

*Critical Review of ADL
Economic Impact Study*

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In re

PROPOSED REVISED PERMANENT
STANDARD FOR OCCUPATIONAL
EXPOSURE TO BENZENE

OSHA Docket No. H-059

TESTIMONY OF JOHN E. SCARBROUGH
BEFORE THE
OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION

July 11, 1977

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TESTIMONY OF JOHN E. SCARBROUGH, API

My name is John Scarbrough. I have a Ph.D. in economics from the University of Minnesota and a Bachelor of Arts degree in economics from Texas Tech Univeristy. I am currently a senior economist in the Policy Analysis Department of the American Petroleum Institute in Washington, D.C. Prior to joining API, I worked as a senior consultant with Peat, Marwick, Mitchell and Co., where I worked on development and application of a programming model for use in the evaluation of policies aimed at improving air transport efficiency.

Before joining Peat, Marwick, Mitchell and Co., I was an assistant professor of economics at Virginia Polytechnic Institute and State University (VPI & SU) in Blacksburg, Virginia, teaching at both the graduate and undergraduate levels. At API I continued research which I began in my PH.D dissertation on the application of the measurement of the economic effects of potential changes in international trade policy.

The comments which I am about to make pertain to the "Technology Assessment and Economic Impact Study of an OSHA Regulation for Benzene," prepared for the United States Occupational Safety and Health Administration by Arthur D. Little, Inc., hereafter referred to as ADL. My comments concern that part of the ADL study that deals with the economic impact of the proposed regulation. In particular, I will document the fact that the assessment of the economic impact presented by the ADL report was based upon serious misunderstandings of basic economic principles; followed

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invalid and unacceptable methodology; and failed to address vitally important issues. In light of this, my view is that the conclusions on economic impact presented by the ADL report in no way satisfies the obligation of OSHA pursuant to Executive Order 11949 (December, 1976), to assess the potential economic impact of the proposed regulation. In support of this conclusion, I would like to present:

1. a brief list of some of the more important factors which are relevant to the economic impact of a regulation;
2. a discussion of what factors the ADL study claims to have addressed; and
3. an evaluation of the adequacy of ADL's analysis of these factors.

Let me preface my remarks concerning the economic impact of the proposed regulation by stating what I do and do not mean by economic impact. By economic impact, I do not mean the direct costs associated with the compliance activities undertaken by firms covered by the regulation. These costs would include the costs of medical surveillance, monitoring, and engineering controls. Those costs are the initial financial effects on the industries directly affected by the proposed regulation but are not the economic impact. While some industries will be adversely affected by the proposed regulation, others such as the medical profession or the manufacturers of sampling equipment, will benefit

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from it. After all, the dollars spent by the affected employers will be received by someone. However, the direct financial costs to affected industries which must comply with the proposed regulation do cause economic effects throughout the economy. These effects include changes in relative prices, production levels, consumption levels, employment levels, etc.

If I may use an analogy to illustrate this meaning of economic impact, think of the state of the economy as being represented by the positions of several billiard balls on a pool table. A shot is made. The direct cost of the proposed regulation is like the initial impact of the cue ball on the billiard ball which it strikes first. As a result of this impact, many, perhaps all, of the balls on the table are involved in an ensuing chain reaction. Once all movement has stopped, the new state of the economy is like the new positions of all of the billiard balls. These new positions could be compared with their old positions and the differences likened to the economic impacts of the regulation.

So it is with the proposed regulation. The first ball struck, like the industries which must comply with the proposed regulation, will be moved. Other balls, or in this case, industries, will be then impacted. These impacts must be analyzed before the shot (or regulation) is made.

The proposed regulation, if adopted, could affect a significant number of facilities, employees and products

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associated with the industries affected by the regulation. Many of these products are themselves used at other facilities, where more employees work to produce more products. Where the presence of benzene is sufficient to cause the firms to engage in compliance activities, the cost of those activities must be paid by those firms. Other firms, not required to undertake compliance activities, will still be impacted by the regulation, however, through the resulting changes in relative prices in the economy.

That the numbers of facilities and employees affected by the proposed regulation are very large cannot be contested. Certainly the impacts of such a far-reaching regulation are potentially significant and widespread. In view of this, it should be OSHA's responsibility to analyze these potential impacts. Surely OSHA intended for them to be analyzed when they contracted with ADL. The purpose of my testimony is to point out that the ADL report does not assess those impacts and, consequently, a study of the economic impact of the proposed regulation is still needed.

Government regulation can impact the nation's economy in a variety of ways. These include impacts on:

- o the Gross National Product, which will ultimately reflect the net economic cost of the regulation;
- o the rate of growth of the economy;
- o the level of employment in the economy;
- o the rate of inflation;

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- o the balance of trade; and
- o the nation's requirements for and supplies of energy and other critical materials.

In addition to these macroeconomic impacts, the potential microeconomic impacts include:

- o changes in the structures of both the supply and demand sides of markets;
- o the question of who ultimately bears the cost burden of the regulation;
- o the effect on sectors of the economy other than the one directly affected by the regulation;
- o effects on factor payments (such as wages) in the affected sectors; and
- o changes in labor productivity in those sectors.

In each case, the ultimate question concerns the difference between the state of the economy with the regulation and without the regulation.

Factors Mentioned by the ADL Report

The ADL report mentions, but does not properly analyze:

- o effects of the regulation on the price of benzene;
- o effects of the regulation on the quantity of benzene produced;
- o effects of the regulation on the productivity of labor in the production of benzene;

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- o effects of the regulation on employment in the production of benzene; and
- o effects of the regulation on the structure of the supply side of the markets for benzene and those chemicals which use benzene as an input.

Important Factors Omitted by the ADL Report

The ADL report does not mention, let alone analyze correctly, the regulation's impact on:

- o the GNP;
- o the rate of economic growth;
- o the overall level of employment;
- o the nation's capital markets; or
- o the national requirements for and supply of energy and other critical materials.

The report also fails to mention or analyze the regulation's impact on:

- o the structure of the supply side of markets other than the benzene market or markets for goods in whose production benzene is used directly;
- o the ultimate incidence of the cost of compliance, (that is, how much of the cost burden falls on producers and how much on consumers);
- o firms other than those producing benzene or those which use benzene directly;
- o small businesses;

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- o plant closings; and
- o factor payments (such as wages) in the affected industries.

Invalid Methodological Approach Taken in the Study

My discussion will be divided into two parts:

1. The first part will present examples of errors in the study which are so fundamental that they alone make it impossible to place confidence in the results.
2. The second part of my discussion addresses the overall framework of the study discussed in the ADL report. My point will be that the study was performed in a naive manner and is methodologically unsound.

Fundamental Errors in the Study

ADL presents a lengthy discussion of the concept of price elasticity of demand. This fundamental economic concept was apparently not well understood in the study. I consider this important because the report throughout refers to the elasticity of demand for products affected by the proposed regulation. I would, therefore, like to give a few examples of the author's incorrect use of the price elasticity of demand.

1. Elasticity = 0 implies that there is zero change

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in th quantity demanded as th pric changes.
The definition given in the report on page 6-5 implies that this is what is meant by "inelastic demand." Inelastic demand simply means that the price elasticity of demand is less than one. It does not have to be zero. It implies that the quantity demanded changes by a smaller percentage than does price. A demand curve must be vertical to have a price elasticity of demand equal to zero everywhere and for the quantity demanded to be insensitive to changes in price. This is not required, however, for demand to be inelastic, a point confused by the ADL report.

2. On page 6-6 the report states that a lack of substitute products causes inelastic demand. This statement is simply incorrect; again, an apparent fundamental misunderstanding appears in the report.
3. Price elasticity of demand equal to one is called unitary price elasticity. It occurs whenever the percentage change in the quantity demanded is equal to the percentage change in price. For the demand curve drawn for illustration of unitary price elasticity of demand in Figure 6.2 on page 6-7, unitary elasticity of demand occurs only at one point. It does not occur over the range shown in the figure. What was not understood, apparently,

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is that, for all but very unusual demand curves, the price elasticity of demand changes as one moves along the demand curve. Typically, as one moves down the demand curve, demand becomes less elastic and, conversely, becomes more elastic as one moves up the curve. A demand curve does not normally have an elasticity.

The report repeatedly states that no appreciable reduction in production and employment levels should result from the regulation, since the demand for the affected products is inelastic. Let me stress that it is the inelastic nature of demand, claimed in the report, that leads to the report's conclusion that changes in production levels will be small and reductions in employment will not occur. These are two extremely critical areas of potential impact of the regulation. Given the incorrect manner in which the concept of price elasticity of demand was used in the report, and the fact that inelastic demand was itself defined incorrectly, I feel that OSHA must disregard any result which depends upon, and I quote from page 6-5, ". . . a qualitative assessment . . . of whether or not demand was elastic or inelastic. . . ."

The ADL discussion of the impact of the regulation on the price of an affected commodity begins by stating that the analysis of price effects will be performed assuming perfect competition in the affected industries. The rami-

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fications of this obviously questionable assumption were never addressed.

The report states at page 6-5 that "...the supply function underlying all the affected products was assumed to be infinitely elastic (horizontal), over the long run, with capital free to enter and leave the industry." This supply curve is the supply curve for the total market. The assumption means that any quantity of the commodity that is desired will be produced without any price change being required. It is one thing to assume a horizontal supply curve for a single producer. However, for the market supply curve to be horizontal requires the very stringent assumption that all producers are alike, an assumption which ADL appears to be making. However, such an assumption is clearly inconsistent with later discussions on page 6-9 of a "...marginal producer or producer with a disproportionate cost of compliance" All producers cannot simultaneously be alike and differ in costs of production or compliance. Simplifying assumptions are required in economics and serve to isolate important issues. However, by assuming horizontal supply curves and vertical or nearly vertical demand curves, many factors that should have been analyzed such as production and labor effects, were assumed away.

The method apparently used in the study to calculate the upward shift in the assumed horizontal market supply curve for a good (and, hence, the manner used to determine the increase in the price of that good) -as to take the

calculation of the direct costs of compliance to the industry producing that good and divide it by the quantity of that good produced in the base year. The ADL report claims that this, then, gives the increase in price resulting from the regulation. One of several problems associated with this approach is that the costs of compliance, as calculated in Chapter 5 of the report, depend upon the number of facilities and the number of exposed employees. As the number of facilities and the number of employees do not vary directly with the level of production, the additional cost per unit will not be constant but will depend upon the level of production. The market supply curve will, therefore, not shift upward in the parallel fashion that the report assumes. It would be more likely (if calculated in this manner) to shift upward more for lower levels of production than for higher levels. This would imply a larger increase in price, and, unless demand is perfectly inelastic, a larger reduction in the level of production than the report assumes. Whether the price increase and reduction in the level of production (and employment) would be significant is simply not known at this time.

It must be emphasized that these are not insignificant errors. The impact of anything on an economic system is essentially based upon two fundamental factors - demand and supply. The analysis of demand in the study presented in the report was based on an assessment of the price elasticity

of demand, which as I have just shown, was erroneous. The analysis of supply in the study was based on very questionable assumptions which were also inconsistent with many of the conclusions drawn. This I will return to later. These crippling errors on both the supply side and the demand side of the analysis comprise the very foundation of the ADL analysis, and, thus, the validity of the study's conclusions must be seriously questioned. The study could not be valid.

Overall Framework of the Study

The overall framework of the study is set forth on page 6-6 of the report: "The overall economic impact of the proposed OSHA standard for benzene was assessed using a set of economic parameters and conditions shown in Table 6.1 which could result in a possible adverse impact on a product or industry group."

Table 6.1 appears on page 6-8 of the ADL report and is called "Description of Parameters in the Economic Impact Assessment Matrix." This table lists seven "parameters" and, for each, what is called the "condition for possible adverse impact." Unfortunately, the report does not define "adverse impact." This is a crucial methodological error. The report fails to estimate satisfactorily the effect of the regulation on those parameters, and also fails to justify adequately the selection of the conditions which would lead to an "adverse impact." The seven parameters listed are:

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1. price increase or annualized cost as a percent of sales;
2. substitute products;
3. price elasticity of demand;
4. market growth;
5. volume of imports and exports;
6. market concentration; and
7. cost structure and/or compliance cost differentials.

I will discuss each of these in turn.

Parameter 1 - "Price Increase or Annualized Cost as a Percent of Sales"

The first parameter is "price increase or annualized cost as a percent of sales." The table states that an increase in the price of benzene greater than 5% is a condition for possible adverse impact. The report indicates that a price increase of less than 5% would not be a condition for a possible adverse impact. The only justification for selecting this cutoff level is explained on page 6-6. There the report says: "The threshold value of 5% selected for this analysis is conservative, since most of the products and industries impacted have had real price increases of greater than 5% without serious consequences." Of course, the logical extension of this line of reasoning would be that incremental price increases of 5% could occur infinitum

without "serious consequences", an obviously absurd conclusion. The important points to be made here are as follows:

1. No conclusions regarding the relations among occurrences can be drawn from simple historical observation of an initial event at a point in time and the occurrences which follow it, even if that observation is accurate. That is, it cannot be assumed that all of the observed occurrences and no others are related. More importantly, it is most certainly not true that all occurrences observed in the past would take place if the initial event were to occur again in the future; and .
2. "Serious consequences..." was not defined in the report and no explanation was given as to how the occurrence or not of serious consequences was determined. The method used to analyze the impact of a past price increase was not demonstrated in the report. The means by which the effects of a particular price increase were isolated from all other events taking place at the same time were also not discussed. Presumably, these analyses were not made.

That historical observations were misinterpreted is evidenced by the statement on page 6-31 of the report that "The demand for gasoline is quite inelastic, as evidenced by th larg pric increase over the past sev ral years with

little or no impact on consumption." If the only factor affecting the level of gasoline consumption were its price, the observation that a relatively small percentage change in consumption occurs after a relatively large percentage change in price might imply a relatively low price elasticity of demand for gasoline. However, a great many factors other than price affect the demand for gasoline, and, consequently, the conclusion in the report regarding the price elasticity of demand based upon such simple observations is completely unjustified.

Moreover, on page 6-12 are diagrams showing the movement of the price and consumption of benzene over time. The conclusions to be drawn from simple observation of these diagrams are not clear, since during the period from the early 1960's to the early 1970's the price of benzene remained fairly constant, yet consumption almost tripled. If the only factor affecting consumption were price, what would have been the conclusion in the report concerning the elasticity of demand - that it was close to infinite? In fact, as the price of benzene rose significantly from 1973 to 1975, consumption dropped considerably. The point simply is that no conclusions can be drawn from simple observations. That is why the science of economics was developed. Simple observations appear to have been the approach used in the study. Fruitful analysis is just not that simple. Consequently, the selection of 5% as the cutoff for a price increase below

which no "adverse impact" will occur and above which it might occur can be no more than arbitrary and, therefore, irrelevant. The fact is that the analysis provided no way of determining what a "cutoff level" should be.

Parameter 2 - "Substitute Products"

The second parameter is "substitute products." No explanation is given for why readily available substitute products for producers and unavailable substitutes for consumers are conditions for possible "adverse impacts". The only mention of substitute products in the report is in a discussion of its effect on price elasticity of demand. (This discussion is incorrect, as I have already indicated.) Nevertheless, since the price elasticity of demand is itself a parameter, it is confusing that substitute products is also a parameter. It does not appear that both would be needed. However, since they were both included, I will discuss them both.

If close substitutes are not available to the consumer, neo-classical economic theory indicates that the consumer's demand curve for the product in question would likely be, ceteris paribus, relatively less elastic than if close substitutes were available. This does not mean that the demand curve would be inelastic over the relevant range. In such a case, an increase in the market price of the good would, ceteris paribus, lead to a smaller reduction in the consumption of the good than would occur if close substitutes were available to the consumer, in which case the

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demand curve would be relatively more elastic. But on page 6-11 the report appears to be saying that a smaller reduction in the levels of consumption and production of the good is better than a larger reduction. This is inconsistent with the condition for possible adverse impact regarding the availability of substitute products.

Parameter 3 - "Price Elasticity of Demand"

The third parameter is "price elasticity of demand". As for the stated condition for possible adverse impact regarding the price elasticity of demand, enough has already been said regarding the incorrect use of this fundamental economic concept in the report. The selection of 1.0 as a critical value for the price elasticity of demand is simply unjustifiable on logical grounds. No such justification was even attempted in the report. Besides, Table 6.1 states that the unavailability of substitute products to the consumer is a condition for a possible adverse impact. On page 6-6 the report states (incorrectly) that "a lack of substitutes causes inelastic demand." Yet, Table 6.1 states that elastic demand (price elasticity exceeding 1.0) is a condition for possible adverse impact, and, conversely, that inelastic demand is not such a condition. Therefore, the table states a condition for possible adverse impact whose effect, according to the report, is exactly the opposite of another condition for adverse impact stated in the table. These statements

are clearly contradictory. Moreover, because the report (1) defines inelastic demand incorrectly (page 6-5), (2) permits a simple observation relating only prices and quantities (page 6-31), and (3) argues erroneously that a lack of substitutes causes inelastic demand (page 6-1), no credence can be placed in the report's "...qualitative assessment...of whether demand was elastic or inelastic..." (page 6-5).

Parameter 4 - "Market Growth"

The fourth parameter listed in Table 6.1 is "market growth". The only reference made to the importance of market growth occurs on page 6-9. First, the true economic cost of a regulation does not involve the effects of market growth on the impact of the regulation, but involves the impact of the regulation on market growth. The relevant causality is just the reverse of that suggested by the report. However, the study did not appear to concern itself with the true economic cost of the regulation. Therefore, the condition for possible adverse impact stated in Table 6.1 must be considered in a different light. Again we are left with the question of the definition and target of an adverse impact. The first sentence on page 6-9 says: "Market growth is important because it influences the ability of producers to raise prices to recover cost increases." It is true that a given producer will be able to increase his selling price for a given quantity by a greater amount at a

point of time in the future where the market demand is growing more rapidly, ceterus paribus. Whether this is good or bad, or whether this leads to the possibility of an adverse impact upon someone depends upon what is meant by "adverse impact" and whom it is believed to affect. It is, however, quite arbitrary under any reasonable definition to set as a cutoff condition for market growth, the rate of increase in the GNP or industrial production. Therefore, the parameter itself is not only irrelevant to the assessment of the true impact of the regulation, but the analysis provides no meaningful way of addressing that parameter.

Parameter 5 - "Value of Imports and Exports"

The fifth parameter is "volume of imports and exports." The second paragraph on page 6-9 says that "the volume of imports and exports indicates the potential for a price increase to result in a reduction in the comparative advantage of U.S. producers compared to those in other countries and in a subsequent adverse impact on the balance of trade." First, the volume of import or export of a commodity does not give an indication of the potential for a price increase to result in a reduction in the level of import or export of that commodity. Moreover, an increase in the price of one commodity can never affect the comparative advantage of producers of that commodity, because producers of a particular

commodity do not have a comparative advantage in the world markets for that commodity. They have an absolute advantage. Comparative advantage is something possessed by the U.S. as a whole, and not by individual producers.

What the report is trying to say seems to deal with the absolute advantage in the world market of U.S. producers of a commodity. However, the volume of import or export of a commodity says nothing of the potential loss of the absolute advantage of U.S. producers resulting from an increase in the cost of producing the commodity domestically. What is important, given the world price of a good, is the price elasticity of the domestic supply of the good over the relevant range of the domestic supply curve. (Parenthetically, it should be noted that, according to the international trade literature, if the domestic supply curve is horizontal, as assumed in the report, then there would not be both domestic supply and import. The fact that a good is imported is an indication that the domestic supply curve is not horizontal but is upward sloping.) The flatter that supply curve, or the relatively more elastic, the greater the increase in the level of import which would result from a given increase in production costs. If the report is even partially correct, and the domestic supply curve for one of the affected commodities is almost horizontal, there could be a substantial increase in the level of import of that commodity.

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Parameter 6 - "Market Concentration"

The sixth parameter is "market concentration." It should be noted that, analogous to market growth, the study was not looking here at the effect of the proposed regulation on market structure. Rather, it was attempting to say whether the current structure of a market (and then, only the supply side) leads to the "possibility of adverse impact." The only justification given in the report for considering market concentration in this manner is stated on page 6-9, that "if the number of firms in a market are few (i.e., high market concentration), the probability that a marginal producer or a producer with a disproportionate cost of compliance can increase price to recover cost is greater than if the industry is fragmented."

(Immediately, it should be stated that this contradicts the report's assumption of horizontal market supply curves.) The fact is that if a commodity from one producer is equivalent in the consumer's eyes to that same commodity from another producer, the extent to which the market price will increase is not affected in any predictable way by the number of firms in the market. Furthermore, a cutoff condition for possible adverse impact for the parameter "market concentration" being set at "very low; fragmented," as the table specifies, is imprecise to say the least. As noted for other areas, the report fails to define such terms as "very low" and "fragmented." Further, no discussion was offered as to why it

was believed that these concepts were important to consideration of impact.

Parameter 7 - "Cost Structure and/or Compliance Cost Differentials"

The seventh parameter, "cost structure and/or compliance cost differentials," provides another imprecise cutoff condition for possible adverse impact in its consideration of "wide variations within the industry." Once again, one has to ask what the report means by "adverse impact" and who must bear it. If the notion involves plant closings or firms going out of business, then differential costs of production among firms is no more relevant to future conditions with the regulation than to current conditions without it. That is, no indication is given for why if a higher cost producer can exist now he could not exist after the regulation and subsequent price increase. His higher costs are not in this case due to the regulation. If, on the other hand, there are differences in the costs of compliance, then those producers with higher costs of compliance might be driven from the market. Under some definitions, this might be called an adverse impact; under others, it would not.

It is not surprising that the report discusses differential compliance costs only for coke oven producers of benzene. In the description of the method of calculating the direct costs of compliance, producers were not grouped

according to those characteristics which would cause differential compliance costs, and all producers within a group were assumed to be exactly alike. Therefore, they would each have the same costs of compliance. It was impossible for the differential costs of compliance to be distinguished within a category; for example, refineries. It therefore seems that the study was not able to address the last parameter in Table 6.1.

Conclusions Concerning the Overall Framework Used in the Assessment of the Economic Impact

The seven parameters presented in Table 6.1, which comprise the economic impact study of the regulation presented by the ADL report, can be summarized in two general categories:

1. Those that are irrelevant to economic impact (such as "volume of imports and exports") or whose association with the economic impact is ambiguous (such as "cost structure" or "market concentration"); and
2. Those which are relevant to economic impact but for which:
 - (a) the condition for possible adverse impact was set arbitrarily; and
 - (b) the effect of the proposed regulation on the parameter was measured incorrectly.

Such a framework can hardly be accepted as a valid process for doing economic analysis, and cannot be considered to provide reliable results.

Specific Comments Regarding Important Factors Omitted by the Report

My final comments refer to some important issues not addressed in the report. One of the most important areas of potential impact of the regulation, given the large number of workers affected, is employment. The study did not satisfactorily analyze the impact of the regulation on the level of employment and labor productivity in the industries which must comply with the proposed standard, much less in the economy as a whole. The report's conclusion seems to be that, since compliance with the proposed regulation will require additional tasks to be performed, employment must increase. It goes on to suggest that increased employment combined with constant or slightly reduced production would then yield reduced average productivity. I have already discussed the fact that the study did not analyze production effects. By its assumptions of inelastic demand and horizontal market supply curves, the report, in effect, assumes that production would not be reduced.

While some of the compliance activities would create new demands for labor (for example, industrial hygienists and medical doctors), compliance costs are directly affected

by the number of employees. That is, the regulation imposes additional costs on the employer for each worker affected by the regulation. The regulation may be considered to act like a tax on labor. As in the case of other input taxes, the employer then begins to substitute, where possible, other inputs for the now higher-priced input (labor in this case). The degree to which such substitution occurs depends, *ceteris paribus*, upon the relative level of the tax and the rate of technical substitution possible between the two inputs. While a tax on labor may merely extract profits from the producers in the short run when less substitution is possible, more substitution would normally be expected over time. This substitution would not necessarily manifest itself through layoffs of workers, although such an outcome could occur. A more predictable result of the imposition of the regulation would be that fewer workers would be hired in the future than would be hired in the absence of the regulation.

The report indicates that the study did not address the impact of the higher cost that each worker would represent to the employer with the regulation than without it. Using the report's methodology for calculating the direct costs of compliance, this tax, or increase in what the employer must pay for each laborer, is somewhere between \$600 to \$1,900 for the first year and \$350 to \$1,000 for subsequent years, depending upon whether all employees are monitored or only a

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representative sample. These costs reflect operating costs alone, and do not include capital costs. This per unit increase in the cost of labor to the employer is not insignificant and can be expected to have an impact on employment.

Another point overlooked in the report is that micro-economic theory states that if additional amounts of labor make capital equipment more productive at the margin (which is normally assumed to be the case), then if the price of labor increases (say due to a tax like that imposed by the proposed regulation), then even though capital will be substituted for labor, in that the ratio of capital to labor will increase, the absolute level of investment will fall, as the level of employment is reduced and the investment becomes less productive at the margin. The implications of such a reduction in investment in the energy sectors was not addressed by the study. The study also neglected to address the impact on the production of energy of an increase in the cost of labor used in the energy industries.

Conclusions Regarding the Adequacy of the Study

In conclusion, let me repeat what I stated at the beginning of my testimony regarding economic impact. The proposed regulation, if adopted, could affect a significant number of industry facilities, employees and products. Many of these products are themselves used at other facilities,

where more employees work to produce more products. Where the presence of benzene is sufficient to cause the firms to engage in compliance activities, the costs of those activities must be paid by those firms. The firms not required to undertake compliance activities will still be impacted by the regulation, however, through the resulting changes in relative prices in the economy.

That the numbers of facilities and employees affected by the proposed regulation are very large cannot be contested. Certainly the impacts of such a far-reaching regulation are potentially significant and widespread. Accordingly, it should be OSHA's responsibility to analyze these potential impacts. The purpose of this part of my testimony has been to point out that the ADL study has not adequately assessed those impacts.

The methodology of economic analysis was not developed yesterday. It is not a secret told only to a select few who are unknown, make themselves unavailable, or will not offer their skills. Competent economists are easily identified who can perform the required study. In view of this, and given the importance of the potential impact on the entire economy, it is disturbing that no real analysis has been performed. Answers should be found to questions regarding such important issues as:

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- the differential compliance costs among small and medium sized producers within categories and the effects of this on the viability of small businesses;
- the potential impact on employment;
- the potential reduction in the supply of energy; and
- the potential effect on prices paid by consumers.

None of these and other important questions have been adequately addressed thus far. OSHA can claim that the potential impacts are unimportant and then explain why, if this is true, ADL was contracted to address them. However, my testimony suggests that OSHA cannot claim to know what the economic impact of the proposed regulation might be if that knowledge was supposedly gained from the ADL report.

The framework or methodology of a study assessing economic impact may be likened to a computer program into which data are entered. The errors in the ADL study that I have discussed are analogous to errors in that computer program. Fortunately, modern computers identify many of the errors contained in a program. These errors can then be corrected. However, if program errors remain, and data are read in and the program run, the resulting outputs will be skewed and the conclusions based on analysis of these outputs will be

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similarly warped. It is the errors in the program of the ADL study on which I have focused. No matter what data were read into the program, or framework for the study, the results would be erroneous. This is the reason why the study's assessment of economic impact cannot be accepted. However, I would now like to add the fact that the certain data feeding into the study were also incorrect. Specifically, the direct costs of compliance of the proposed OSHA regulation on benzene as estimated by ADL in Chapter 5 of its report are significantly understated. The general nature of the errors is as follows:

1. Several industries which would be affected by the proposed benzene regulation were omitted from the ADL study. Within the petroleum industry alone, two major industry categories -- production and transportation -- were excluded from ADL's cost estimates. These two industry categories could account for as much as 30% of all direct costs of compliance borne by the petroleum industry.
2. The costs of some compliance activities were underestimated. In particular, measurement and medical surveillance activities that would be required by the proposed standard were undervalued in the ADL study.

3. Some compliance activities were not identified and costed out in the ADL report. For example, the costs associated with increased shutdown time at certain oil refinery and petrochemical plant process units were neglected in the study.

In addition to these deficiencies, the ADL study failed to consider the differential impact that costs of compliance would likely impose on different facilities and firms within industry categories.

Because of these errors and omissions within ADL's costs of compliance estimate, we have conducted an independent assessment of the direct costs of compliance with the proposed benzene regulation for the petroleum industry. We have also attempted to identify the differential impact the proposed standard might have on independent as opposed to major company-owned facilities and on small versus large facilities.

The results of our analysis of the direct cost of compliance that would be borne by the petroleum/petrochemical industry can be compared to the findings of the ADL study as follows:

I. INDUSTRY SECTORS INCLUDED:

<u>API ANALYSIS</u>	<u>ADL STUDY</u> ^{1/}
Benzene Production from Petroleum Derivatives	Benzene Production from Petroleum Derivatives
All Marine Transportation	Barge Transportation of Benzene
Tank Car Transportation of Benzene	Tank Car Transportation of Benzene
Chemical Processing	Chemical Processing
Petroleum Refining	Petroleum Refining
Bulk Terminals	Bulk Terminals
Production	
Pipeline Transportation	

II. FIRST YEAR DIRECT OPERATING COSTS OF COMPLIANCE FOR THE PETROLEUM INDUSTRY:

API Analysis:	\$155 million
ADL Study:	\$ 73 million

III. RECURRING ANNUAL DIRECT OPERATING COSTS OF COMPLIANCE FOR THE PETROLEUM INDUSTRY:

	<u>With a 1% Standard</u>	<u>With a .1% Standard</u>
API Analysis:	\$105 million	\$152 million
ADL Study:	\$ 44 million	\$ 44 million

^{1/} The ADL Study also included Bulk Storage of petroleum products. This category has since been excluded by OSHA.

IV. COSTS ASSOCIATED WITH INCREASED REFINERY PROCESS
UNIT SHUTDOWN TIME:

API Analysis: \$4.9 million

ADL Study: \$ 0 million

V. COSTS ASSOCIATED WITH INCREASED PETROCHEMICAL PLANT
PROCESS UNIT SHUTDOWN TIME:

API Analysis: \$ unknown

ADL Study: \$ 0

VI. CAPITAL INVESTMENT COSTS FOR THE PETROLEUM INDUSTRY:

API Analysis: \$ unknown

ADL Study: \$212 million

Our findings with respect to the differential impact of the proposed regulation on facilities and firms within industry categories suggest that, at least for petroleum refining, costs of compliance will vary significantly on the basis of facility size and that the type of facility ownership (independent versus major) will influence the manner in which the costs are imposed (i.e., direct versus indirect).

To discuss the direct costs of compliance to the petroleum industry of the proposed benzene standard in more detail, I will focus on two major areas: first, I will address the petroleum industry's estimates of likely industry-wide direct costs of compliance; and second, I will address the petroleum

industry's efforts to identify differential impacts of these costs within industry categories.

Direct Industry-Wide Costs of Compliance

Consistent with the format and terminology of the ADL study, our direct costs of compliance estimates for each of the petroleum industry sectors include first year and recurring operating costs as well as capital investment costs. In addition, our cost assessment identifies costs associated with the increased shutdown time at certain refinery and petrochemical process units that would be necessitated by compliance with the proposed regulation.

All of our calculations of compliance costs are documented in the tabular materials which have been submitted with this testimony, and are labeled Tables 1-11.

First Year Operating Costs

Beginning with first year operating costs, compliance activities include the measurement of employee exposure levels, medical surveillance of exposed employees, the purchase of respirators and personal protective equipment, the implementation of an employee information and training program, the keeping of records, and the purchase of appropriate labels and signs. These are the same compliance activities considered in the ADL study.

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For some of these activities, including the purchase of respirators and personal protective equipment and the cost of labels and signs, we have used the cost estimates prepared by ADL because there was insufficient time to do a full independent examination of these cost areas.

However, with respect to measurement, medical surveillance, employee training and recordkeeping activities, we judge ADL to have miscalculated compliance costs. In particular, ADL underestimated the costs of the required medical surveillance program and miscalculated measurement costs that would be incurred using appropriate sampling techniques.

Our estimate of probable first year operating costs for petroleum/petrochemical facilities is \$155 million, compared to \$73 million estimated by ADL. The major differences between the two estimates are: first, the inclusion in our estimate of employees in the petroleum production and transportation sectors; and, second, our inclusion of all bulk terminal employees. According to our estimates, major first year operating costs of compliance will be incurred in the production, marine and pipeline transportation, and refining sectors of the petroleum industry.

We would like to note, too, that only \$20 per facility has been allocated for initial measurement costs. While no specific data are available at this time, we believe this cost significantly underestimates initial measurement costs

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at certain facilities, such as production facilities, where samples would have to be taken and analyzed.

Recurring Annual Operating Costs

Taking recurring operating costs next, our estimates include costs attributable to measurement, medical surveillance, employee training, and recordkeeping. These are the same cost areas considered by ADL, with the exception of employee training. ADL failed to include an annual cost for training new (that is, turnover) employees.

In addition to these recurring annual costs, we submit, as does ADL, that some additional costs will likely be incurred for respiratory protective equipment following the installation of engineering controls. These additional costs have not been included in our estimates.

Consistent with the methodology employed by ADL, we have assumed full compliance with the benzene standard following the first year. To the extent that any part of the industry does not comply within one year, recurring operating costs will be increased.

Our estimate of recurring annual operating costs to the petroleum industry resulting from compliance with the proposed regulation totals \$105 million. This estimate compares to an estimate of \$44 million prepared by ADL. Again, the major cost differences result from our inclusion of production and

transportation sector facilities and all bulk terminal employees.

These estimates assume that the standard's exclusion criteria remains at 1%. Lowering the standard to include all streams containing .1% benzene or greater would increase recurring annual costs by over \$45 million, according to our estimates, plus an additional \$25 million during the first year of the .1% standard. These incremental costs would fall solely on the production sector.

Increased Shutdown Time Costs

In addition to annual operating costs, we have also identified increased process unit shutdown time as representing another cost area. We estimate that an extra two-thirds to one full day will be required during each planned turnaround and emergency shutdown at many refinery and petrochemical plant process units in order to fully purge streams and otherwise meet the exposure limits imposed by the proposed regulation. Conservatively, we estimate that this extra two-thirds to one full day of down-time will be incurred once each year for some process units.

This additional down-time imposes two kinds of costs. First, there is a loss of separation value from decreased production of benzene and of toluene and xylene at BTX units. And second, there is lost value from reduced reforming,

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cracking, and other processing of refinery and petrochemical plant streams and labor costs from the additional shutdown activities required at these units.

We have estimated the lost separation value from reduced benzene, toluene and xylene production at \$1.7 million per year. We have estimated other shutdown costs at refineries at \$3.2 million per year. ADL provides no estimate of these costs.

It should be noted that these shutdown costs would also accrue to petrochemical plants in that units where benzene is manufactured, is present as a by-product, or is used as a raw material would also require additional shutdown time. Unfortunately, it has not been possible to estimate these costs in the short time available prior to this hearing.

Capital Investment Costs

The final type of cost that would result from the proposed regulation is capital investment in required engineering controls. These costs have been estimated by ADL for those segments of the petroleum industry that were included in their cost assessment. We have been unable to examine fully these capital investment estimates and prepare similar estimates for the other sectors of the petroleum industry. However, based on the ADL estimates, it is apparent that capital investment represents a major cost element for many sectors of the petroleum industry, particularly refining, bulk storage

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and chemical processing. These capital costs should be more carefully examined before promulgating any regulation, in our opinion.

Differential Impact of Costs of Compliance Within Industry Categories

The costs of compliance estimates prepared by both ADL and API have focused on total industry-wide costs. Aggregating costs in this way tends to obscure the fact that these costs will likely not be borne equitably throughout each industry category.

Our analysis of the direct costs of compliance also includes an attempt to identify the differential impact the proposed standard might have on independent as opposed to major company-owned facilities and on small versus large facilities. Because of the limited time and data available to undertake this type of analysis, we have focused on petroleum refining as the primary industry sector in which differential impacts are likely to occur. However, we would like to note that differential impacts on the basis of ownership and/or size is also likely within other sectors of the industry, particularly in chemical processing operations and at bulk terminals.

Operating Costs

With respect to operating costs of compliance, labor usage will be the primary determinant of cost. However, labor usage per unit of output varies considerably with the size of the refinery and its ownership. For example, a typical 20,000 b/d refinery owned by an independent company employs about 125 workers compared to about 180 workers employed by a major company-owned refinery of the same size. Therefore, it would appear that direct operating costs of compliance might be lower for the independent refinery.

However, one of the major reasons for the labor usage differential is that independent refining companies tend to contract out more of their maintenance work than the major companies. This has two implications: first, direct operating costs of compliance to the independent refinery will be lower than those borne by the major refinery of comparable size, but the independent refiner will incur indirect costs in the form of increased contract maintenance charges to cover compliance costs borne by the contractors; and second, total refining operating costs are understated to the extent that these indirect cost increases to small independent refineries are not included.

The next point to be made relative to differential operating costs to refiners is that labor usage within ownership categories decreases markedly with size. For instance,

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a major company-owned refinery of 40,000 b/d capacity typically employs 90 workers per 10,000 b/d capacity while a major company-owned refinery of 300,000 b/d capacity typically employs less than half that number, 42 workers per 10,000 b/d capacity. Therefore, operating compliance costs, on a per unit of output basis, will be considerably lower for a large refinery than for a small refinery. Our calculations indicate that typical annual operating costs for major company refineries will be approximately \$4.23 per b/d capacity the first year and \$2.49 per b/d capacity thereafter for a 40,000 b/d refinery compared to \$2.58 and \$1.53 respectively for a 300,000 b/d refinery.

Increased Shutdown Time Costs

With regard to lost separation value and other increased shutdown time-related costs, refineries will of course incur costs in direct proportion to the extent to which their processing schemes include those affected units. Refineries incurring these costs will include many independent, as well as major company-owned, facilities.

Capital Investment Costs

The distribution of capital investment costs among refineries will depend on a number of factors, including the product mix and age of each particular refinery and the type of crude it runs.

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For example, a refinery producing largely gasoline will have different process units than a refinery producing largely distillates. An older refinery will generally require more capital investment than a new refinery. And a refinery running a crude such as North Slope crude, with a high natural benzene content, will require more engineering controls than a refinery running a crude such as Gulf Coast crude with a much lower natural benzene content.

Because of all these individual facility differences, it is difficult to generalize about the differential capital costs that will be incurred at refineries differing with respect to ownership and size. However, a couple of observations can be made. First, there is no reason to believe that capital investment costs would vary from refinery to refinery merely on the basis of ownership. And second, it is reasonable to assume that, given refineries of the same age, crude type and product mix, capital investment costs will rise less than proportionately with refinery size, thus imposing a greater per unit of output investment cost burden on smaller refiners.

In our judgment, considerable further effort should be devoted to assessing ADL's direct cost of compliance estimates. In particular, the industries included should be critically reviewed; the capital estimates should be further examined; and the distribution of the direct costs of compliance

among facilities and among firms, together with the potential economic impact of this distribution of costs, should receive careful consideration.

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CURRICULUM VITAE
of
JOHN E. SCARBROUGH

Dr. Scarbrough is a senior economist in the Policy Analysis Department of the American Petroleum Institute (API).

Prior to joining API, Dr. Scarbrough was a senior consultant with Peat, Marwick, Mitchell & Co.

His research there involved the development of a mixed-integer programming model to analyse the effectiveness of various policy decision regarding air transportation by time of day and the effects of such policies on an air transport system. He applied this model to the analysis of policies aimed at reducing congestion at major U.S. airports. On the other projects there, Dr. Scarbrough conducted several studies of the relative impacts of various investment incentives in stimulating innovation in industry.

Before joining Peat, Marwick, Mitchell & Co., Dr. Scarbrough was an assistant professor of economics at Virginia Polytechnic Institute and State University (VPI&SU) in Blacksburg, Virginia. His research there involved the application of mathematical programming models to the analysis of the effects of domestic and international policies upon production levels and costs of industries in South America.

Dr. Scarbrough's Ph.D. dissertation involved an application of a mathematical programming model to selected countries in South America in order to study the economic effects of multilateral tariff reductions in Latin America. Since that time, he has also authored papers related to various methods of empirically measuring the economic effects of customs unions, the relative impacts of unilateral tariff reductions and multilateral trade agreements, and the economic efficiency of the airlines.

While at VPI&SU, Dr. Scarbrough taught graduate courses in production theory, conducted graduate seminars in applied international trade models, and also taught public finance and economic growth and development. Previously, he taught economics at the University of Minnesota.

Dr. Scarbrough received the Bachelor of Arts degree in economics from Texas Tech University and the Doctor of Philosophy degree in economics from the University of Minnesota.

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Table 1

P troleum/P troch mical Industry Employ s
Affected by the Propos d Benz ne Regulation

<u>Industry Sector/ Facility Type</u>	<u>Number of Facilities</u>	<u>Exposed Employees</u>
<u>Oil/Gas Production</u>		
At 1% <u>1/</u>	49,200	19,600
At .1% <u>2/</u>	329,600	65,800
<u>Transportation</u>		
Marine (barges)	1,100	13,200
Pipelines	3,000	12,000
Tank Car (Benzene)	100	100
Tank Truck (Benzene)	200	200
<u>Manufacturing</u>		
Benzene Producers	48	2,160
Petroleum Refineries	275	98,000
Chemical Processing	92	2,760
<u>Marketing</u>		
Bulk Terminals	11,925	40,222

1/ Facilities estimated at 2% of all producing oil wells (total oil wells = 500,000); plus 30% of all producing gas wells (total gas wells = 130,000); plus 25% of all gas plants (total gas plants = 754). Exposed employees estimated at 40% of all affected wells.

2/ Facilities estimated at 45% of all producing oil wells plus 80% of all producing gas wells; plus 75% of all gas plants. Exposed employees estimated at 20% of affected wells.

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Table 2

First Year Direct Operating Costs of
Compliance for the Petroleum/Petrochemical Industry
(At 1%)

<u>Industry Sector/ Facility Type</u>	<u>Measure- ments</u>	<u>Medical</u>	<u>Respira- tors</u>	<u>Personal Protective Equipment</u>	<u>Employee Training</u>	<u>Record- keeping</u>	<u>Labels & Signs</u>	<u>Total</u>
<u>Oil/Gas Production</u> ^{1/}	\$14,212,616	\$5,507,600	NA	NA	\$1,108,120	\$288,000	\$305,450	\$21,421,786
<u>Transportation</u>								
Marine ^{2/}	9,499,978	3,709,200	2,692,800	33,000	304,040	123,200	22,917	16,385,135
Pipelines ^{2/}	7,390,680	3,372,000	0	0	476,400	144,000	111,750	11,494,830
Tank Car (Benzene)	124,751	28,100	20,000	300	11,470	2,400	2,000	189,021
Tank Truck (Benzene)	248,476	56,200	41,000	500	22,940	4,800	4,000	377,916
<u>Manufacturing</u>								
Benzene Producers	268,205	606,960	441,000	6,000	36,552	18,048	12,000	1,388,765
Petroleum Refineries	8,498,949	27,538,000	19,987,000	258,000	1,468,100	788,400	68,000	58,606,449
Chemical Processing	393,249	775,560	561,000	6,570	49,772	23,552	12,600	1,832,303
<u>Marketing</u>								
Bulk Terminals	27,500,035	11,302,382	2,446,000	31,000	783,763	352,576	498,000	42,913,756
Total								\$154,609,960

1/ Assumes 6 facilities per workplace and 100% compliance

2/ Assumes 100% compliance

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Not s to Table 2

Measurements: Assumes a 100% sample of affected facilities with a 16% sample of employees at facilities with 30 or more employees and a 100% sample of employees at facilities with less than 30 employees. Also assumes that 80% of all sampled employees are below permissible exposure limits (and require quarterly monitoring) and that 20% of all sampled employees are above permissible exposure limits (and require monthly monitoring) unless otherwise noted.

Calculated as follows:

(1) Initial evaluation	\$20 per facility
(2) Measurements:	
- labor	\$20 per employee
- charcoal tubes @ 2 per employee plus 1 blank per facility (cost of \$.71 per tube;)	\$1.42 per employee plus \$0.71 per facility
- Analysis @ \$35 per sample	\$70 per employee plus \$35 per facility
- Calibration @ \$10 per sample; 2 samples per employee plus 1 sample per facility	\$20 per employee plus \$10 per facility
- Notification @ \$2 per employee	\$2 per employee
- Measurement equipment @ one pump (\$348) plus one calibration kit (\$98) per facility	\$446 per facility per year
- Total	\$113.42 per employee plus \$45.71 per facility plus \$446 per facility per year

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Medical: Calculated as follows:

(1) Annual exam:

- physician's time
- lab fees
- employer's time
- employee's time

\$35 per employee
34 " "
10 " "
28 " "

- Total

\$107 per employee

(2) Follow-up exams:

- employee's time
- lab fees
- physician's time

\$ 14 per employee
34 " "
10 " "

- Total

\$ 48 per employee

(3) Total medical costs @ one annual exam and 3 follow-up exams per year

\$281 per employee

Employee Training: Calculated as follows:

(1) Preparation cost @ 4 hours per facility, \$20 per hour

\$ 80 per facility

(2) Materials cost @ one copy for each employee of the regulation and appendices (5 pages) and appropriate background and instructional information (2 pages) (total 7 pages; 10¢ per page)

\$.70 per employee

(3) Training Costs @ 1 hour of trainer's time (\$20) plus 1 hour of each employee's time (\$14)

\$ 14 per employee plus \$20 per facility

(4) Total employee training costs:

\$ 14.70 per employee plus \$100 per facility.

Recordkeeping: Calculated @ 2 hours of clerical
time per year (at \$8 per hour) plus one hour
of clerical time per employee for medical records
(at \$8 per hour)

\$ 8 per employee plus \$16 per
facility

Labels and Signs: Calculated @ one roll of 100
chemical labels (\$14.75) per facility plus
\$22.50 per sign per facility

\$14.75 per facility plus \$22.50
per sign per facility

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Table 3

**Subsequent Year Direct Operating Costs
of Compliance for the Petroleum/Petro-
chemical Industry (At 1%)**

<u>Industry Sector/ Facility Type</u>	<u>Measurements</u>	<u>Medical</u>	<u>Employee Training</u>	<u>Record- keeping</u>	<u>Total</u>
<u>Oil/Gas Production</u> ^{1/}	\$10,621,016	\$ 5,507,600	\$355,440	\$288,000	\$ 16,772,056
<u>Transportation</u>					
Marine	6,220,500	3,709,200	62,480	123,200	10,115,380
Pipelines	6,076,680	3,372,000	136,800	144,000	9,729,480
Tank Car (Benzene)	66,452	28,100	4,140	2,400	101,092
Tank Truck (Benzene)	132,904	56,200	8,280	4,800	202,184
<u>Manufacturing</u>					
Benzene Producers	166,912	606,960	4,944	18,048	796,864
Petroleum Refineries	7,171,683	27,538,000	148,200	788,400	35,646,283
Chemical Processing	219,742	775,560	7,544	23,552	1,026,398
<u>Marketing</u>					
Bulk Terminals	18,653,784	11,302,382	133,311	352,576	30,442,053
Total					\$104,831,000

^{1/} Assumes 6 facilities per workplace

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Notes to Table 3

Measurements: Assumes a 100% sample of affected facilities, with a 16% sample of employees at facilities with 30 or more employees. Also assumes that all sampled employees are below permissible exposure limits (and require quarterly monitoring). If any employees are still above permissible exposure limits, costs will be higher.

Calculated as follows:

- labor	\$20 per employee
- charcoal tubes @ 2 per employee per sample & 1 blank per facility (cost of \$.71 per tube);	\$1.42 per employee plus \$0.71 per facility
- Analysis @ \$35 per sample	\$ 70 per employee plus \$35 per facility
- calibration @ \$10 per sample; 2 samples per employee plus 1 sample per facility	\$ 20 per employee plus \$10 per facility
- notification @ \$2 per employee	\$ 2 per employee
- measurement equipment @ 1 pump overhaul (@ \$85) every 3 years	\$28 per facility per year

Total

\$113.42 per employee plus
\$ 45.71 per facility plus \$28 per
facility per year.

Medical: Calculated as follows:

(1) Annual exam:

- physician's time	\$35 per employee
- lab fees	\$34 " "
- employer's time	\$10 " "
- employee's time	\$28 " "
- Total	\$107 per employee

(2) Follow-up exams:

- employee's time	\$14 " "
- lab fees	34 " "
- physician's time	10 " "
- Total	\$58 per employee

(2) Total medical costs @ one annual exam and 3 follow-up exams per year

\$281 per employee

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Employee Training: Calculated as follows:

- (1) Preparation cost @ 1 hour per facility,
\$20 per hour
- (2) Training costs @ 1 hour of trainer's time
(\$20) plus 1 hour of employee's time (\$14)
for new employees @ 10% turnover

\$20 per facility

\$14 per employee x 10% plus
\$20 per facility

- (3) Total employee training costs:

\$1.40 per employee plus \$40 per
facility

Recordkeeping: Calculated @ 2 hours of
clerical time per year (@ \$8 per hour)
plus one hour of clerical time per employee for
for medical records (@ \$8 per hour)

\$8 per employee plus \$16 per facility

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Table 4

First Year Operating Costs for th
Oil and Gas Production Sector, At 18^{1/}

Measurements	\$61,837,672
Medical	18,489,800
Respirators	NA
Personal Protective Equipment	NA
Employee Training	6,460,560
Recordkeeping	1,405,328
Labels and Signs	1,740,804
Total	\$89,934,164

1/ Assumes 6 facilities per workplace

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Table 3

Subsequent Year Operating Costs for
the Oil and Gas Production Sector, At. 1^{1/}

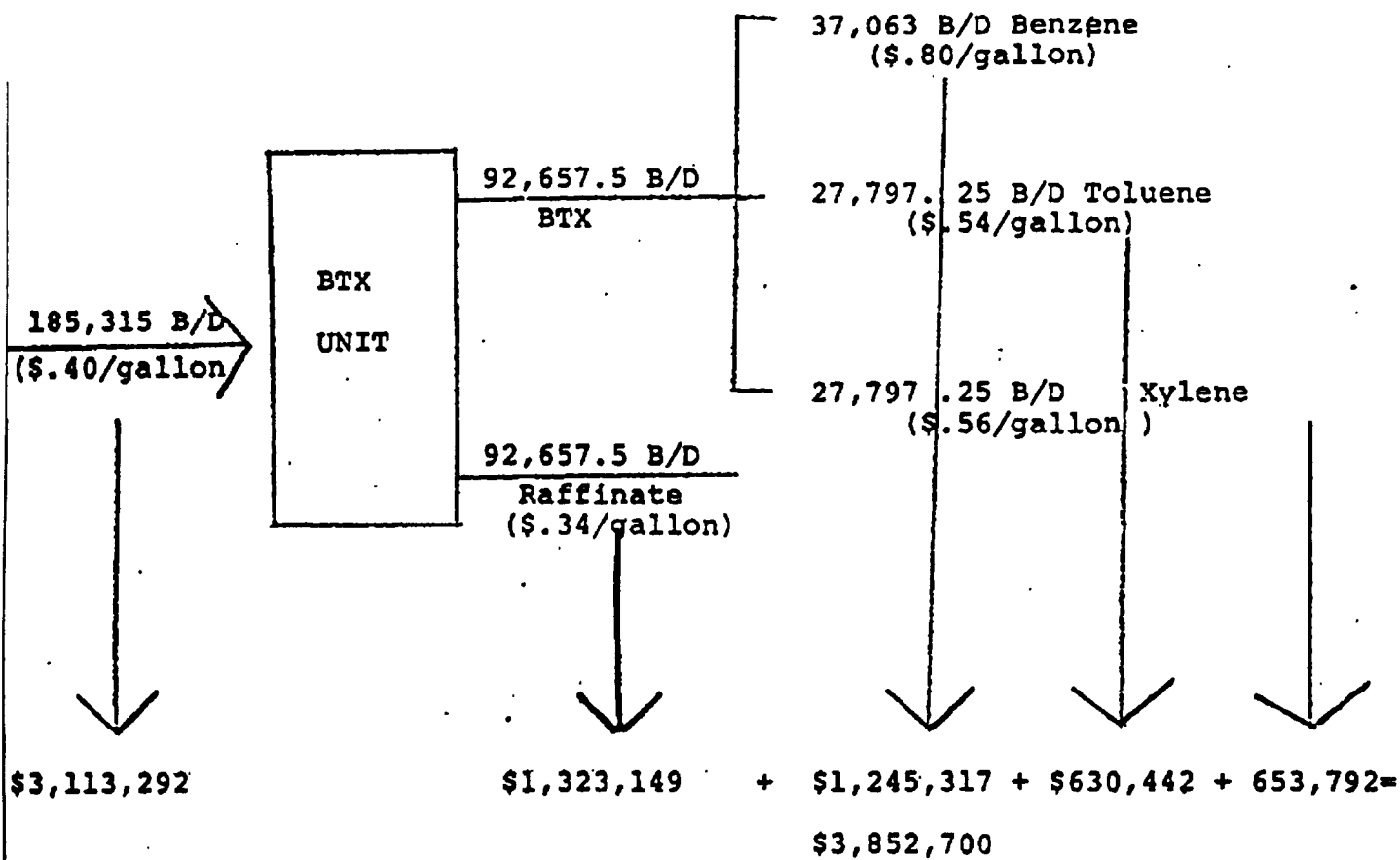
Measurements	\$41,434,218
Medical	18,489,800
Employee Training	2,289,440
Recordkeeping	1,405,328
Total	\$63,618,786

1/ Assumes 6 facilities per workplace

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Reduced Benzene, Toluene, and Xylene Production
At BTX and Other Refinery Units
 (At One Day Lost Time Per Year)



Lost BTX Separation Value (Per Day) = \$3,852,700
 - 3,113,292

 \$ 739,408

Lost Value From Other Benzene
 Production from Petroleum (Per Day) = \$2,332,243 gallons
 x \$.40 per gallon

 932,897

TOTAL LOST SEPARATION VALUE = \$1,672,305

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Table 7

**Estimated Incremental Shutdown Time Costs
at U. S. Refinery Process Units**

	No. of Facilities ^{1/}	U.S. Daily Capacity ^{1/} (Barrels)	Costs of Oil (inc. Profit Loss) of 2/3 Day Additional Downtime ^{2/}		Labor ^{3/} Cost
			(Cents Per Barrel)	(Total Dollars)	
Cat hydrotreating :					
Naphtha Olefin					
or Aromatics Saturation	14	96,600	10.7	10,336	2,520
BTX	27	185,315	14.7	27,241	4,860
Hydrodealk lation	10	25,750	10.7	2,755	1,800
Cyclohexane	6	12,100	10.7	1,295	1,000
Cat Hydrocracking	35	907,823	42.4	384,917	6,300
Cat Reforming	177	3,670,206	14.7	539,520	31,860
Thermal Process:					
Visbreaking	17	199,550	2.5	4,989	3,060
Thermal cracking	25	273,350	1.7	4,647	4,500
Coking	51	1,017,360	8.4	85,458	9,180
Cat cracking	144	4,932,022	42.4	2,091,177	25,920
				<u>3,152,335</u>	<u>91,080</u>

^{1/}Source: "Annual Refining Survey," Oil and Gas Journal, March 28, 1977, pp. 97-123

^{2/}Based on W.L. Nelson, "Downtime Cost - Part II," Guide to Refinery Operating Costs, p. 88, inflated to 1977 dollars using the process unit cost index from W.L. Nelson, "Here's How Operating Cost Indexes are Computed," Oil and Gas Journal, Jan. 10, 1977, p. 87, and "Nelson Cost Indexes," Oil and Gas Journal, June 6, 1977, p. 190. Assumes 2/3 day incremental downtime per shutdown (@ one shutdown per year) based on conversations with refinery management personnel.

^{3/}Based on \$7.50 per hour average wage plus 50% overhead per employee at 2/3 day (see footnote ^{2/})

Table 8**Typical Labor Usage Patterns
at U. S. Petroleum Refineries****Ownership/Capacity (B/D)****Workforce per 10,000 B/D Capacity****Independents**

10,000	92.8
20,000	61.5
30,000	49.4
40,000	43.0

Majors

20,000	89.5
40,000	68.5
60,000	58.7
80,000	54.0
100,000	51.1
150,000	46.5
200,000	44.4
300,000	42.0

Source: W. L. Nelson, "Effects of Size on Refinery Operating Cost," The Oil and Gas Journal, January 15, 1973, page 79.

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Table 9

**First Year Direct Operating Costs at
U.S. Refineries, By Ownership and Size
of Refinery**

(In Dollars)

<u>Refinery Capacity (B/D)</u>	<u>Measure- ments</u>	<u>Medical</u>	<u>Respira- tors (@ \$204/emp.)</u>	<u>Personal Protective Equipment (@ \$2.63/emp.)</u>	<u>Employee Training</u>	<u>Record- keeping</u>	<u>Labels/ Signs</u>	<u>Total</u>
<u>Independents</u>								
10,000	10,467	26,133	18,972	245	1,467	760	247	58,291
20,000	15,719	34,563	25,092	323	1,908	1,000	247	76,609
30,000	16,057	41,588	30,192	389	2,276	1,200	247	91,949
40,000	18,497	48,332	35,088	452	2,628	1,392	247	100,636
<u>Majors</u>								
20,000	19,208	50,299	36,516	471	2,731	1,448	247	110,920
40,000	28,864	76,994	55,896	721	4,128	2,208	247	169,058
60,000	36,792	98,912	71,808	926	5,274	2,832	247	216,781
80,000	44,923	121,392	88,128	1,136	6,450	3,472	247	265,748
100,000	52,953	143,591	104,244	1,344	7,612	4,104	247	314,091
150,000	71,959	196,138	142,392	1,836	10,361	5,600	247	428,533
200,000	91,271	249,528	181,152	2,335	13,154	7,120	247	544,867
300,000	129,527	354,060	257,040	3,314	18,622	10,096	247	770,906

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Table 10

Subsequent Year Direct Operating Costs at
U. S. Refineries, By Ownership and Size of
Refinery

<u>Refinery Capacity (B/D)</u>	<u>Measurements</u>	<u>Medical</u>	<u>Employee Training</u>	<u>Record- keeping</u>	<u>Total</u>
<u>Independents</u>					
10,000	6,963	26,133	170	760	34,026
20,000	9,141	34,563	212	1,000	44,916
30,000	10,956	41,588	247	1,200	53,991
40,000	12,698	48,332	281	1,392	62,702
<u>Majors</u>					
20,000	13,206	50,299	291	1,448	65,244
40,000	20,103	76,994	424	2,208	99,729
60,000	25,766	98,912	533	2,832	128,042
80,000	31,574	121,392	645	3,472	157,082
100,000	37,309	143,591	755	4,104	185,760
150,000	50,886	196,138	1,017	5,600	253,641
200,000	64,680	249,528	1,283	7,120	322,611
300,000	91,715	354,060	1,804	10,096	457,675

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Table 11**Estimated First Year and Recurring Operating
Costs at U.S. Refineries, by Ownership and
Size of Refinery****Direct Annual Operating Costs Per B/D Capacity (In Dollars)****Refinery Capacity (B/D)****First Year****Subsequent Years****Independents**

10,000

5.83

3.40

20,000

3.83

2.25

30,000

3.06

1.80

40,000

2.67

1.57

Majors

20,000

5.55

3.26

40,000

4.23

2.49

60,000

3.61

2.13

80,000

3.32

1.96

100,000

3.14

1.86

150,000

2.86

1.69

200,000

2.72

1.61

300,000

2.58

1.53

Source: From tables 9 and 10DO 068441
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