed in this paper, by contrast, represent instances where OSHA has failed to apply analytical methodologies that recognize fundamental and important differences between small and large businesses.

OSHA Fails to Recognize Important Differences Between Small and Large Businesses When Estimating Compliance Costs

OSHA's approach to estimating compliance costs for a to-be-regulated business essentially makes the compliance cost a direct linear function of the business' number of employees, as follows:

Compliance Cost	=	(# of employees)	(A)
		x (fraction of employees at-risk of silica exposure)	(B)
		x (fraction of at-risk employees who are overexposed)	(C)
		x (cost to protect an overexposed employee)	(D)

OSHA does not distinguish between small and large businesses in either quantities (B) or (C). OSHA assumes that small and large businesses have an identical fraction of their employees at risk of silica exposure and an identical fraction of exposed employees who are overexposed. Both of these assumptions are debatable, particularly the second. I might guess that compliance rates are lower and exposure levels are somewhat higher at small businesses in contrast to large businesses, probably because of lesser ability to afford compliance expenditures and lesser ability to devote management attention to compliance responsibilities.

The result of assuming that (B) and (C) are identical for small and large businesses in an industry is that a business' estimated compliance cost is a direct multiple of the business' number of employees. According to OSHA's cost estimating procedures, a large business with 1,000 employees will have approximately 50 times the compliance cost as a small business in that same industry with 20 employees. OSHA simulates virtually nothing in the way of economies of scale in compliance measures or, to put it the other way around, virtually nothing in the way of diseconomies of small scale.

The following table demonstrates that OSHA fails to distinguish small businesses from large businesses to any meaningful degree when estimating costs to comply with the Proposed Standard. I developed this table from OSHA's cost estimates shown in the workbook titled "Silica_PEA_Excel_Workbook_-_#7 …" that is included in the Docket.

Differences in OSHA's Estimated Costs Per Affected Employee for Small vs. Large Businesses

NAICS	Industry	Up to 500 Employees (Small Businesses)							500 or More Employees (Large Businesses)						
		Control Costs	Respirator Costs	Exposure Monitoring	Medical Surveillance	Training	Regulated Areas	Total	Control Costs	Respirator Costs	Exposure Monitoring	Medical Surveillance	Training	Regulated Areas	Total
324121	Asphalt paving mixture and block manufacturing	$35.52	$0.55	$1.69	$0.19	$10.41	$0.21	$48.57	$35.52	$0.55	$1.52	$0.19	$9.14	$0.21	$47.12
324122	Asphalt shingle and roofing materials	$499.19	$25.89	$171.56	$9.09	$10.41	$9.67	$725.82	$499.19	$25.96	$153.99	$8.75	$9.14	$9.67	$706.70
327111	Vitreous china plumbing fixture & bathroom accessor	$402.85	$27.30	$132.87	$9.59	$10.44	$10.19	$593.24	$402.85	$27.36	$118.31	$9.22	$9.14	$10.19	$577.07
327122	Ceramic wall & floor tile mfg	$1,357.56	$30.05	$113.74	$10.53	$10.24	$11.23	$1,533.35	(OSHA's workbook appears to show no costs for large businesses. Error?)						
327124	Clay refractory mfg	$185.02	$12.82	$76.13	$4.50	$10.44	$4.79	$293.70	$185.02	$12.85	$67.79	$4.33	$9.14	$4.79	$283.91
327320	Ready-mix concrete mfg	$160.06	$42.39	$133.47	$14.89	$10.44	$15.83	$377.08	$160.06	$42.49	$118.86	$14.32	$9.14	$15.83	$360.69
327390	Other concrete product mfg	$285.40	$27.06	$116.58	$9.50	$13.82	$10.10	$462.46	$285.40	$27.12	$103.81	$9.14	$12.09	$10.10	$447.66
327991	Cut stone & stone product mfg	$487.77	$35.72	$153.20	$12.56	$10.53	$13.33	$713.11	$487.77	$35.79	$133.68	$12.06	$9.14	$13.33	$691.76
331511	Iron foundries	$514.32	$29.15	$119.16	$10.19	$10.09	$10.91	$693.83	$514.32	$29.28	$116.13	$9.86	$9.14	$10.91	$689.64
331524	Aluminum foundries (except die-casting)	$535.18	$30.25	$127.74	$10.60	$10.22	$11.31	$725.30	$535.18	$30.36	$120.45	$10.23	$9.14	$11.31	$716.68

The table shows OSHA's estimated costs for several of the affected industries to comply with the requirements of the Proposed Standard. Costs are shown per affected employee in each industry, and OSHA's estimated costs per employee for small businesses are contrasted against OSHA's estimated costs per employee for large businesses. All the other affected industries show the same patterns in small business costs compared against large business costs as do the industries included in the table:

- OSHA's estimated total costs per affected employee are less than 5% higher for small businesses than for large businesses for every industry.
- OSHA estimates that engineering control costs per affected employee – which account for the largest fraction of total costs by far -- are identical for small and large businesses.
- Among the program requirements, exposure monitoring and training are the only two for which OSHA estimates appreciably higher (about 10 - 15% higher) costs per affected employee for small businesses than for large.

In short, OSHA's cost estimates do not reflect in any meaningful way any of the factors that usually make regulatory compliance costs significantly higher as a function of scale (e.g., per employee, per unit of output, per unit of revenue) for small businesses than for large businesses. Among these factors are:

- Economies of scale for control equipment. The cost of a piece of control equipment usually increases less than proportionally with its size. EPA, for example, typically applies a scale exponent somewhere between 0.4 and 0.9 in estimating the capital costs of pollution control equipment as a function of its size, including ventilation, ductwork and emission controls (e.g., baghouse) such as are commonly needed in general industry to reduce worker exposure to crystalline silica. Another example of economies of scale in control measures is the cost per square foot of professional cleaning, which likely declines with increasing size of the facility cleaned. Although OSHA failed to include any costs for professional cleaning in its cost model, it now appears ready to correct that oversight.[1] However, it apparently plans to assume a constant cost per square foot for professional cleaning rather than recognizing that the cost per square foot declines as the facility size increases.

- Fixed or semi-fixed costs. Many activities that businesses will need to undertake to comply with the Proposed Standard cost the same amount, or only modestly more, at a large facility as at a small facility; for example, developing an exposure monitoring plan, developing a training program, or developing a respirator program.

- Indivisibility of some key inputs that are needed for reducing worker exposures to crystalline silica. Many of the control measures that OSHA identifies in Appendix A of Chapter V of the PEA involve use of a HEPA vacuum for more intensive housekeeping. OSHA assumes generally that one HEPA vacuum will be needed for every five overexposed workers in a particular job category or particular area of a plant. This assumption seems plausible for a large facility with many overexposed workers; HEPA vacuums might be purchased at the assumed 1:5 ratio for such a facility. However, a small facility with only one overexposed worker in a job category or an area of the plant cannot purchase only one-fifth of a HEPA vacuum; such a small facility will need to purchase an entire HEPA vacuum, at a cost per worker five times higher than the cost per worker for a large facility. Some other examples of inputs needed for compliance that must usually be acquired in whole rather than fractional units include: a training video, a day of an industrial hygienist's time to conduct exposure assessment,[2] and a "competent person" to oversee a facility's silica compliance efforts.

[1] See Eastern Research Group, 2014. Personal Telephone Interview with Representative of Professional Industrial Cleaning Service. May 15, 2014 (Docket Item No. OSHA-2010-0034-3487).

[2] In estimating the costs for exposure monitoring, OSHA assumes that an industrial hygienist will have differing productivity at small, medium and large facilities. OSHA assumes that an IH will be able to take two samples per day at a small facility, six at a medium facility, and eight at a large facility. OSHA then divides the assumed IH rate of $500 per day by 2, 6, or 8 in order to estimate the IH fee per worker needing exposure assessment at small, medium and large facilities. Although OSHA does thus recognize lesser efficiency in exposure sampling for smaller facilities, the Agency nevertheless still wrongly assumes, in effect, that an employer can purchase a fraction of an

These factors, which OSHA does not recognize, make unit compliance costs (e.g., compliance costs per worker, per unit of facility output, per dollar of facility revenue) higher for small businesses than for large businesses.

URS Corporation argues in the documentation of their cost model[3], and I have argued in several previous submittals to OSHA over several years, that a major conceptual error in the Agency's approach for cost estimation is to estimate costs on a "per overexposed employee" basis. I believe, to the contrary, that compliance cost is not a constant amount per overexposed employee. Instead, cost can best be estimated on a facility-by-facility basis. After having done so, one would find that cost is far from constant per overexposed employee. To the contrary, cost per overexposed employee declines with the number of overexposed employees at a facility. In a small facility, there will be substantial fixed costs of compliance that can be spread over relatively few employees. In a large facility, these same fixed costs of compliance can be spread over many more employees. Among very small facilities, there will often be only one employee who can be protected by an investment to control a silica source (e.g., covering a conveyor in the materials yard of a brick plant, or a conveyor from the sand hopper in a foundry), while in a large facility there are likely to be many employees who can be protected by a similar investment.

In choosing to estimate compliance costs for the Proposed Standard on a "per overexposed employee" basis and assuming that compliance costs in nearly all instances are constant "per overexposed employee" within an industry, OSHA fails to reflect important differences between small and large facilities and small and large businesses. There are many reasons why costs are *not* constant "per overexposed employee" across facilities or businesses, and these reasons very often have to do with the size of the regulated facility or business. If OSHA instead estimated costs on a facility-by-facility basis -- perhaps by estimating costs for representative very small, small and large "model plants" in each industry and then scaling up from the models to the industry -- the Agency would tend to reflect in the analysis the important factors that differentiate the costs to comply at a small facility or business from the costs to comply at a large one.[4] And, though I won't make the effort here to go into the reasons for this, I believe that a

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IH's day. In an industry where the average very small facility has only one overexposed worker needing periodic monitoring, OSHA wrongly estimates costs for these very small facilities as if each can purchase a half day of an IH's time in order to conduct full-shift monitoring that takes an entire day.

[3] See Critique of OSHA's Cost Models for the Proposed Crystalline Silica Standard and Explanation of the Modifications to Those Cost Models Made by URS Corporation, February 7, 2014. ("URS Feasibility Report").

[4] URS uses a size-based model plant procedure for estimating compliance costs for the general industries. For each industry, URS defines a model very small facility (<20 employees), a model small facility (20 to 500 employees) and a model large facility (500 or more employees) and estimates the compliance costs for each of these models. The cost for an entire industry is then estimated by multiplying the cost for a model plant by the number of actual plants that the model represents and then summing across models. The models are defined as simple averages of the data that OSHA provides. For very small iron foundries, for example, OSHA estimates that there are 201 facilities at which 427 at-risk production workers work. Among these at-risk workers, as a further example, 85 are estimated to be "coremakers", and 53% of all coremakers (45 of the 85) are estimated to be exposed at greater than 50 ug/m^3. URS therefore defines their very small model iron foundry to have 2.1 at-risk production workers (427/201), among

size-based model facility approach to the analysis would also yield more accurate estimates of aggregate compliance costs for an industry as well as more accurately differentiating costs between small and large businesses.

OSHA misses the lesser efficiency -- when viewed on a per-worker basis -- of exposure-reducing control measures implemented at a small business relative to the greater efficiency of these controls when implemented at a large business

Perhaps the most inappropriate of OSHA's assumptions in the Agency's "per overexposed employee"-based cost analysis is the assumption that for most industries and job categories, one application of the package of controls that OSHA believes will protect overexposed workers in a particular job category will serve to protect 4 overexposed workers on average. OSHA then estimates control costs for an industry (for both small facilities and large) by multiplying the cost for the package of controls by the number of overexposed workers in the industry divided by 4. This approach fails to recognize the fact that at small facilities there are virtually never as many as four overexposed workers in any job category, and it is simply impossible that one application of a package of controls in this situation could protect as many as 4 overexposed workers on average. A package of controls implemented at a small facility owned by a small business will typically protect many fewer workers than the same package of controls implemented at a large facility owned by a large business. Four overexposed workers protected per package of controls might be a reasonable assumption for large businesses, but it certainly is not a reasonable assumption for small and very small businesses. I have done some analysis to demonstrate this.

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whom 0.42 are coremakers (85/201) and 0.22 coremakers (45/201) are presumed to be exposed at greater than 50 ug/m^3. URS then estimates engineering control costs sufficient to protect 45 overexposed coremakers who are spread across 201 very small facilities in a manner consistent with the binomial distribution.

URS' size-based model plant approach requires no more data than OSHA has already provided. I see no reason why OSHA could not estimate costs similarly, for both engineering controls and the ancillary requirements, using a size-based model plant approach. I disagree with OSHA's conclusions with respect to this issue that are discussed on page V-15 of the PEA. I agree, as OSHA says, that the Agency has no way to "match up" most of the industry data that OSHA has collected to individual firms. I also agree that the absence of "facility-specific data on worker exposure to silica or even facility-specific data on the level of activity involving worker exposure to silica" would make it very difficult for the Agency to characterize particular individual firms or particular individual facilities as would be necessary in order to estimate costs for specific individual firms or facilities. However, none of these issues that the Agency cites would prevent OSHA from characterizing a relatively small set of ***model*** firms or facilities instead of, as OSHA sets up in the Agency's straw man discussion, characterizing ***specific individual*** firms or facilities. URS, I believe, has shown that characterizing a set of model firms or facilities can be done in a reasonable way, using only the data that OSHA has developed.

And finally, note that the U.S. Environmental Protection Agency (USEPA) makes a common practice of estimating an affected industry's compliance cost via this size-based model facility approach, for effluent guidelines, MACT/NESHAP standards and many other industry-specific regulations. Thus, a size-based model facility approach would be feasible for this Proposed Standard, and this approach would yield both more accurate estimates of aggregate compliance costs for each General Industry sector as well as more accurately differentiating costs between small and large businesses.

For the following table, I have analyzed all the worker job categories (e.g., coremaker, material handler, pouring operator, maintenance operator, forming line operator) in all the industries for which URS has estimated costs.[5] The table addresses the question of whether for small and very small facilities[6] there are as many as four overexposed workers who can all be protected simultaneously when a package of silica control measures is implemented to protect workers in a particular job category at a particular facility. All of the data analyzed for the table are estimates that have been developed by OSHA; the table assembles and displays data that OSHA has developed, but in a manner that differs from OSHA's presentations in the Preliminary Economic Analysis.

Distribution of Establishment-Job Category Combinations by the Number of Workers Exposed at >50 ug/m3

Avg. # of such workers in the job category & facility:	< 0.5	0.5 to 1.0	1 to 2	2 to 3	3 to 4	4 to 6	6 to 8	> 8	All
Combinations among Very Small Establishments	32,160	5,094	1,454	78	0	0	0	0	38,786
Combinations among Small* Establishments	9,020	5,569	2,699	2,220	2,643	879	2,533	366	25,929
Total # of establishment-job category combinations	41,180	10,663	4,153	2,298	2,643	879	2,533	366	64,715
Percentage	63.6%	16.5%	6.4%	3.6%	4.1%	1.4%	3.9%	0.6%	100.0%

* "Small" establishments are those with 20 - 500 employees

The table addresses all the "establishment-job category combinations" in the industries addressed by URS. An "establishment-job category combination" represents a single affected job category at a single affected facility. A couple of examples will make clear what I mean with this terminology and how to interpret the table:

- Example #1. OSHA estimates that there are 78 very small facilities in the Ground or Treated Mineral and Earth Manufacturing industry. OSHA has determined that there is only one worker job category in this industry that is at-risk of silica exposure, "Production Operator". Across the 78 very small facilities in this industry, OSHA estimates that 177 Production Operators are exposed above 50 ug/m^3, thus resulting in an average of 2.27 overexposed workers in this job category per facility (177/78 = 2.27). At very small Mineral Earth Manufacturing industry facilities, then, the package of controls that OSHA postulates a facility will need to adopt in order to protect any overexposed

[5] URS has estimated costs for the great majority of industries that OSHA has identified as affected by the Proposed Standard, but has not estimated costs for several industries for which they believe OSHA has very inaccurately estimated the number of facilities existing in the industry. See URS Feasibility Report.

[6] Here I diverge from what OSHA means by "small" establishments. In the following table, very small establishments are as OSHA defines them: establishments owned by entities with fewer than 20 employees. But I define small establishments differently from OSHA -- I define small businesses as those businesses with 20 to 500 employees, excluding those with less than 20, and I define small establishments as those owned by small businesses. I have thus defined very small and small as mutually exclusive, and I believe the table is clearer using these definitions, in contrast to OSHA's approach where very small is defined to be a subset of small.

Production Operators[7] will thus protect an average of only 2.27 workers instead of the 4 workers that OSHA assumes. OSHA estimates the costs to protect all the overexposed Production Operators in very small facilities in this industry as equal to the cost to install 44.25 of these packages of controls, as follows:

(177 overexposed workers) ÷ (4 overexposed workers protected per package of controls) = 177/4 = 44.25 packages of controls needed across all the very small facilities in this industry in order to protect all the overexposed Production Operators.

In fact, though, among the 78 very small facilities in the Mineral Earth Manufacturing industry, installation of one package of controls at a single facility to protect the overexposed Production Operators at that facility will, on average, result in protecting only 2.27 overexposed workers. Based on averaging the number of overexposed Production Operators across the facilities in this segment of the industry, every one of these facilities -- all 78 of them -- can be expected to need installation of the package of controls.[8] Based on this averaging approach, to protect overexposed Production

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[7] The package of controls that OSHA assumes as appropriate to protect an overexposed Production Operator in this industry includes: i) "Enclosed ventilation equipment;" ii) "Conveyor ventilation;" and iii) "Improved area cleanup with HEPA," all of which OSHA assumes must be implemented in order to protect an average of 4 overexposed Production Operators.

[8] This conclusion that every facility will need to implement the package of controls to protect one or more overexposed Production Operators at the facility is based on averaging the total number of overexposed Production Operators across the total number of very small facilities. In practice, though, individual facilities will differ from the segment-wide average across facilities. Some among the 78 very small facilities may have no overexposed Production Operators; if so, they will not need to implement the package of controls and the number of facilities that will ultimately need to implement this package of controls will fall short of the maximum of 78. A few others among the 78 facilities may perhaps have more than 4 overexposed Production Operators, in which case they will be able to protect even more than OSHA's assumed figure of 4 overexposed workers per package of controls.

It is because of this likely variation from the average across the actual facilities within a segment of the industry that URS has estimated engineering control costs, in part, by using the binomial expansion. Among the 78 very small Mineral Earth Manufacturing facilities, OSHA estimates there to be 392 Production Operators, among whom 177 are estimated to be exposed above 50 ug/m^3. The probability that any individual Production Operator is overexposed might thus be assumed to be 177/392 = 0.45. URS then uses a binomial expansion to estimate how many of the 78 facilities might have zero overexposed Production Operators, how many might have one overexposed Production Operator, etc.. Each of the 78 facilities is regarded as having an average of 5 Production Operators (rounded from 392/78 = 5.02), and whether or not each of the five production operators is overexposed is regarded as 5 independent Bernoulli trials, each with probability of "success" (i.e., overexposure) equal to 0.45. The binomial distribution then gives the resulting probabilities that any individual facility has zero, one, two, three, four, or five overexposed Production Operators. URS then applies these resulting probabilities to estimate the fraction of the 78 facilities that will need to install a package of controls in order to protect whatever number of overexposed Production Operators exists at each facility.

In developing the table discussed in this section of this document, I take an averaging approach rather than the more accurate binomial distribution approach that URS adopts for their cost estimate. In this document, I am attempting to show only that OSHA's assumption to the effect that a package of controls protects an average of 4 overexposed workers is grossly inappropriate for small and very small entities. OSHA's assumption is made on an average basis; in criticizing OSHA's assumption I adopt a similar averaging approach. I believe that, when it comes to re-

Operators in the very small segment of the industry, 78 packages of controls would be needed, not the 44.25 packages that OSHA estimates, and costs should be estimated accordingly.

In this example, there are 78 facilities in this segment of the industry and I have been discussing one job category ("Production Operator"), and I thus address 78 x 1 = 78 "establishment-job category combinations." The average number of overexposed workers in this job category per facility in this segment is 2.27, a figure that is between 2 and 3. In the table, then, I place these 78 "establishment-job category combinations" in the column labeled "2 to 3" and in the row labeled "Combinations among very small establishments". These 78 combinations involving very small Mineral Earth Manufacturing facilities and Production Operators in fact represent the only combinations among all the affected industries where "2 to 3" overexposed workers on average can be protected by a single installation of a package of controls. Among very small facilities, there are no other combinations (i.e., no other industries, no other job categories) where as many as "2 to 3" overexposed workers (on average) can be protected by a single package of controls. There are no combinations where 3 to 4 overexposed workers can be protected by a single package of controls, and no combinations where more than 4 overexposed workers can be protected by a single package of controls. OSHA's assumption that an average of 4 overexposed workers can be protected by a single package of controls is clearly highly inappropriate for very small facilities.

- Example #2 involves another industry and another job category. In the Iron Foundries industry, OSHA identifies 12 at-risk job categories. One of these job categories is "Furnace Operator". OSHA estimates that there are 221 small Iron Foundries, and working at these facilities are 187 Furnace Operators that OSHA estimates to be exposed above 50 ug/m^3. On average, then, installation at a small Iron Foundry of the package of controls that OSHA has identified as appropriate to protect overexposed Furnace Workers will protect an average of only 0.84 overexposed Furnace Workers (184/221 = 0.84), well short of the 4 overexposed Furnace Workers that OSHA assumes. In the table, I thus include these 221 "establishment-job category combinations" (221 small Iron Foundries x the one Furnace Worker job category) in the column labeled "0.5 to 1.0" and in the row labeled "Combinations among small establishments".

I build up the table in this manner: 1) calculating the average number of overexposed workers who can be protected by a package of controls for each at-risk job category for each industry and

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estimating engineering control costs more accurately rather than simply discussing the advisability of the assumptions that go into OSHA's cost estimating procedure, one should consider the variability across facilities in the number of overexposed workers in each segment of the industry (i.e., in the very small segment of this industry, some facilities actually do have zero overexposed workers, some actually have one, etc.), and that URS' binomial distribution approach is a reasonable way to reflect this variability.

for each of the very small and small business segments of the industry; then 2) multiplying by the number of facilities in that industry in the very small or small segment; and then 3) inputting this number of "establishment-job category combinations" in the appropriate column and row of the table. For convenience, I show the table again, here.

Distribution of Establishment-Job Category Combinations by the Number of Workers Exposed at >50 ug/m3

Avg. # of such workers in the job category & facility:	< 0.5	0.5 to 1.0	1 to 2	2 to 3	3 to 4	4 to 6	6 to 8	> 8	All
Combinations among Very Small Establishments	32,160	5,094	1,454	78	0	0	0	0	38,786
Combinations among Small* Establishments	9,020	5,569	2,699	2,220	2,643	879	2,533	366	25,929
Total # of establishment-job category combinations	41,180	10,663	4,153	2,298	2,643	879	2,533	366	64,715
Percentage	63.6%	16.5%	6.4%	3.6%	4.1%	1.4%	3.9%	0.6%	100.0%

* "Small" establishments are those with 20 - 500 employees

Across all the at-risk job categories and among the small and very small establishments in all the industries that URS evaluated (most of the General Industries), in only 5.9% of these circumstances will a package of controls protect more than OSHA's assumed average of 4 overexposed workers. In more than 94% of these circumstances a package of controls will protect fewer than OSHA's assumed average of 4 overexposed workers.[9] The frequency with which engineering controls will be needed among small entities will be far higher than OSHA's assumption of one package of controls for every four overexposed workers. In most instances among small and very small entities or establishments, a package of controls would protect an average of less than ½ an overexposed employee. Engineering controls will be needed for small entities far more often than OSHA estimates, and costs for small entities will thus be far higher than OSHA has estimated. OSHA's cost analysis for small entities fails to reflect this key difference between small and large entities -- in small entity facilities an overexposed worker tends to be the only overexposed worker in his job category at the facility, while in large entity facilities there tend to be several overexposed workers per job category. A package of controls is thus, in a sense, more efficient -- it can protect more overexposed workers -- when implemented at a large entity facility than when implemented at a small entity facility. OSHA misses or overlooks this important distinction because the Agency has chosen to build the cost analysis based on the number of overexposed employees needing protection. If OSHA were instead to build the cost analysis on a facility-by-facility basis (or, more practically, on a model facility-by-model facility basis), the Agency would be much more likely to accurately reflect this key difference between small and large businesses.

[9] Curiously, the great majority of the circumstances where an average of more than 4 overexposed workers can be protected with a single package of controls are found in only a handful of job category/industry combinations. 2,337 of the 2,533 combinations in the "6 to 8" category for small establishments are the Truck Driver job category for the 2,337 small facilities in the Ready-mixed Concrete industry. 225 of the 326 combinations in the ">8" category are Jewelry Workers at the 225 small entity facilities in the Fine Jewelry industry. Might this suggest that OSHA should devote particular attention to estimating control costs in these seemingly rare circumstances where many overexposed workers are concentrated in a single job category at facilities in an industry rather than assuming some average figure for the number of overexposed workers protected per package of controls that is skewed so as to represent these rare circumstances?

OSHA omits from the Agency's cost analysis many sorts of "fixed" costs that affect small businesses proportionally more than large businesses

A second respect in which OSHA fails to reflect an important difference between small and large businesses involves "fixed" costs. When I use this terminology in a context involving small vs. large businesses, I define a "truly fixed" cost as a cost that does not vary with the size or scale of the facility or business. Extending this concept, a "semi-fixed" cost is one that does increase with the size or scale of the facility or business, but less than proportionally. OSHA's failure to include in the Agency's cost analysis many sorts of costs that are "truly fixed" or "semi-fixed" on a per facility or per business basis makes OSHA's cost estimates too low in general, but even more inappropriately low for small businesses than for large businesses. The following are some examples of such costs that OSHA has omitted from its cost analysis:

- Cost to read the rule, become familiar with it and plan a compliance strategy for the facility or business;
- Costs for someone to qualify and serve as a silica "competent person" at each facility owned by an affected business;[10]
- Cost to plan for, contract for, set up for and accompany an industrial hygienist who will perform exposure monitoring at the facility;
- Costs to compile, assess, justify and submit "objective data" for an exposure assessment procedure being employed as an alternative to initial exposure monitoring;
- Cost to set up a medical surveillance program;
- Cost to acquire or modify an air permit for a change to a facility's ventilation system.

OSHA Does Not Reflect the Differences in Profitability Between Small and Large Businesses.

OSHA assumes the same profitability for the small business portion of an industry as for the industry as a whole. Although the pattern can differ from industry to industry and from year to year, my general impression is that the large businesses in an industry usually have higher average profitability than the small businesses in the industry. OSHA should analyze the profitability data that the Agency ultimately uses, and reflect the differences between small and large business profitability that are revealed in that data set.

[10] Although the Proposed Standard does not explicitly require a competent person, a facility seeking to comply effectively with the regulatory requirements will likely need to have a qualified individual perform the functions of a competent person.

The issue of estimating profitability by small vs. large business is complicated by the fact that small vs. large is defined by the SBA based on the number of employees in the business, while all the available data of which I am aware on pre-tax profitability by size of business is organized by asset size of the business (CSB, RMA, Bizminer) or by revenue size of the business (RMA, Bizminer). Cross-walking employment size against assets or revenues is not straightforward. The process is perhaps a little more direct to cross-walk between employment and revenues. One criterion that OSHA should consider in judging which data sources to use for profitability estimates for the industry-wide economic feasibility screening analysis is the degree to which the profitability data set can also provide a good crosswalk for the small business-only regulatory flexibility screening analysis.[11] CSB is not so good in this respect as it provides size breakouts by asset size only. RMA and Bizminer would be better.

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[11] I have discussed in other materials provided to OSHA several additional criteria that the Agency should consider in choosing a source or sources for information on profitability. 1) In using CSB, OSHA should use information on profits that reflects the entire industry, not solely the corporations that are profitable in any year -- hence "net income less deficit" from all returns rather than "net income" from only those returns showing positive net income. 2) CSB has an important disadvantage insofar as it provides profitability information only for 3 or 4-digit NAICS code industries (which could be called "sectors" rather than "industries"), thus likely misrepresenting and failing to provide any granularity in estimating profitability for the affected 6-digit NAICS code industries for which OSHA estimates costs. RMA is better in providing information on profitability for some of the affected 6-digit industries; Bizminer is even better in providing information on profitability for virtually all of the affected 6-digit industries. 3) However, RMA (and Bizminer to a lesser degree) has a major disadvantage relative to CSB because RMA's data are collected from the financial statements of companies that have come to the attention of banks and other financial institutions, typically because these companies have applied for loans or sought other financing. RMA thus likely collects and publishes a biased sample of the companies in an industry; biased toward those that are more profitable and can consider external sources of financing, in contrast to more marginal companies that have little prospect of obtaining external financing and hence do not pursue it. Data from CSB, in contrast, has the very significant advantage of deriving from a true random sample of tax returns from corporations active in the industry of interest, thus including both more profitable and less profitable corporations. Though I have not yet used it, I would guess that Bizminer is likely somewhere in the middle -- it is a much larger dataset and derives from a broader variety of sources than RMA, but it is still probably short of a true random sample and unbiased representation of the industry. 4) I do not recommend that OSHA use profitability information from Dun & Bradstreet. This data source has shrunk in recent years and now provides less coverage of the affected industries than RMA, and it also provides data on post-tax profitability rather than pre-tax profitability. For the sake of consistency in how OSHA calculates the profitability benchmark for economic feasibility screening analyses, OSHA should continue to estimate pre-tax profitability rather than switch to post-tax, as would be necessary if the Dun & Bradstreet profitability information were to be used.

After considering the various alternative data sources on profitability of affected industries, I recommend that OSHA pursue a two-step approach: 1) Use CSB (net income less deficit) to determine year-by-year profitability for the 3- or 4-digit NAICS code sector; then 2) Use RMA or Bizminer for information on how profitabilities for the affected six-digit industries within the sector vary from the sector-wide aggregate profitability. For example, assume for some year that CSB shows pretax profitability for a 4-digit sector as 4%, and that RMA or Bizminer show profitability for that sector instead as 5%. Assume also that RMA or Bizminer show profitability for one of the affected six-digit industries (industry "A") in that sector as 4.5% and profitability for another of the affected six-digit industries in the sector (industry "B") as 6%. I suggest then that RMA/Bizminer could be interpreted as showing, for this particular year, that profitability for industry A is 10% less than for the sector as a whole, while profitability for industry B is 20% higher than for the sector as a whole. If I then assume the CSB figure as the best unbiased estimate of profitability for the entire sector, then using the two-step approach I would estimate profitability for industry A as 3.6% (10% below 4%) and profitability for industry B as 4.8% (20% above 4%).

I have investigated profitability by size of business for a couple of the sectors/industries affected by the General Industry standard, but only using CSB, which is accessible at no cost, in contrast to RMA and Bizminer. The following table shows estimated profitability for the years 2004 through 2011 as derived from data in CSB for Foundries (NAICS 3315) and Clay Product and Refractory Manufacturing (NAICS 3271).[12] I believe these are the only two 3- or 4-digit sectors with data available in CSB that include only 6-digit General Industries affected by the proposed standard. All other 3- or 4-digit sectors for which data are available in CSB consist of both some 6-digit industries affected by the Proposed Standard and a substantial share of additional 6-digit industries that will not be affected by the Proposed Standard. In a sense, then, Foundries and Clay Product and Refractory Manufacturing are the two sectors for which the CSB data are likely the most accurate in reflecting the profitability of affected industries only.

After this two-step approach is used to estimate the profitability of the affected six-digit industries comprising an affected four-digit sector, it could be extended to estimate how the profitability of small and large businesses differ within each six-digit industry. Consider the previous example for industry B, which has been estimated to have profitability of 4.8% even though RMA or Bizminer indicate (in the biased sample that they collect) erroneously that industry B has profitability of 6%. I might estimate that RMA or Bizminer therefor overestimates profitability in industry B by 20% (i.e., estimated at 6% in RMA/Bizminer whereas the true profitability as given by the unbiased CSB is 4.8%). I could then extend this conclusion that RMA/Bizminer overestimate profitability in industry B by 20% to "correct" RMA/Bizminer's estimates for the differing profitabilities of the small and large business segments of industry B. Let's say RMA/Bizminer indicate that small businesses in industry B have an average profitability of 5% and large businesses have an average profitability of 7%. If so, and using my finding that RMA/Bizminer overestimate profitability in this industry by 20%, I would then estimate the average profitability of small businesses in industry B as 4.17% (when increased by 20%, 4.17% becomes 5%) and the average profitability of large businesses in industry B as 5.83% (when increased by 20%, 5.83% becomes the 7% that RMA/Bizminer report for large businesses in industry B.

[12] I estimate profitability for each sector using CSB data as: "net income (less deficit)" for all businesses in the sector, divided by total receipts for all businesses in the sector. I have discussed the reasons for defining profitability in this manner – reflecting the financial performance of all businesses in the sector instead of only profitable businesses in the sector – in previous submittals to OSHA.

Pre-Tax Profitability for Smaller vs. Larger Businesses in Two Affected Sectors[13]

	Foundries		Clay Products and Refractory Mfg.	
	Larger Businesses	Smaller Businesses	Larger Businesses	Smaller Businesses
2000	-0.3%	3.1%	0.2%	4.1%
2001	4.0%	-0.7%	1.1%	0.6%
2002	1.8%	-0.7%	-2.3%	1.9%
2003	-0.2%	-0.6%	-2.6%	2.2%
2004	1.6%	1.7%	1.2%	5.0%
2005	5.3%	4.6%	5.4%	7.3%
2006	8.0%	3.8%	-11.0%	6.6%
2007	10.4%	4.0%	-20.7%	5.0%
2008	10.6%	2.5%	4.5%	1.7%
2009	9.3%	-0.6%	3.0%	1.0%
2010	8.8%	4.7%	-1.2%	2.7%
2011	10.9%	3.0%	3.6%	3.4%

For foundries, the table shows that profitability for large businesses is higher than that for small businesses in 10 of the 12 years from 2000 through 2011, the most recent year for which CSB data are available. For clay products and refractory manufacturing businesses, the pattern is the opposite, though not as consistently so: for 8 of the 12 years, profitability for small businesses is higher than that for large businesses.

I conclude from this and other data that I have reviewed regarding profitability by size of business that small and large businesses very often differ in terms of average profitability, and that small businesses often exhibit lower profitability than large businesses. OSHA should reflect the differences in profitability between small and large businesses in the Agency's regulatory flexibility screening analysis.

[13] For each of these sectors, I have defined "smaller" businesses as those with less than $500,000 in assets while "larger" businesses are those with more than $500,000 in assets. I have chosen this asset breakpoint so as to divide each of these sectors so that "smaller" and "larger" businesses will each account for about half of total sector revenues. Small and large businesses also account for roughly half of sector revenues for these two sectors when small and large are defined by SBA based on employment size of business entity. I thus have done the best I can in choosing an asset breakpoint distinguishing small from large in a manner that roughly matches the SBA's employment-based breakpoint.

OSHA's Procedure for Estimating the Average Revenues of Small vs. Large Businesses is Not Valid

OSHA's procedure for estimating the average revenues for small and large businesses in each affected industry is inaccurate and inappropriate. OSHA's procedure systematically overestimates the revenues of small businesses relative to large ones.

Information on revenues for the industries affected by the Proposed Standard and on how total revenues for these industries are distributed between small and large businesses is available only for the years in which the Economic Census has been published -- thus for 2002 and 2007 and soon for 2012 -- but not for any other years since 2000. For the years in which the Economic Census has not been conducted, OSHA estimates small and large business revenues for each affected industry based on two assumptions:

1. The ratio between total industry revenues and total industry payroll remains constant over time; and

2. The small business share of total industry revenues is equal to the small business share of total industry payroll, and likewise the large business share of total industry revenues is equal to the large business share of total industry payroll.

These two assumptions are incorrect. I have previously provided data in this rulemaking showing that the assumption of a constant ratio between an industry's total revenues and total payroll over time is wrong.[14] In the table below, I provide further information showing that the second of OSHA's assumptions also is substantially incorrect.

[14] Because this ratio is not constant over time, I argue that OSHA should not estimate revenues for affected industries in recent years based on payroll in these years. Instead, OSHA should wait for the availability of information specifically on revenues, which will be forthcoming when the relevant results from the 2012 Economic Census are released later this year.

Data on Small Business Share of Total Industry Revenues and Payroll, from 2002 and 2007 Economic Census

NAICS	Sector	Industry	Small Business Share of Total Industry			
			2007 Receipts	2007 Payroll	2002 Receipts	2002 Payroll
324122	Asphalt Roofing Materials	Asphalt shingle and roofing materials	22.1%	27.0%	19.6%	29.4%
327111	Pottery	Vitreous china plumbing fixture and bathroom accessories manufacturing	11.8%	14.8%	4.3%	5.7%
327112	Pottery	Vitreous china, fine earthenware, and other pottery product manufacturing	54.5%	62.7%	56.6%	56.9%
327113	Pottery	Porcelain electrical supply manufacturing	46.4%	50.8%	43.9%	47.8%
327121	Structural Clay	Brick and structural clay tile manufacturing	37.4%	41.1%	36.9%	41.4%
327122	Structural Clay	Ceramic wall and floor tile manufacturing	48.1%	64.0%	43.3%	46.0%
327123	Structural Clay	Other structural clay product manufacturing	65.9%	67.2%	45.0%	49.7%
327320	Ready-Mix Concrete	Ready-mix concrete manufacturing	46.1%	58.1%	58.7%	64.5%
327331	Concrete Products	Concrete block and brick manufacturing	57.8%	64.6%	65.7%	70.5%
327332	Concrete Products	Concrete pipe manufacturing	38.7%	47.2%	46.7%	52.7%
327390	Concrete Products	Other concrete product manufacturing	56.2%	62.7%	60.1%	65.6%
327991	Cut Stone	Cut stone and stone product manufacturing	89.1%	91.0%	87.0%	88.5%
327993	Mineral Wool	Mineral wool manufacturing	20.0%	23.9%	17.7%	20.2%
327999	Concrete Products	All other miscellaneous nonmetallic mineral product manufacturing	42.8%	54.5%	51.9%	58.2%
331511	Iron Foundries	Iron foundries	28.2%	29.4%	23.1%	24.3%
331512	Non-Sand Casting Foundries	Steel investment foundries	28.0%	30.8%	35.2%	36.0%
331513	Other Ferrous Sand Casting Foun	Steel foundries (except investment)	53.5%	47.8%	59.4%	57.2%
331524	Nonferrous Sand Casting Foundri	Aluminum foundries (except die-casting)	51.2%	57.1%	43.3%	51.5%
331524	Non-Sand Casting Foundries	Aluminum foundries (except die-casting)	51.2%	57.1%	43.3%	51.5%
331525	Nonferrous Sand Casting Foundri	Copper foundries (except die-casting)	88.1%	89.3%	88.2%	90.0%
331525	Non-Sand Casting Foundries	Copper foundries (except die-casting)	88.1%	89.3%	88.2%	90.0%
331528	Nonferrous Sand Casting Foundri	Other nonferrous foundries (except die-casting)	35.7%	35.3%	33.9%	31.2%
331528	Non-Sand Casting Foundries	Other nonferrous foundries (except die-casting)	35.7%	35.3%	33.9%	31.2%

For nearly all industries and for both of the years for which data are available (2002 and 2007), the small business share of industry revenues is substantially less than the small business share of industry payroll. For 18 of the 20 industries in 2002, and for 18 of the 20 industries in 2007 as well, the small business share of industry revenue was less than the small business share of industry payroll. The small businesses in an industry consistently account for a much lower share of the industry's revenues than their share of the industry's payroll. OSHA's indirect approach for estimating small business revenues in the absence of direct data from the Economic Census results in substantially overestimating small business revenues (and similarly overestimating small business profits, since

OSHA estimates small business revenues by applying estimated industry-wide profitability -- which OSHA assumes as also representing small business profitability -- to estimated small business revenues.) Furthermore, for each industry, the small business share of total industry receipts varies from year to year. For 16 of the 20 industries shown in the table, the small business share of total industry receipts/revenues changed by more than five percent (up or down) between 2002 and 2007.

In sum, OSHA's approach for estimating small business revenues for the Agency's regulatory flexibility screening analysis is substantially inaccurate, resulting in systematically overestimating the revenues of the small businesses that will be affected by the Proposed Standard. I can see no viable approach by which OSHA can estimate small business revenues in some recent year other than by waiting for the 2012 Economic Census data to become available.

Conclusion Regarding OSHA's Small Business Analysis

In estimating each of the three quantities that OSHA compares in the Agency's regulatory flexibility screening analysis -- i) an industry's compliance costs; ii) the industry's revenues; and iii) the industry's profits -- OSHA fails to recognize important distinctions between small and large entities. OSHA systematically underestimates small business compliance costs and overestimates small business revenues and profits. As a result, OSHA's economic impact analysis fails to reflect the fact that compliance with the Proposed Standard is even more likely to be economically infeasible for affected small businesses than for large ones.

II. Estimated Economic Impacts from the Proposed Crystalline Silica Standard for General Industry

In this section of the Post-Hearing Brief, I estimate the economic impacts that will result from the compliance costs that URS Corporation projects the affected general industries will incur to meet the requirements of the Proposed Standard. This analysis represents an update and some modifications to previous economic impact analysis reports prepared by Environomics, Inc. and URS Corporation for the American Chemistry Council (ACC) Crystalline Silica Panel (the Panel) in July 2011 and October, 2011. The latter Report has been included in the Docket as Item No. OSHA-2010-0034-4015.[15] Most notably, my previous economic impact analysis addressed a potential standard corresponding to that which OSHA had suggested to the SBREFA Panel in 2003, and addressed both General Industry and Construction. This economic impact analysis, in contrast, addresses the standard that OSHA is now proposing (somewhat different from what I believed the 2003 proposal to be), and this analysis addresses only the economic

[15] Environomics, Inc., "Estimated Costs and Adverse Economic Impacts of a Potential New OSHA Occupational Exposure Standard for Crystalline Silica With a PEL of 50 ug/m^3 and Ancillary Requirements," Final Report For the American Chemistry Council Crystalline Silica Panel, October, 2011 (Docket Item No. OSHA-2010-0034-4015).

impacts of the Proposed Standard for General Industry and not the additional economic impacts expected from the proposed requirements for Construction. Both my previous economic impact analysis and the current one used the IMPLAN input-output model as the primary analytical tool.

A. Response to Inforum

Later in 2011, Inforum developed for OSHA an analysis of the industry and macroeconomic impacts on the U.S. economy of the cost of OSHA's current proposed silica rule, using the LIFT (Long-term Interindustry Forecasting Tool) model of the U.S. economy.[16] Inforum's impact estimates were much different from those that I had developed for the Panel. Inforum provided in their report on pages 7 and 8 some review of the economic impact methodology and estimates contained in my July 2011 draft Economic Impact Analysis Report. In the following paragraphs, I provide a brief response to Inforum's review of my 2011 analysis and some further explanation of the impact assessment methodology that I used in my earlier analysis and that I have continued to use in my current analysis. Below, I show in italics and quotation marks some of Inforum's comments on the subject of "What accounts for the difference between LIFT simulations and the ACC's estimates?" (Inforum, page 7), and I follow each quoted comment with my response in normal text.

1. *"Most important, the ACC's estimate starts with compliance costs that are 5 to 8 times larger than the OSHA estimates employed here."* (Inforum, page 7) I agree that the widely differing compliance cost estimates developed by OSHA in contrast to those developed by URS for the ACC Crystalline Silica Panel is the most important factor accounting for the difference in economic impact estimates. The much larger compliance costs that ACC/URS estimates relative to OSHA's cost estimates should be expected to yield much larger estimates of economic impact. For the Proposed Standard and the 19 affected general industry sectors for which URS has estimated costs, URS estimates compliance costs as $6.131 billion per year while OSHA estimates compliance costs as $114.7 million per year, about one-fiftieth as much. See Table 1 for a comparison of OSHA's and URS' compliance cost estimates for 19 affected general industry sectors. URS' compliance cost estimates are far higher than OSHA's for two reasons: 1) URS estimates the "full" costs for affected industries to reduce employees' silica exposures from current levels to levels compliant with the Proposed Standard, while OSHA (wrongly, I believe) estimates costs for reducing exposures only for employees estimated to be currently exposed at between 50 and 100 ug/m^3, while failing to count the much larger estimated costs for reducing exposures for the many more employees estimated to be currently exposed above 100 ug/m^3; and 2) In estimating compliance costs, URS makes more accurate assumptions than does OSHA on such issues as: i) The fraction of affected facilities that will need to implement the package of controls that OSHA believes

[16] Interindustry Economic Research Fund (Inforum). *Preliminary Economic Analysis for OSHA's Proposed Crystalline Silica Rule: Industry and Macroeconomic Impacts*. Final Report for the Occupational Safety and Health Administration. November 30, 2011.

will be needed when an employee in a particular job category in a particular industry is overexposed; ii) Unit costs for various compliance equipment or activities; iii) Increasing marginal costs per ug/m^3 of exposure reduction at lower exposure levels; iv) Additional costs resulting from the proposed change to the ISO/CEN monitoring protocol; and so forth.

2. *"Moreover, the ACC assumes that the same peak cost estimates are imposed each year, where[as instead] the OSHA cost estimates vary over the 10 year time period, with peak costs occurring in the first year."* (Inforum, page 7) OSHA evidently provided Inforum with year-by-year compliance cost estimates for the first ten years during which compliance with the Proposed Standard is expected. Inforum's Table 1 (page 9) does indeed show that this schedule of costs varies from year to year with a peak in the first year, presumably reflecting relatively high capital costs to be incurred in the first year when compliance is expected and a lower stream of annual continuing O&M costs in the nine subsequent years. Inforum evidently then calculated that the ACC cost estimates were only *"5 to 8 times larger than the OSHA estimates."* (Inforum, page 7)

   Contrary to Inforum's first statement, URS/ACC did not develop any "peak cost estimates" in the 2011 analysis. Instead, in both my 2011 analysis and in my present analysis, I estimate costs as the annualized or levelized figure, recurring each year forever, that would be financially equivalent to the varying year-by-year stream of costs that the Proposed Standard will actually impose. Compliance costs will vary in a complex manner from year to year, with various capital costs incurred in the initial year of compliance and then recurring at differing intervals (e.g., capital costs for long-lived structures such as an enclosed control room might not recur for twenty or more years, whereas capital costs for short-lived assets such as a HEPA vacuum or an initial exposure assessment might recur every two to five years), and O&M expenditures will tend to remain relatively constant from year to year. To simplify what would otherwise be an extremely complex and difficult-to-appreciate stream of costs varying from year to year in the future, OSHA in the PEA estimates costs in an annualized rather than year-by-year manner, and I do likewise. For General Industry, I currently estimate annualized compliance costs per year as more than 50 times higher than the annualized compliance costs per year that OSHA estimates for those same industries. I have estimated compliance costs only on this annualized basis. I have not estimated any "peak", first-year costs that would be incurred for compliance with the Proposed Standard, nor did I estimate these peak costs in my analysis in 2011, despite Inforum's contention.

   Inforum appears to suggest that an advantage of their economic impact analysis based on the LIFT model is that their model is dynamic in contrast to the IMPLAN model that I use, which is static. Inforum suggests that their model can both trace the year-by-year dynamic response to a single cost shock that occurs in a particular year, and that the model can accept as input a schedule of cost shocks that varies from year to year (presumably high costs in the initial "peak" year and then lower costs in subsequent years as capital needs diminish and costs reflect mostly the need for ongoing O&M). While it may be true in theory that the LIFT model offers these benefits in terms of a dynamic simulation capability, I question whether the year-by-year compliance cost estimates that were provided to Inforum for their 2011 analysis were appropriate so that the model would in fact generate reasonably accurate year-by-year ("dynamic") impact estimates for the Proposed Standard. If the year-by-year compliance cost estimates provided by OSHA were not appropriate, the theoretical "dynamic simulation" benefits of the LIFT model would not be realized.

The schedule of year-by-year compliance costs given to Inforum and shown in Inforum's Table 1 appears to be well short of the total compliance costs that OSHA now estimates for the Proposed Standard. As shown in the Preliminary Economic Analysis (page V-1), OSHA estimates the cost of the Proposed Standard to be $658 million per year in 2009 dollars on an annualized basis, excluding the hydraulic fracturing industry. Assuming a 7%/year discount rate, this annual cost, continuing forever as OSHA estimates it will, is equivalent to a present value cost of $9.4 billion dollars in the initial year of compliance. For comparison with this figure, I calculate (also assuming a 7% discount rate) that the present value in the first year for the ten-year schedule of compliance costs shown in Inforum's Table 1 is only $5.0 billion. Inforum apparently thus loaded or "shocked" the LIFT model with compliance costs amounting to only about 53% of the costs that OSHA now estimates for the Proposed Standard. It's not clear to me why OSHA provided Inforum with compliance cost estimates totaling only roughly half the amount that OSHA estimates the Proposed Standard will now cost. Perhaps OSHA's cost estimate has changed in the time between providing the estimate to Inforum in 2011 and now. Perhaps truncating the unending annual stream of compliance costs at only 10 years for the LIFT model run results in a sharp reduction in total costs. Perhaps there was some error in OSHA/ERG's process of building the year-by-year compliance cost estimates to give to Inforum, in contrast to the process of building the annualized/levelized compliance cost estimates as OSHA/ERG did for the PEA.[17] Moreover, as discussed in Section II.B. below, OSHA's annualized cost estimate of $658 million for general industry, maritime, and construction combined is only a small fraction of the annualized

[17] I expect that it would require a great deal of effort for OSHA to develop a fully accurate year-by-year schedule of estimated compliance costs as would be necessary to drive the LIFT model and utilize the model's dynamic capabilities. At a very early point in the Agency's cost analysis for the PEA, OSHA collapses the year-by-year stream of capital and annual O&M costs for each potential engineering control and each ancillary requirement activity into a corresponding single, recurring levelized/annualized cost figure for each of these items. It would be quite difficult to avoid collapsing the cost estimates for each control and each ancillary requirement activity in this manner, and instead carry through the entire analysis the information on capital cost, useful life and annual O&M cost for each of these controls/activities, as would be necessary to develop correspondingly accurate year-by-year cost totals. Perhaps there might have been some error in how OSHA or ERG performed this process so as to provide the year-by-year cost estimates to Inforum.

compliance cost estimate of $6.13 billion that URS calculated for 19 general industry sectors alone.

3. *"The ACC's application of the IMPLAN model did not account for the increase in demand for capital equipment and intermediate goods and services needed to comply with the proposed silica rule. Thus, the employment and income boosting impacts of these expenditures are not captured in their analysis."* (Inforum, page 8) I disagree. The IMPLAN model estimates all the increases or decreases in demand for capital equipment and intermediate goods and services that occur throughout the entire economy as a result of the particular increases or decreases in final demands for individual industrial sectors that the user chooses to enter into the model. I estimate the change in final demand (actually the reduction in final demand) that each affected general industry will incur as a result of its projected regulatory compliance costs, enter these changes in final demand for each of the affected general industries into the model, and IMPLAN then projects the impacts throughout the economy of these specified changes in final demand, including changes involving capital equipment suppliers to the affected general industries and intermediate goods and services.

   IMPLAN does this, however, based on a fixed set of input-output relationships among all industries and other sectors of the economy, and this is perhaps what Inforum is criticizing. Let's assume hypothetically that IMPLAN estimates relationships among the brick industry and the sectors that supply the brick industry such that a $1 decrease in final demand for bricks in the U.S. results directly in a $.01 decrease in consumption of medical services by the brick industry (e.g., reduced brick sales mean fewer brick industry employees which causes slightly lower expenditures for brick industry employee health plans) and a $.02 decrease in consumption of output from the refractories industry (reduced brick sales result in slightly decreased need for refractory materials to reline brick kilns) . IMPLAN will estimate the economy-wide impacts of the regulation-induced reduction in final brick industry demand by applying previously estimated input-output relationships such as these. However, the compliance activities that the brick industry will need to pursue as a result of the Proposed Standard will likely differ somewhat from these previously estimated and fixed input-output relationships. The particular reduction of $1 in final brick demand that is induced by compliance with the silica standard may ultimately involve something less than a $.01 decrease in medical services consumption, and something more than a $.02 decrease in purchases of refractory industry products. In this sense IMPLAN is not dynamic. It simulates the economy-wide impacts of a change in final demand for the subject industry, but does so using fixed input-output relationships that have been estimated previously and which may not correspond exactly to the relationships that will prevail for the particular regulation-induced change in final demand that is under investigation. IMPLAN is unlikely to be precisely accurate in forecasting the exact pattern of changes of inputs from different supplier industries that will result when compliance with the silica standard causes a reduction in final demand for an affected general industry. But IMPLAN likely will be accurate in predicting the overall total reduction in inputs that will result from the reduction in final demand.

4. *"In computing revenue loss by industry, the report claims to use a price elasticity of demand of -1.5 and a price elasticity of supply of 1.0 to compute the revenue impacts for all regulated industries. However, it is not clear that they produce any connection between compliance costs and a price impact by commodity, so it is unclear how or if such price elasticities are used. Instead, they use an apparently arbitrary ratio of revenue loss to compliance cost of 1 to 5 across all sectors."* (Inforum, page 8) My explanation of how I performed this step in the analysis was evidently not clear in my previous report, and I have attempted in this report to explain myself more fully. If I make the following four assumptions for each affected general industry:

   (i) a price elasticity of demand of -1.5;

   (ii) a price elasticity of supply of 1.0;

   (iii) constant-elasticity demand and supply curves; (note: assumptions i through iii are consistent with common EPA practice in regulatory economic impact analyses); and

   (iv) I enter the regulation-induced backward shift in the supply curve on a percentage basis rather than on an absolute basis (e.g., I regard the regulatory compliance costs as representing, say, 1% of the industry's revenues instead of representing, say, $1 per unit of output);

   then it can be calculated mathematically that the regulation-induced reduction in the affected industry's revenues, after markets equilibrate, will equal approximately 20% of the affected industry's compliance costs. I discuss my mathematical model that shows these results on pages 25-26 of this Post-Hearing Brief. The model itself is provided in a Microsoft Excel workbook titled "Model Impact of Compliance Costs on Revenues.xls" that I am submitting to accompany this Brief. The results of the model calculations, showing that the result is typically around 20%, are shown in Table 2 below.

   In sum, my estimate for each affected general industry to the effect that the regulation-induced reduction in final demand will amount to approximately 20% of the industry's compliance cost is derived mathematically given the set of (reasonable, I believe) assumptions that I apply. This 20% estimate is not arbitrary, but instead is a mathematical result that ensues given the model and set of assumptions that I enter into the model.

5. *"The IMPLAN model is static and cannot compute employment and output impacts over time, and it cannot show how the economy evolves to cope with changes in costs. In order to extrapolate over ten years, the authors simply multiply the first year effects by 10. The results are implausible for a dynamic economy as the full static one-year impact is unlikely to be the average impact over the course of several years. At least theoretically, the economy contains powerful forces pushing it towards full employment equilibrium. Therefore, most changes to output and employment due to cost or demand shocks tend to be neutralized through time. That is, most impacts, negative or positive, will approach zero over the long term."* (Inforum, page 8) I do not understand the implications of this comment. I agree that the impact of a single cost or demand shock in a single year will tend to dissipate over subsequent years as the economy tends toward an eventual full employment equilibrium. This concern does not seem relevant for the current analysis, however, where I am investigating the impact not of a single shock in a single year but instead I am investigating the impact of an unending series of equal, repeated shocks every year as will result from the estimated annualized compliance costs. As I discussed in comment #2, above, both my analysis and OSHA's cost analysis in the Preliminary Economic Analysis estimate costs in recurring, annualized terms, and it is this stream of costs that I seek to address in the economic impact analysis.

6. *"More important, any reputable impact analysis must provide the magnitude of effects relative to the size of the industry or economy under study (e.g., jobs lost as a percent of total employment). The absence of such figures from the ACC report is inexplicable."* (Inforum, page 8) I have provided estimates of relative impacts in this report, in the manner suggested by Inforum. I did not provide relative (as opposed to absolute) impact estimates in my previous report because I did not realize that OSHA might find such information important.

B. Economic Impacts From the Projected Costs for General Industry To Comply With the Proposed Standard

The compliance costs for the proposed crystalline silica standard will represent an increased cost of doing business for firms in the industries affected by the regulation. As U.S. firms incur higher costs for the goods and services they produce that involve worker exposure to crystalline silica, market prices for these goods and services will tend to increase to reflect some or all of the increases in production costs. Competing products and services will begin to appear relatively more attractive in the marketplace, and the market share for goods and services produced by the industries affected by the regulation will decline relative to that for competitors. Thus, for example, the domestic U.S. foundry industry will find its castings less competitive than before the regulation relative to both imported castings (which in some years have accounted for more than 20% of the U.S. market) and competing products (e.g., forged, die cast or stamped items; items made from plastics or composites). The same will be true of bricks, clay tiles, concrete products, glass, cut stone and other products made by the general industries that involve worker exposure to crystalline silica.

In economists' terms, the compliance costs for a new silica standard will shift the supply curves for affected firms backward -- after the regulation, the quantity of products or services that an affected producer is able to provide at any given price will be less than the quantity that could have been supplied absent the regulatory compliance costs. After compliance with the regulation, the backward-shifted supply curve in combination with the unaffected demand curve for the product or service will yield a new market equilibrium with some combination of increased price for the product or service and reduced quantity sold. The exact combination of increased price and reduced quantity will depend on the nature of the supply and demand curves for the product or service. If the demand curve for the item is relatively elastic (e.g., if there are ready substitutes or competitors for the item such as low-priced imports or easily substitutable products made from other materials), then the market impact of the regulation will ultimately tend to be a larger proportional reduction in quantity sold and a smaller proportional increase in price. If, on the other hand, the demand curve is relatively inelastic and the item is a necessity with little in the way of competitive alternatives, the market response to the regulation will be a larger proportional increase in price and a smaller proportional reduction in quantity sold.

I estimate the economic impacts from the compliance costs associated with the potential new silica regulation in two steps. By "economic impacts", I mean the effects on overall economic output (GDP), employment, governmental tax revenues, prices, imports and exports and other variables of interest that will ultimately ensue as a result of the regulation after all market adjustments. My two analytical steps are:

1. Estimate the impact of the proposed regulation's compliance costs on the value of output (revenues) for the affected general industries. I make assumptions about the nature of the supply and demand curves for each affected general industry and estimate the eventual market impact of each affected U.S. industry's regulatory compliance costs on that industry's revenues.

2. Estimate how the expected change in revenues for each directly affected industry will then reverberate throughout the economy. If an industry incurs a change in its sales or revenues, this reduction in economic activity will be felt by the industry's suppliers and employees. Several alternative input-output models exist for the U.S. economy that mathematically simulate the customer/supplier/employee relationships for each U.S. industry. I have purchased and used one particularly well-suited input-output model, IMPLAN, to estimate the eventual economic impacts throughout the entire economy that will result from the changes in revenues that I estimate for each affected industry in my first analytical step.

Step 1: Estimate the impact of projected silica regulatory compliance costs on affected U.S. general industries' revenues

This two-step process that I employ has often been used in other analyses estimating the likely economic impact of potential regulatory costs. The several available input-output models represent a widely respected and convenient tool for estimating economic impacts, but any of these models need as the key input an estimate of the revenue loss for the affected industry that will result from the projected regulatory compliance costs. One approach for this first step in these other analyses has been simply to assume that the annual loss in revenues for the affected industry is equal to the annualized projected regulatory compliance costs for that industry.[18]

I believe that this assumption -- that the revenue loss for the affected industry will equal 100% of that industry's estimated compliance costs -- is too extreme. In general, the demand curve for an affected industry's output is unlikely to be so elastic as to lead to a revenue loss as high as 100% of compliance costs. A less elastic demand curve would suggest that some of the compliance costs incurred by affected producers will ultimately be passed through into the market in the form of increased prices: the industry's revenues will tend to decrease as a result of the lesser quantity of goods and services sold, but this impact on revenues can be partly or even completely offset by the increased price that is realized for the reduced output.

In fact, the mathematical relationship between the magnitude of the compliance cost incurred by an industry and the magnitude of the eventual resulting change in industry revenues after market adjustments have occurred depends on the elasticities of the demand and supply curves for the industry's output. In my view, accurately estimating the impact of regulatory compliance costs on an affected industry's revenues should involve simulating the industry's supply and demand curves (which will require estimating supply and demand elasticities) and then modeling the results when the regulatory costs shift the industry's supply curve backward. EPA's Air Office typically conducts its regulatory economic impact analyses in this manner.[19] (In contrast, OSHA typically conducts a much less detailed, "screening analysis" when investigating the economic impacts of regulations. In OSHA's screening analyses, compliance costs are simply compared against an industry's revenues and profits, and impacts are judged to be of potential concern if compliance costs exceed 1% of the industry's revenues or 10% of its profits. Because OSHA

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[18] For example, an economic impact analysis that received substantial publicity in the ongoing debate about the jobs impacts of potential new environmental regulations: IHS Global Insight. *The Economic Impact of Proposed EPA Boiler/Process Heater MACT Rule on Industrial , Commercial, and Institutional Boiler and Process Heater Operators*. Prepared for Council of Industrial Boiler Owners. August, 2010. Another analysis on another major environmental regulation made a similar assumption: NERA Economic Consulting. *Estimated Economic Impacts of EPA 2010 Ozone Proposal*; cited in MAPI/Manufacturers Alliance. *Economic Implications of EPA's Proposed Ozone Standard*. September, 2010.

[19] See, for example, EPA's *Economic Impact Analysis for the Brick and Structural Clay Products Manufacturing NESHAP: Final Rule*. February, 2003. And, more generally, see Section 5 of U.S. EPA. *OAQPS Economic Analysis Resource Document*. April, 1999.

rarely performs the sort of economic impact analysis that I want to conduct here,[20] I have chosen generally to follow the EPA model for how to perform this sort of analysis.)

However, fully implementing EPA's preferred approach to projecting the market impacts of a regulation will usually require a very substantial analytical effort in order to estimate the elasticities of demand and supply for the major outputs of the various industries that will be affected by the regulation. Appropriately transferable pre-existing estimates for an industry's supply and demand elasticities are rarely available. Econometric estimation of industry supply and demand functions is technically difficult and requires difficult-to-obtain price and quantity information for the industry's product markets. In practice, when EPA projects the market response to a regulation, the Agency typically makes assumptions about industry supply and demand elasticities rather than deriving estimates for them or adopting pre-existing estimates. EPA typically assumes an elasticity of supply of 1.0, and often assumes various plausible values for the elasticity of demand and conducts a sensitivity analysis assuming each of these plausible values. Specifically, in EPA's economic impact analysis for an air pollution regulation affecting the structural clay products (mostly brick and clay tile) manufacturing industry, the Agency assumed a market elasticity of supply of 1.0 and an elasticity of demand of -1.5 (see the reference cited above).

For the first step in my current economic impact analysis for the potential new silica standard -- the step in which I estimate the impact of each industry's projected compliance costs on each industry's post-regulatory revenues -- I adopt the EPA Air Office approach. I cannot afford the effort required to estimate supply and demand elasticities for each of the twenty or so different affected general industries.[21] Instead, I adopt EPA's approach of assuming for all affected industries a supply elasticity of 1.0 and a demand elasticity of -1.5 (from EPA's structural clay products analysis) and conducting a sensitivity analysis to assess the results if other plausible values were assumed for demand elasticity.

[20] The economic impact analysis for the Proposed Standard that OSHA contracted for with Inforum represents another approach for estimating economic impacts. Inforum performed their analysis using a dynamic general equilibrium model of the entire U.S. economy, in contrast to the input-output modeling approach that I use here.

[21] One can define "industry" at various levels of aggregation. OSHA identifies the proposed general industry standard as directly affecting some 25 industry "sectors," or more than 120 6-digit NAICS "industries". Of the 25 affected sectors that OSHA identifies, I estimate in this analysis the economic impacts that will result from the projected compliance costs for the 19 sectors for which URS has estimated compliance costs for the ACC Crystalline Silica Panel. URS did not estimate compliance costs for 6 sectors (captive foundries, porcelain enameling, railroads, dental equipment, dental laboratories, refractory repair) because they did not find OSHA's estimates for the number of affected facilities in these 6 sectors to be credible. In the PEA, OSHA estimates compliance costs for the 19 sectors for which URS also estimated costs at $114.7 million per year. OSHA estimates costs for all 25 affected general industry sectors plus the maritime sector at $146.8 million per year, about 28% more than for the 19 sectors. If URS's compliance cost estimates for all 25 sectors plus maritime were to bear the same relationship to the URS cost estimates for the 19 sectors as do OSHA's estimates for the two groups of sectors, then if I were to estimate the economic impacts from the Proposed General Industry Standard for all 26 affected sectors instead of only for 19 sectors, I might estimate economic impacts about 28% larger than those I estimate here.

I developed a simulation model to assess the relationship between the regulatory compliance costs that an industry bears and the change in the affected industry's revenues after market adjustments, as a function of various assumed values for supply and demand elasticities. In this model, I assumed (as EPA typically does) constant elasticity supply and demand curves, resulting in a functional form of the following sort:

$Q = A \times P^{\varepsilon}$

- Where Q is the Quantity demanded or supplied;
- P is the Price at which that Quantity will be demanded or supplied;
- ε is the elasticity of demand or supply, assumed to be constant across the entire relevant range of prices and quantities; and
- A is a different parameter in each of the demand and supply functions.

Because of my interest in understanding the relationship between compliance costs and revenues, I entered compliance costs in the model as a constant backward percentage shift in the industry's supply curve, and not (as is most frequently assumed in regulatory impact analyses) as a constant per unit backward shift in the industry's supply curve. I entered regulatory compliance costs in the analysis as a constant percentage of industry revenues (i.e., what percentage of baseline industry revenues does the projected industry compliance cost represent?), not as a constant cost per unit of the industry's output (i.e., for the brick industry, what cost per brick produced does the projected brick industry compliance cost represent?). Thus, for example, I developed the model so as to investigate what would happen if the brick industry incurred a regulatory compliance cost equal to 1% or 5 % or 10% of the industry's revenues, instead of setting the model up to investigate what would happen if the industry incurred regulatory costs equivalent to, say, 1¢ or 2¢ or 3¢ per brick.

I am providing an Excel workbook titled "Model Impact of Compliance Costs on Revenues.xls" that shows my model investigating the relationship between compliance costs and revenue loss for affected industries. Some results from my model are shown in Table 2. In sum, I conclude that:

- For any of the alternative chosen pairs of assumed supply and demand elasticities, the relationship between the equilibrium revenue loss that an industry will suffer and the compliance costs that the industry incurs is nearly invariant with respect to the magnitude of the compliance costs (at least for compliance costs amounting to 10% or less of industry revenues). This is perhaps a surprising result. Said another way, once the supply and demand elasticities are specified for an industry and are assumed to be constant, then the equilibrium revenue loss the industry will suffer after compliance with a regulation will be a constant fraction of the compliance cost the industry incurs, without regard to the magnitude of this compliance cost (at least for costs amounting to roughly 10% or less of industry revenues). The revenue loss the industry will suffer will be a fixed percentage of the compliance costs the industry incurs, without regard to how large the compliance costs are.

- If an industry's elasticity of supply is assumed at 1.0 and elasticity of demand at -1.5 (EPA's typical assumptions and my preferred assumptions for this analysis), the industry's revenue loss after market adjustments will be 20% of compliance costs, or only slightly more if annualized compliance costs/year amount to much more than 5-10% of annual pre-regulation industry revenues. These results are bolded and shown in the box in Exhibit 1.

- As should be expected, the industry's post-equilibrium revenue loss will exceed this amount (i.e., will exceed 20% or so of annualized compliance costs) if demand is more elastic than -1.5, and will be less than this amount if demand is less elastic than this figure.

- The model suggests that rather extreme circumstances will need to prevail if the industry's revenue loss is to approach 100% of its compliance costs, as some previous industry-sponsored economic impact analyses have assumed. When the elasticity of supply is 1.0, either demand will need to be extremely elastic or compliance costs will need to be very large relative to revenues in order for the post-equilibrium revenue loss to approach 100% of compliance costs.

- The impact of compliance costs on revenues is diminished when the elasticity of supply is assumed at less than 1.0, and the impact is increased (though this result is not shown in the table in the Appendix) when the elasticity of supply is assumed at more than 1.0. EPA, however, commonly assumes a market supply elasticity of 1.0

I assume for Step 1 of my economic impact analysis the results shown for my preferred elasticity assumptions in the bolded section of Table 2. I estimate that each U.S. industry affected by the potential new occupational exposure standard for crystalline silica will face a post-equilibrium revenue loss equal to 20% of the annualized compliance costs projected for that industry.[22]

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[22] The results shown in the bolded section of Table 2 might appear to suggest some variation in this 20% assumption. For any industry incurring compliance costs so large as to amount to roughly 10% or more of pre-regulation industry revenues, I could perhaps more appropriately estimate that the post-equilibrium revenue loss due to the regulation will equal 21%, not 20%, of the annualized compliance costs projected for that industry. I believe, however, that the added precision apparently gained by considering the intensity of the cost burden on the regulated industry (e.g., 1% of revenues vs. 5% of revenues vs. 10% of revenues) is small relative to the uncertainty inherent in assuming supply and demand elasticities. I will use for this analysis a simplified conclusion to the effect that the post-equilibrium revenue loss for an affected industry is always equal to 20% of the annualized compliance costs projected for that industry. Note for some affected General Industry sectors that URS's estimated compliance costs do exceed 10% of the revenues that OSHA projects for that sector (see, for example, Table 2 in the Preliminary Letter Report of Environomics to the American Chemistry Council's Crystalline Silica Panel Regarding the

Contrary to Inforum's assertion that this estimate represents only an assumed "arbitrary ratio of revenue loss to compliance cost", I want to emphasize that this 20% estimate instead represents the result from my set of assumptions and model. This conclusion is derived rather than assumed, and it is not arbitrary.

Table 1, below, shows the annual compliance costs and resulting revenue losses that I estimate will be incurred by 19 directly affected U.S. general industries if OSHA promulgates the Proposed Standard. The revenue losses for each industry are estimated at 20 % of their annual compliance costs. Note in the Table below that URS estimates compliance costs for these 19 general industry sectors at $6.13 billion per year, about 50 times larger than OSHA's estimate for these 19 sectors at $114.7 million per year. I estimate the revenue loss for these 19 sectors after compliance with the proposed rule to be 20% of the $6.13 billion/year cost, or $1.23 billion/year in annual revenue losses.

Economic Impact of the Occupational Safety and Health Administration's Proposed Standard for Occupational Exposure to Respirable Crystalline Silica (February 7, 2014), which shows 3 of 19 sectors incurring compliance cost burdens exceeding 10% of revenues). The Preliminary Letter Report of Environomics was submitted to the Docket as Attachment 9 to the Comments of the American Chemistry Council Crystalline Silica Panel (Docket Item No. OSHA-2010-0034-2307).

Table 1: Estimated Annual Compliance Costs and Resulting Post-Equilibrium Revenue Losses for 19 General Industry Sectors Directly Affected by the Proposed Standard (2009 $ in millions per year)

Sector	Annualized Compliance Costs, OSHA (Incremental)	Annualized Compliance Costs, URS (Full)	Annual Revenue Losses Resulting from URS Compliance Costs
Asphalt Paving Products	$0.2	$4.0	$0.8
Asphalt Roofing Materials	$3.2	$180.6	$36.1
Concrete Products	$22.1	$920.6	$184.1
Costume Jewelry	$0.2	$2.3	$0.5
Cut Stone	$8.6	$163.8	$32.8
Fine Jewelry	$1.9	$19.9	$4.0
Flat Glass	$0.3	$21.0	$4.2
Iron Foundries	$15.3	$1,322.8	$264.6
Mineral Processing	$4.6	$128.6	$25.7
Mineral Wool	$1.1	$86.6	$17.3
Nonferrous Sand Casting Foundries	$5.3	$515.6	$103.1
Non-Sand Casting Foundries	$8.8	$799.8	$160.0
Other Ferrous Sand Casting Foundries	$4.6	$416.1	$83.2
Other Glass Products	$1.8	$57.6	$11.5
Paint and Coatings	$0.1	$27.7	$5.5
Pottery	$6.0	$523.0	$104.6
Ready-Mix Concrete	$16.5	$413.0	$82.6
Refractories	$1.1	$75.1	$15.0
Structural Clay	$12.9	$452.8	$90.6
TOTAL	**$114.7**	**$6,131.1**	**$1,226.2**

Table 2. Impact of Regulatory Compliance Costs on Post-Equilibrium Industry Revenues, as a Function of Elasticities

Regulatory Compliance Costs as % of Pre-Regulation Industry Revenues	Elasticity of Supply	Elasticity of Demand	Industry Revenue Loss (after Market Adjustments) as % of Compliance Cost
1%	1	-1.0	0%
5%	1	-1.0	0%
10%	1	-1.0	0%
0.1%	**1**	**-1.5**	**20%**
1%	**1**	**-1.5**	**20%**
5%	**1**	**-1.5**	**20%**
10%	**1**	**-1.5**	**21%**
20%	**1**	**-1.5**	**22%**
1%	0.5	-1.5	13%
5%	0.5	-1.5	13%
10%	0.5	-1.5	13%
1%	1	-2.0	33%
5%	1	-2.0	34%
10%	1	-2.0	35%
1%	1	-3.0	50%
5%	1	-3.0	51%
10%	1	-3.0	51%
1%	1	-4.0	60%
5%	1	-4.0	61%
10%	1	-4.0	61%
1%	1	-5.0	67%
5%	1	-5.0	67%
10%	1	-5.0	68%
1%	1	-10.0	82%
5%	1	-10.0	82%
10%	1	-10.0	83%

Step 2: Use the input-output model to estimate the economic impacts resulting from the reductions in U.S. industry revenues due to projected silica regulatory compliance costs

Input-output models are commonly used to trace and estimate the economic impacts that will result from a change in final demand or output for one or more sectors of the economy.[23] The model simulates the flows of goods and services necessary to produce each economic sector's output. A very large system of multipliers within the model describes the change of output for each and every regional industry caused by a one dollar change in final demand for any given industry. Input-output models are geographically based, and can usually be run to simulate the impacts of a change in final demand on economic flows within a locality, within a region, within a State, within the entire nation, or within many other sorts of geographies. In my application, the regulation-induced projected annual change in revenues for each directly affected industrial sector, as shown in Table 1, is the change in final demand that drives the model. I use an input-output model to estimate the eventual changes in economic flows in other sectors and in the U.S. economy as a whole that will result from the projected changes in revenues for the sectors directly affected by the regulation.

Three input-output models are commonly used for such purposes: REMI/Policy Insight, the Department of Commerce/Bureau of Economic Analysis RIMS II system of multipliers, and IMPLAN. IMPLAN is an acronym for "Impact Analysis for Planning", and the model is maintained and marketed by the Minnesota IMPLAN Group, Inc.. I chose to use IMPLAN because it has several advantages for my particular purposes:

- IMPLAN is much less expensive to purchase and run than REMI/Policy Insight;
- IMPLAN has significant advantages over RIMS II for nationwide applications, in contrast to applications for smaller geographic zones;
- The IMPLAN data and relationships are updated frequently and the model represents relatively recent economic conditions. I purchased the 2009 IMPLAN data set as the most recent one available when I performed my initial economic impact analysis in 2011. To keep my costs down I did not purchase a more recent data set for the current analysis. Use of the 2009 data matches the year in which both OSHA and URS have expressed their compliance cost estimates;
- The manner in which industrial sectors are grouped in IMPLAN is reasonably similar to the manner in which OSHA grouped them in the Agency's regulatory cost analysis; and
- The IMPLAN software and user interface are very easy to work with.

[23] Some of the following discussion of input-output models and IMPLAN as a specific input-output model has been drawn from IHS Global Insight, op cit., August 2010.

For my purposes, IMPLAN can estimate the impact of my estimated reductions in general industry revenues with respect to five primary areas of economic activity:

- Employment: the number of jobs potentially at risk of being lost as a consequence of compliance with the standards;
- Labor income: the amount of employee compensation potentially lost due to compliance with the new standards;
- Value added: the economic contribution by different industries that could be affected by implementing the standards:
- Output: the value of the output lost as affected employers attempt to pass the compliance costs on to their customers, and as they ultimately produce less (including perhaps facility closures); and
- Tax implications: the potential loss of federal, state and local tax receipts with reduced economic activity.

For each of these five measures of economic impact, IMPLAN will calculate the total national effect of the regulation-induced loss of revenues and indicate how this effect has arisen:

- Direct effects include impacts on the particular general industries that directly bear the regulatory compliance costs;
- Indirect effects include impacts on suppliers to the directly affected industries;
- Induced effects are the impacts resulting from reduced spending by employees of the directly and indirectly affected industries, as a result of reduced earnings by these employees; and
- The total effect is the sum of direct, indirect and induced effects.

I entered into IMPLAN the estimated revenue losses for each affected general industry, as shown in the rightmost column of Table 1. The industry sectors shown in Table 1 are as they were defined by OSHA. In order to enter the resulting revenue losses into IMPLAN, I cross-walked the OSHA-defined sectors into corresponding industry groupings as IMPLAN defines them. I show this cross-walk in Table 3.

Table 3. Crosswalk from OSHA Sectors to IMPLAN Sectors

NAICS	OSHA Industry	IMPLAN Sector Corresponding to this NAICS	IMPLAN Sector Name
324121	Asphalt paving mixture and block manufacturing	116	Asphalt paving mixture and block manufacturing
324122	Asphalt shingle and roofing materials	117	Asphalt shingle and coating materials mfg
325510	Paint and coating manufacturing	136	Paint and coating manufacturing
327111	Vitreous china plumbing fixture and bathroom accessories mfg	153	Pottery, ceramics, and plumbing fixture mfg
327112	Vitreous china, fine earthenware, and other pottery product mfg	153	Pottery, ceramics, and plumbing fixture mfg
327113	Porcelain electrical supply manufacturing	153	Pottery, ceramics, and plumbing fixture mfg
327121	Brick and structural clay tile manufacturing	154	Brick, tile, and other structural clay product mfg
327122	Ceramic wall and floor tile manufacturing	154	Brick, tile, and other structural clay product mfg
327123	Other structural clay product manufacturing	154	Brick, tile, and other structural clay product mfg
327124	Clay refractory manufacturing	155	Clay and nonclay refractory manufacturing
327125	Non-clay refractory manufacturing	155	Clay and nonclay refractory manufacturing
327211	Flat glass manufacturing	156	Flat glass manufacturing
327212	Other pressed and blown glass and glassware manufacturing	157	Other pressed and blown glass and glassware mfg
327213	Glass container manufacturing	158	Glass container manufacturing
327320	Ready-mix concrete manufacturing	161	Ready-mix concrete manufacturing
327331	Concrete block and brick manufacturing	162	Concrete pipe, brick, and block manufacturing
327332	Concrete pipe manufacturing	162	Concrete pipe, brick, and block manufacturing
327390	Other concrete product manufacturing	163	Other concrete product manufacturing
327991	Cut stone and stone product manufacturing	166	Cut stone and stone product manufacturing
327992	Ground or treated mineral and earth manufacturing	167	Ground or treated mineral and earth mfg
327993	Mineral wool manufacturing	168	Mineral wool manufacturing
327999	All other miscellaneous nonmetallic mineral product mfg	169	Miscellaneous nonmetallic mineral product mfg
331511	Iron foundries	179	Ferrous metal foundries
331512	Steel investment foundries	179	Ferrous metal foundries
331513	Steel foundries (except investment)	179	Ferrous metal foundries
331524	Aluminum foundries (except die-casting)	180	Nonferrous metal foundries
331525	Copper foundries (except die-casting)	180	Nonferrous metal foundries
331528	Other nonferrous foundries (except die-casting)	180	Nonferrous metal foundries
339911	Jewelry (except costume) manufacturing	310	Jewelry and silverware manufacturing
339913	Jewelers' material and lapidary work manufacturing	310	Jewelry and silverware manufacturing
339914	Costume jewelry and novelty manufacturing	310	Jewelry and silverware manufacturing

This cross-walking process that I used in order to enter the regulation-induced revenue losses that I estimated for OSHA's industries into IMPLAN is parallel to the process that Inforum used to enter into the LIFT model the regulation-induced compliance costs that OSHA estimated for these same industries. The major difference is that the estimated compliance costs and revenue impacts that I entered into IMPLAN are far higher than the costs that Inforum entered into the LIFT model.

Results from IMPLAN: Projected Economic Impacts From the Proposed Standard for General Industry

IMPLAN projects that the Proposed Standard for General Industry will cause the following annual losses in economic activity.

Annual Economic Impacts of Proposed Crystalline Silica Standard for General Industry (2009 $/yr in millions)

ImpactType	Employment	Labor Income	Total Value Added (GDP)	Output	Federal Tax Receipts	State/Local Tax Receipts
Direct Effect	-5,408	-$326.5	-$481.2	-$1,195.2	ND	ND
Indirect Effect	-5,143	-$314.1	-$532.3	-$1,115.0	ND	ND
Induced Effect	-7,493	-$336.7	-$597.8	-$1,078.7	ND	ND
Total Effect	-18,044	-$977.2	-$1,611.3	NA	-$201.1	-$137.1

Entire U.S. Economy	172,400,746		$14,119,100.0
Percentage Impact	-0.0105%		-0.0114%

The Proposed Standard would cause a reduction of employment of more than 18,000 full-time-equivalent jobs per year and a loss in economic output/GDP of more than $1.6 billion per year.[24] These impacts would continue to occur every year in which the Proposed Standard remains in effect, since I (as well as OSHA in the PEA) have chosen to express the estimated compliance costs as a levelized stream of costs incurred each year and continuing indefinitely. A continuing reduction of employment amounting to 18,000 each year is equivalent to a permanent loss of 18,000 jobs. Over a 10-year period, the Proposed Standard would cause a loss of more than $16 billion of economic output/GDP. The projected losses in employment and GDP from the Proposed Standard each amount to about 0.01% of the national total.

These estimated costs and impacts do not reflect complete corrections and adjustments to OSHA's compliance cost estimates across all affected industries, so the overall impacts likely would be greater than what I show here. URS has estimated costs for only 19 of the 25 industry sectors that OSHA identified as affected by the Proposed Standard for General Industry, and URS has also not developed compliance cost estimates for the hydraulic fracturing industry nor for the maritime sector. And, URS provides in their description of their compliance cost estimates many reasons why they believe the estimates they did develop are likely to be underestimates of the compliance costs that affected industries will actually bear.

There are many reasons why these economic impact estimates that I have developed are difficult to compare against those that Inforum developed for OSHA. Notably, Inforum estimated the summed impacts resulting from both the General Industry and Construction standards while I estimated impacts from the General Industry Proposed Standard only. Inforum also used a

[24] One might expect the total of the output losses estimated in the model to equal the loss in GDP. However, as Inforum explains in their review of my 2011 economic impact analysis:

> "In an input-output framework such as IMPLAN, figures for "output" usually correspond to gross output or total revenue by sector. When gross output is added across sectors there is substantial double counting of intermediate input purchases. Value added, on the other hand, is the labor, capital, and indirect tax income generated in each sector. It corresponds to total revenue minus intermediate costs of goods and service inputs and, therefore, avoids double-counting." (Inforum, page 7)

In IMPLAN, the total estimated impact of the Proposed Standard on GDP is given by the total estimated impact on Value Added, not the total impact on gross output.

different sort of dynamic general equilibrium model in contrast to the static input-output model that I used; Inforum loaded the model with compliance costs that varied widely from year to year; and Inforum generated impact estimates that also varied substantially from year to year. (As discussed above, there is reason to doubt that the compliance costs given to Inforum in 2011 amounted to what OSHA now estimates the Proposed Standard will cost.) Nevertheless, despite these differences, I believe that my results are very roughly consistent with Inforum's when the far greater compliance cost estimates that I entered into IMPLAN in comparison to those that Inforum entered into the LIFT model are taken into account. I presume that Inforum entered estimated compliance costs into their model equivalent to somewhere between approximately $350 and $660 million per year on an annualized basis for General Industry, Construction and Maritime, while I entered estimated compliance costs of $6.1 billion per year for General Industry alone, nearly 10 times higher than Inforum's total.[25] Presuming compliance costs approximately 10 to 15 times greater than Inforum's, I estimate a loss of GDP over 10 years at a little more than $16 billion, while Inforum estimates a 10-year cumulative loss of GDP of $6.6 billion, also in 2009 dollars (Inforum, pages 5-6). I estimate an employment loss from the Proposed Standard for General Industry at 18,000 full-time equivalent jobs each year, while Inforum estimates that non-construction employment will decline by an average of 1,620 jobs each year (derived from Inforum, Table 6, page 23), quite close to the 10 to 15:1 ratio that might be expected based on the relative magnitude of the compliance costs estimated for the two analyses.

III. Appropriate Approach To Using Data Sources To Identify General Industry Profitability

I previously provided comments to OSHA on the subject of data sources for estimating general industry profitability. These were contained in a Preliminary Letter Report of Environomics to the American Chemistry Council's Crystalline Silica Panel Regarding the Economic Impact of the Occupational Safety and Health Administration's Proposed Standard for Occupational Exposure to Respirable Crystalline Silica (February 7, 2014), which was submitted to the Docket as Attachment 9 to the Comments of the American Chemistry Council Crystalline Silica Panel (Docket Item No. OSHA-2010-0034-2307) and in my oral testimony at the Public Hearing on March 26, 2014. I stated three major concerns about the specific manner in which OSHA had estimated general industry profitability in analyzing economic impacts from the Proposed Standard using data from the U.S. Internal Revenue Service's publication titled "Corporation Source Book" (CSB):

1. OSHA averaged information on each industry's profitability over the years 2000 through 2006 and used this average to represent the future profitability of the affected industries.

[25] See Table 1 in my letter report of February 7, 2014 to the Panel that was submitted as a part of the Panel's public comments

OSHA should use more recent data that is more representative of these industries' post-recession profitability and ability to incur costs during the years when compliance with the Proposed Standard will be required.

2. The CSB has a major drawback relative to several other potential sources of information on profitability for the general industries affected by the Proposed Standard, *viz*., the CSB provides information only for industries defined at the 3- or 4-digit NAICS level. OSHA has estimated costs for the affected industries defined instead at the 6-digit NAICS level. Data for a far larger, aggregated 3- or 4-digit industry is unlikely to closely match or accurately represent the data for a much smaller, specialized and potentially different 6-digit industry. Other data sources on profitability exist at the 6-digit level, e.g., RMA, Dun & Bradstreet, Bizminer and industry profile and benchmark studies. On the other hand, CSB has a major advantage over most of these other data sources insofar as the CSB data is derived from a statistical random sample of tax returns from corporations in each industry and, accordingly, is likely to be unbiased. By contrast, the procedures used to acquire information on profitability by the other data sources lead one to believe that these other data sources tend to acquire information largely on the more profitable businesses in the industries being investigated, thereby likely producing estimates of industry profitability that are biased high.

3. In using information from the CSB to represent an industry's profitability, OSHA should use data that represents the average profitability of all firms in the industry, including both the firms that are profitable and those that are not. OSHA should not, as the Agency has done, select information from the CSB that reflects the profitability of only those firms in the industry that had positive profits in the year in question.

I concluded both sets of my comments to OSHA on this issue by suggesting that OSHA should use some combination of the data sources that I had cited in order to develop better estimates of general industry profitability, but in neither instance did I recommend exactly how the Agency might best combine these data sources.

Subsequent to my providing these two sets of comments, OSHA has added to the docket materials indicating that the Agency is considering some of the alternative data sources on profitability that I suggested. See, for example, Docket Item # OSHA-2010-0034-3768, indicating that OSHA has acquired financial information from RMA. For my part, since providing my earlier comments, I have investigated further and thought further about the various potential data sources on profitability. I can now provide a more specific recommendation about how OSHA should proceed in estimating profitability for the affected general industries than I did earlier. I recommend that:

- OSHA should start with an unbiased source of information on industry profitability, specifically the CSB. OSHA should choose data from the CSB for the larger 3-or 4- (or more, if available) digit industry as representing the profitability of the component affected 6-digit general industry. OSHA should use "Net Income (less deficit)" in calculating profitability from the CSB data, thus reflecting the profitability of all companies within the affected industry, not only the profitable ones. OSHA should choose a reasonably long series of years of data, ending with the most recent year available in the CSB (2011 at present), as representing an industry's likely future profitability when compliance with the Proposed Standard is expected. Averaging the profitability information from CSB over the twelve years from 2000 through 2011 (or the 13 years through 2012, if the additional year becomes available) seems reasonable.

- OSHA should use one of the other data sources, probably Bizminer or perhaps RMA, to obtain information on i) how profitability for a smaller component industry may diverge from the profitability of the larger 3- or 4-digit industry of which it is a part; and ii) how profitability for the large and small business segments of an industry may diverge from the profitability of the entire industry. The CSB can provide an unbiased "anchor" estimate of profitability, while Bizminer or RMA can be used to estimate the percentage by which profitability for a component industry lags or exceeds this anchor figure. I have described the specific two-step procedure that I recommend for developing this further detail in footnote 11 of this Post-Hearing Brief on pages 12 and 13. I expect that Bizminer would be better for this purpose than RMA, as I believe that Bizminer covers more of the affected six-digit general industries than does RMA, and I believe that for most industries, Bizminer has obtained profitability information from more companies than has RMA, and hence is likely less subject to bias. I do not recommend Dun & Bradstreet for this purpose.