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The Cost and Benefits of Process Safety Management: Industry Survey Results

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Process safety management (PSM) is a relatively new phrase that encompasses many activities for controlling process-related hazards in the workplace. These activities (also called PSM elements) have been maturing at different rates over the past two decades. Since 1986, state and federal regulators have been mandating implementation of PSM programs at workplaces that handle hazardous chemicals, including explosives, toxics, and flammables. Before promulgating their regulations, the regulators estimated the cost and benefit of compliance with these regulations, but in all cases their cost estimates have fallen orders of magnitude short of actual implementation costs. This paper presents the actual costs that some companies have expended and provides estimates of future costs to comply with either self-imposed standards or government regulations related to PSM. The data on actual costs were provided in response to a recent survey. The costs are broken into categories so that companies just now implementing PSM will be able to gear up for their future efforts. Also discussed are the types of benefits and, where possible, the actual benefits that have been achieved by implementing PSM programs. The cost of developing and implementing PSM is great, however, most companies have seen comparable or greater benefits as a result of implementing PSM programs. Finally, this paper explores the cost of implementing EPA's forthcoming regulation for risk management programs.

Introduction

"Process safety management (PSM) is the application of management principles to the identification, understanding, and control of process hazards to prevent process-related injuries and incidents" [1]. PSM entails development and implementation of programs or systems to ensure that the practices and equipment used in hazardous processes are adequate and are maintained appropriately. The primary categories of programs or systems have come to be called elements of PSM. However, the basic elements of PSM have been defined by many groups in a number of ways. Table I lists the elements of PSM systems from various industry and government groups. Many of the elements with different names have essentially the same meaning. For instance, "maintenance and inspection of facilities," together with some aspects of "personnel" practices, both under CMA's Process Safety Code of Management Practices, are essentially the same as the single element, "mechanical integrity," under 29 CFR 1910.1190). However, some

safety management regulations, especially EPA's proposed risk management program, New Jersey's Toxic Catastrophe Prevention Act, and Nevada's Highly Hazardous Substances Act, have elements (requirements) that are unique to those programs. This article focuses on those PSM systems (or the PSM sections of other hazard and risk management systems) with requirements similar to those of 29 CFR 1910.119. The cost of related risk management

activities that are not a part of a PSM program, such as consequence modeling, will be discussed briefly at the close of this article. The first column of Table 1 shows the acronym used throughout this article for each element.

TABLE 1 COMPARISON OF PSM SYSTEMS

OSHA 29 CFR 1910.119	American Petroleum Institute	AIChE Center for Chemical Process Safety	CMA Process Safety Code
Employee Participation (EP)	Process Safety Information	Accountability	Management Leadership Commitment Accountability Performance Measurement Incident Investigation Information Sharing CAER Integration
Process Safety Information (PSI)	Process Hazard Analysis	Process Knowledge and Documentation	
Process Hazard Analysis (PHA)	Management of Change	Project Reviews and Design Procedures	
Operating Procedures (OP)	Operating Procedures	Risk Management	Technology Design Documentation Process Hazards Information Process Hazard Analysis Management of Change
Training (TNG)	Safe Work Practices	Management of Change	
Contractors (CONT)	Training	Process Equipment Integrity	
Pre-startup Safety Review (PSSR)	Critical Equipment QA and Mechanical Integrity	Incident Investigation	Facilities Siting Codes and Standards Safety Reviews Maintenance and Inspection Multiple Safeguards Emergency Management
Mechanical Integrity (MI)	Prestart-up Safety Review	Training and Performance	
Hot Work Permit (SWP)	Emergency Response and Control	Human Factors	
Management of Change (MOC)	Process-Related Incident Investigation	Standards, Codes and Laws	Personnel Job Skills Safe Work Practices Initial Training Employee Proficiency Fitness for Duty Contractors
Incident Investigation (II)	Auditing of PHM Systems	Audits and Corrective Actions	
Emergency Planning and Response (EPR)		Enhancement of Process Safety Knowledge	
Compliance Audits (CA)			
Trade Secrets (TS)			

OSHA's PSM regulation is a collection of performance based requirements for the key elements listed in Table 1. OSHA based these requirements on successful process safety practices already existing in the chemical and hydrocarbon process industries. Although nearly the entire industry agrees that implementing PSM is the right thing to do, interpreting and converting the PSM requirements into practices is unique to each company, and even to each plant site. Not only can the requirements be interpreted differently for each site based on local needs, but each site also starts from a different point when they begin to implement a system that is consistent with this regulation. These starting points are important factors when estimating the cost of implementing each element. Many companies are choosing to interpret the regulation in a minimalistic manner, and though they may survive an OSHA audit, they are also minimizing the benefits their company will receive. Other companies are going well beyond the minimal interpretation; therefore their cost (and presumably their benefits) will be higher than average. In later sections of this paper, we will discuss how the different interpretations companies make regarding starting points and requirements affect the data collected in this survey.

To understand the cost of PSM, we must realize that the two main phases of implementing PSM are installing a program and then maintaining the quality of the program. What industry is finding is that to get buy-in throughout the facility so that the PSM maintenance phase becomes feasible, you first have to make PSM a part of the facility's culture. This does not

happen overnight-it is a gradual process requiring sincere management commitment and constant nurturing. Installation should provide the sound foundation for the ongoing program. The installation phase is typically viewed as a one-time project, and includes activities such as developing concepts for each element, planning the work, training the PSM resources, writing draft programs and practices, pilot testing major programs, implementing the finished product (usually with more training), and responding to findings and recommendations of certain programs (such as recommendations from PHAs, MOC hazard reviews, and incident investigations). Most of the cost related to the development and initial implementation of a PSM program is labor, whereas the major cost related to responding to recommendations is capital improvements. The labor cost for developing and implementing a PSM element can be accounted for in one or more of the following categories:

- Meetings
- Writing
- Reviewing
- Revising
- Training/orientation
- Pilot testing
- More revising
- Initial implementation

Background of Survey

Three different survey formats were tried with varying success. The final survey form solicited data on the facility and the individual providing the facility's response (much of this is held confidential), the PSM model(s) being followed (OSHA's, CMA's, and API's), data on the size of the facility affected by PSM, and the equivalent cost of labor and capital to implement and maintain the PSM program and practices. The survey also requested data on the level of effort required to complete key elements such as updating P&IDs, writing operating procedures, and performing and responding to PHAs. Finally, the survey requested data on the benefits derived from PSM. (Contact the author to receive a copy of the survey form.) The remainder of this paper presents the results of this survey. These results were first presented at the International Process Safety Management Conference and Workshop, September 22-24, 1993, in San Francisco, which was co-sponsored by the Center for Chemical Process Safety (CCPS) of AlChE, Health and Safety Executive-UK, U.S. EPA, European Federation of Chemical Engineering, and the Japanese Society of Chemical Engineers.

The goal of our survey was to collect as much actual data as possible, but in several instances we used a company's best estimate of the ultimate cost and benefits. Most companies are concurrently implementing related programs, such as ISO 9000 certification, which overlap to a large degree with certain PSM elements (such as operating procedures and training). Therefore, many companies had difficulty isolating the benefits derived only from implementing a PSM program.

Survey Sample Size

Eighty-four facilities, representing a total of 25 companies, completed surveys. The companies allowing us to use their names are listed in Table 2.

TABLE 2 COMPANIES RESPONDING

Allied-Signal	Martin Marietta Energy Systems
ARCO Alaska	Mobil Chemical
Boise Cascade	Monsanto
Champion International	Neste Resins
Chevron	NutraSweet
Citgo	Phoenix Chemical
Coastal Refining	Scott Paper
ITT Rayonier	Tennessee Eastman
Keil Chemical	Unocal
Kerr-McGee Chemical	US Steel
Koch Nitrogen	Valero Hydrocarbons
Longview Fibre	
Plus two confidential returns	

Dow Chemicals and Olin Chemicals responded with helpful comments and data, but were unable to complete a survey, since their programs are so mature and they did not gather data on major elements of PSM during each program's evolution. Both companies also shared some interesting insights and data on PSM benefits. The facilities that completed surveys together employ about 3 1,000 workers, which represent about 1 % of the workers which OSHA claims are protected by the PSM regulation [2]. The size of the survey sample and breakdown of respondents by industry segment are shown in Tables 3 and 4, respectively.

TABLE 3 SAMPLE SIZE

- 25 companies
- 84 locations
- 25,000 direct hire employees
- 6,000 contract employees
- 20,000 P&IDs
- 850 PHAs

TABLE 4 INDUSTRY REPRESENTATION

Industry	Number of Sites
Gas Plant/Oil Field	46
Refinery	5
Petro-Chem/Plastic	3
Pulp/Paper	13
Chemical	16
Iron & Steel	1
All Surveyed	84

Table 5 shows the size range of companies responding to the survey and also provides a breakdown of whether the respondents operated batch processes, continuous processes, or plants with an even mix of batch and continuous processes.

TABLE 5 SIZE VARIATION

- $0.4 to $10 billion annual revenue per company site
- 1 to 27 locations per company
- 50 to 13,000 total employees per site
- 3 to 7,000 P&IDs per site
- 1 to 300 PHAs per site
- 3 batch, 73 continuous, 8 even mix

Table 6 shows the average sizes of the facilities for each industry segment by number of employees, P&IDs, and PHAs.

TABLE 6 AVERAGE FACILITY SIZES

	Number of Employees				
Facility	Direct Hire	Contract	Total	No. of P&IDs	No. of PHAs
All surveyed	295	76	371	237	10
w/o very large plant and gas plant/oil field data	340	70	410	278	10
Gas Plant/Oil Field*	29	8	37	44	4
Refinery	671	85	756	1232	30
Petro-Chem	375	150	525	524	28
Pulp/Paper	369	61	430	46	6
Chemical	892	265	1157	623	26
w/o very large plant	221	63	284	153	8

* Each size estimate includes multiple facilities; companies are assuming that the majority of PSM efforts such as PHAs and MOC can be shared by plants. Also, the percentage of overall costs related to resolving recommendations (such as those from PHAs) is lower for gas plant/oil field production.

For purposes of comparison of PSM-related costs, we feel it is best to use the number of employees and the number of P&IDs for scaling. The number of PHAs is typically not a good scaling factor for PSM cost because the way companies define PHA scope varies widely (e.g., for two virtually identical facilities, one company may perform a single, large

PHA while another company may perform several smaller PHAs). The number of employees shown in Table 6 are those significantly affected by OSHA's PSM regulation at the responding facility. In many situations, especially the pulp/paper industry, the number of employees affected is a low percentage of the total number of employees at the facility.

PSM Cost Data

All of the respondents provided the requested cost data; however, some respondents did not have much confidence in the estimates they supplied. The primary reason for this uncertainty were as follows:

• Insufficient data due to a low level of compliance at the date of the survey. Companies' estimates for their level of compliance ranged from 0% to 86 %

• Insufficient data due to incomplete record keeping. Some companies began incorporating PSM as part of their culture many years ago. For some of these companies, much of the labor and other cost data were not being tracked until recently.

• Uncertainty about what 100% compliance actually means. Most believe they can achieve compliance within 1 to 2 years from now, but they view OSHA's definition of PSM as a moving target, especially in light of changes in interpretation of OSHA with each inspection, citation, or written clarification.

Table 7 shows averages of the level of compliance and estimated dates for achieving compliance. The average level of compliance for the surveyed facilities was 40% when the facilities began tracking and/or began estimating costs rigorously, which was October, 1992, on the average. The term "excellence" in this figure means that the responding company intends to go well beyond a minimal interpretation of the scope of OSHA's PSM regulation (exceeding the physical scope or element requirements).

TABLE 7 COMPLIANCE LEVELS—AVERAGES

- 40% level of compliance on 10/92
- 50% level of compliance on 4/93
- 100% level of compliance anticipated 12/94
- Excellence in PSM program anticipated 9/96

Table 8 summarizes the PSM costs per facility for each industry represented in the survey.

TABLE 8 AVERAGE COST PER FACILITY
(in $millions)

Facility	Beginning at Average of 40% Compliance, 10/92* Years 1-5	Years 6-10	Years 1-10	Annual Ongoing Cost	Years 1-10 adjusted to 0% compliance
Aggregate	3.6	2.2	5.8	0.40	7.0
w/o very large plant and gas plant/oil field	4.3	2.6	6.9	0.50	8.0
Gas Plant/Oil Field	0.7	0.3	1.0	0.07	2.4
Refinery	10.9	6.7	17.6	1.30	20.0
Petro-Chem	11.9	4.1	16.0	0.80	19.0
Pulp/Paper	1.3	0.4	1.7	0.08	1.9
Chemical	10.2	7.6	17.8	1.40	19.0
w/o very large plant	3.6	3.1	6.7	0.60	8.0

* The cost for each facility for each time period was estimated individually before averaging with the data from other facilities.

The cost per facility for years 1-5 includes (1) the remaining cost to reach 100 % compliance and (2) the ongoing cost to maintain compliance (or quality) for the remaining years if the company reaches 100 percent compliance in that period. Years 6-10 typically involve ongoing cost, though for some respondents the capital cost of responding to PHA recommendations is anticipated to carry over into years 6- 10. Ongoing cost, after final implementation, was difficult for many respondents to estimate; however, most feel the cost will be split fairly evenly between the labor and capital categories. The last column of Table 8 is the 10-year cost anticipated for each facility in each industry segment, assuming the facility was beginning from 0 % compliance instead of the average of 40% compliance. (A period of 1-10 years was chosen to allow a comparison of these results with estimates developed by others, as discussed later.) Since there was one very large chemical plant and also many gas plant/oil field processing plants in the survey, the cost per facility in Table 8 has been shown with and without data from these plants (since they tend to skew the results beyond the industry average due to either their size or relative number of facilities per industry segment). The total cost for years 1-10 for the 84 facilities surveyed was $484 million beginning at an average compliance of 40 %, or $592 million is extrapolated proportionally back to 0% compliance.

Figure 1 illustrates the distribution of the cost of compliance based on an average of all survey data, versus the three primary categories:

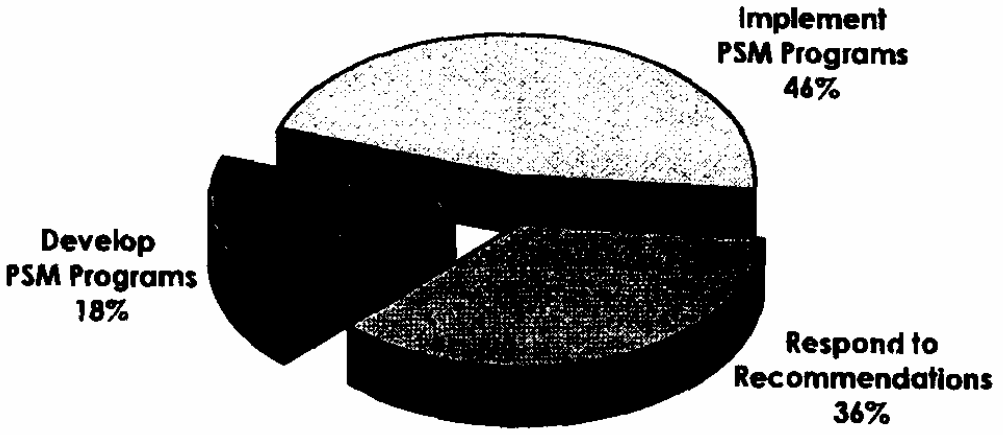

FIGURE 1. Distribution of compliance costs.

- ***Developing PSM Programs***. The cost, primarily in equivalent labor costs, to bring the PSM program (and individual element programs) from the concept stage through the final design (such as developing an MOC or MI written program that your facility personnel are confident will work). This category also includes the cost of training personnel to be proficient in various PSM activities, such as leading PHAs, leading incident investigations, leading compliance audits, writing procedures, and leading employee training.

- ***Implementing PSM Programs.*** The cost (again primarily in equivalent labor costs) to do implementation tasks, such as writing operating procedures, updating PSI, doing initial training of operators and maintenance personnel, and performing/documenting PHAs.

- ***Responding to Recommendations.*** The cost, primarily capital costs and expenses, to implement improvements to address recommendations from PHAs, MOC hazard reviews, incident investigations, and MI deficiency reports.

Government estimates for PSM implementation seem to have almost completely ignored the cost of responding to recommendations. An extrapolation of this survey data to estimate PSM cost in the U.S. is provided later.

A detailed analysis of the survey data (which is only summarized in this paper) indicates that the combined cost of (1) training personnel to lead PHAs (or contracting leaders), (2) performing and documenting PHAs, and (3) responding to PHA recommendations accounts for about 50% of the cost of PSM. Therefore, it is in every facility's best interest to maximize the benefit (value) of each PHA. Using the right PHA techniques, providing skilled (efficient) leaders and scribes, and allocating the highest qualified personnel to participate as subject-matter experts during the PHA meetings are fundamental ways to optimize the PHA efforts. Also, expanding the scope of the meetings to uncover more operability improvements can result in significant benefits that have proven to far outweigh (often by a factor of 10 or

more) the incremental cost of longer PHA meetings to uncover and discuss operability problems. (There are many fine papers on how to perform high quality PHAs [3, 4].)

The highest cost elements to develop, implement, and respond to are listed in Table 9 in descending order (lower cost elements are not shown). Most respondents indicated verbally that MI and MOC were the most difficult elements for facilities' employees to develop and implement, since so much indoctrination and "culture" change were necessary.

TABLE 9 RELATIVE COST RANKING OF PSM EFFORTS, BY ELEMENT

Develop	Implement	Respond
MOC	PSI	PHA
MI	MI	MOC
TNG	OP/TNG	MI
	PHA/MOC	II

Table 10 provides factors that may prove useful in developing "ball park" estimates for the cost of PSM. As the footnote to the exhibit warns, these averaged factors are not appropriate for estimating the cost of PSM at an individual facility. However, large, multi-facility companies will be able to use these averaged factors with more confidence. Note that the average cost per facility of $5.8 million (over a period of 10 years, beginning at 40% compliance) is based on the average facility responding to this survey (refer back to Tables 4 and 5 for data that describe the survey composition and average facility size). For a continuous process plant, I recommend that the factor of $22,000 per P&ID be used rather than the factor per employee-more reliable results are produced.

TABLE 10 COST VS. SIZE/COMPLEXITY

Size/Complexity Parameter	PSM Overall Cost for Years 1–10 (assuming facility begins at 40% compliance) Cost
Per Employee (batch	$16,000
Per Employee (continuous)	$17,000
Per Employee (all data)	$16,000
Per P&ID (batch)	$45,000
Per P&ID (continuous)	$22,000
Per P&ID (all data)	$24,000
Per Facility (all data)	$5,800,000

NOTE: The variation in PSM cost did not produce a statistical correlation to any single size parameter. The sample size is too small to account for influence of all PSM variables in a multiple regression. Therefore, the averages are only valid for overall industry comparisons, and cannot be accurately applied to individual facilities.

In the survey we also collected cost data for completing individual PSM activities. These data are summarized in Table 11. The average cost to update a D-sized P&ID was $1,800. An informal survey of over 500 attendees of a 3-day course on PSM indicates that the average cost is (1) $1,500 to field validate and then update an existing D-sized P&ID and (2) between $2,500 to $3,500 to create (or substantially revise) a P&ID. The cost to develop an operating manual and/or associated training module was $800 per step of instructions. The spread of data reflects the fact that there is not a consistent definition of a "step ... .. procedure," or "operating manual" throughout the industry. The average cost to perform and document a PHA (counting the labor spent by all participants) was $55,000, with an understandably large data spread. The best way indicated by this survey for estimating the cost of a PHA for a continuous process is to use the factor based on the number of P&IDs ($2,900/P&ID). There is a broad range of styles, level of detail, quality, and thoroughness for a PHA. However, to perform a high quality PHA and achieve the highest payback (value), we feel the average cost of a PHA using predominantly the HAZOP technique is probably closer to $4,000/P&ID (assuming about 6 to 8 sections, or nodes, per P&ID).

TABLE 11 PSM ACTIVITY COST

Activity	Average	Stnd. Dev.
Update each P&ID	$1,800	$1,000
Develop an operating manual and training module (per step)	$800	$700
PHA	$55,000	$60,000
PHA per P&ID (all data)	$4,500	$6,000
PHA per P&ID (continuous)	$2,900	$1,600

Extrapolation to Entire U.S. Industry

Several estimates have been performed by industry groups (specific to their industry) and by regulatory agencies for the cost of implementing PSM throughout the U.S. Table 12 compares compliance estimates for the petroleum refining industry. Note that there is good agreement in the cost estimates for JBF Associates, Inc. (JBFA) and the American Petroleum Institute (API) [5] but the estimate by OSHA (from their regulatory impact analysis for promulgation of the PSM regulation) is a factor of about 22 times lower than either industry based estimate. It should be noted that OSHA's estimate is not based on either survey results or extrapolation of actual plant data. Although not shown in Table 12, OSHA estimated that it would cost the average pulp/paper mill just $115,000 to come into initial compliance (over a I -year period). A survey (in 1991) [61 by the pulp/paper industry indicates that this cost will be closer to $770,000/mill over a nominal 3-year period, and our survey estimates the cost at about $1,300,000/mill (over a 5-year period).

TABLE 12 EXAMPLE PSM COST COMPARISON FOR THE REFINING INDUSTRY

Source	Remaining Costs 1–10 Yr (from 1991)	Remaining Costs 1–10 Yr (from 1992)
OSHA April 1990 estimate	$0.12 billion*	$0.09 billion**
JBFA summer 1993 survey: 3 respondents		$1.9 billion***
API summer 1991 survey: 22 respondents	$2.4 billion	$2.1 billion**

Based on 198 refinery-type facilities; average size of 80,000 BBL/day crude distillation capacity.

* Adjusted to summer of 1991 based on 5% inflation rate and 0% increment in compliance from April 1990 until summer 1991.

** Assumes 5% inflation rate and 15% increase in compliance per year.

*** Assumes one-to-one ratio of cost vs. refinery capacity for extrapolating our survey data to the entire industry.

Table 13 compares estimates for the cost of compliance with the PSM regulation for all covered industries throughout the U.S. Adjusting OSHA's estimate to a comparable time frame would make it about $6 billion over 10 years. The survey estimate, when extrapolated based on the number of employees in the U.S. that are affected by the OSHA PSM regulation, is about $48 billion (assuming OSHA estimated the total number of facilities and employees properly). I believe this cost estimate may still be low because some of the survey respondents are still far from compliance and may not fully appreciate all the future costs. Companies closer to reaching compliance tended to estimate a higher cost for compliance, especially for the category of cost related to responding to recommendations. If the ratio of the difference between API's and OSHA's estimate for the refining industry is used as a scaling factor for OSHA's overall U.S. industry estimate, the overall cost estimate rises to $137 billion. Based on these estimates and several other factors, we believe the total industry cost will be in the range of $100 billion (over 10 years)-about 17 times higher than OSHA's estimate.

TABLE 13 ESTIMATED COST OF PSM FOR ENTIRE INDUSTRY

Source	10-Yr Overall Cost (compliance costs beginning 6/92)
OSHA's estimate (corrected to 10/92)	$6 billion
JBFA survey based on ratio of employees — assuming 25,000 facilities (3 million employees)*	$48 billion
Ratio of OSHA's estimate (based on the difference to API's estimate for the refining industry)	$137 billion

* OSHA's estimate of number of facilities and employees covered by 1910.119.

Benefits

Very few respondents provided benefit data, since the cost avoided due to implementing PSM is so difficult to isolate from other ongoing safety and quality improvement efforts. Of the estimates of benefits provided, about one half thought PSM would pay for itself. Obviously, better data on the benefits of individual PSM activities are needed. Many companies have stated that an effective PHA program, especially when expanded to include hazard evaluations during the early phases of new projects, will produce benefits far beyond the cost of performing and responding to the PHAs. In the preamble to 29 CFR 1910.119, OSHA quoted one plant manager concerning PSM benefits:

"Our small organization was quietly infused with a rebirth of innovative thinking. Process technology that was more than 35 years old was routinely being questioned .... This quickly led to the same questioning being applied to process improvement .... Ultimately, I believe that this thoroughness and training approach will result in cost savings to a small plant site on the order of 4 to 7 percent of an operating budget" [2].

Overall, the majority of companies responding said they feel PSM should be implemented, though most objected to some of the paperwork requirements (especially process safety information). Companies with more than 5 years of PSM experience unanimously echoed the comment in one survey response:

"It is indefensible not to implement PSM, and it's worth it."

However, I have to agree with some companies, that due to the "fear of citations resulting from insufficient documentation on what we've done," the paperwork and associated labor to over-document PSM activities could outweigh the benefits that would otherwise be realized in the absence of regulatory pressure.

Table 14 shows various types of benefits for PSM. Where possible, we list the associated benefit value for each type (estimated by EPA in their regulatory impact analysis [81 for proposed rule 40 CFR 68, which is discussed next). It should be possible to estimate benefits using these benefit factors (or better ones than these) together with facility-specific data. This would be a useful exercise, if management is currently unconvinced of the need to implement PSM. Most managers become convinced (by several factors) within the first year of implementation to apply the proper resources to complete the installation and to follow through on PSM.

TABLE 14 PSM COMPLIANCE BENEFITS
BENEFITS: Avoided Incidents

Type of Incident Avoided	EPA $ Value per Incident*
• Impact to Facility/Operations**	
— Business/Production Interruptions	8,225
— Equipment Damage	Not available
• Environmental Damage	
— Soil Contamination	199,695
— Vegetation Damage	50,000
— Groundwater Contamination	1,500,000
• Personal Injury (per person)	
— Injury/First Aid/Outpatient	17,943
— Hospitalization (excess over injury alone)	11,605
— Death (and litigation)	5,790,736
• Other Expenses	
— Litigation per Environmental Action (facility's cost only)	56,000
— Evacuation and Sheltering in Place (per incident, effects on the public only)	77,719

* Source: EPA's regulatory impact analysis related to RMP regulations. EPA expects a 40 to 60% reduction in frequency or severity of these categories of losses for implementing risk management planning.

** Olin Corporation reported that their PHA program cost was completely offset by reductions in these losses alone.

OTHER (LESS TANGIBLE) TYPES OF BENEFITS

- Quality and Productivity Improvements (due to less process upsets, improvements in training, etc.)***
- Lower Insurance Rates (or lower increase in rates in future)
- Lower Workers' Compensations for Lost Time

*** Some facilities have reported that improvements in productivity and quality that were identified during their PHAs more than offset the total cost of the PHA program.

What's Next: Risk Management

As mandated by the Clean Air Act Amendments of 1990, EPA is promulgating a risk management program (RMP) regulation. The proposed rule, 40 CFR 68, was published in the Federal Register on October 20, 1993. Many of the requirements for RMP are similar to those in OSHA's PSM regulation; however, the differences will cause significant impact to U.S. industry. The biggest differences arise from EPA's list of extremely hazardous chemicals being broader than OSHA's. Also, unlike OSHA, EPA is not proposing exemptions for retail sale and remote, unoccupied facilities. The major differences between EPA's proposed RMP rule and OSHA's PSM regulation are:

Hazard Assessments

Requires quantitative modeling of the consequence of worst case and more probable scenarios for toxic releases and fires/ explosions.

PSM Elements

- Extending the consequences of concern for PHAs and incident investigations to outside the fenceline
- Adding new requirements to the PHA paragraph.
- Adding a requirement for a written management program for the overall PSM/RMP effort
- Omitting specific requirements for employee participation and trade secrets.

Emergency Response Planning

Expanding the scope of EPR required by OSHA.

Risk Management Plans

A summary of the RMP efforts, programs, and organization. (This document becomes accessible to the public!)

EPA originally estimated (in their regulatory impact analysis for their list of chemicals) that the total impact on industry would be only $1.1 billion over the first 5 years, and $1.4 billion over 10 years at a total of 140,000 covered facilities [7, 81. In support of the publication of the proposed rule on RMP, EPA placed an addendum to the regulatory impact analysis in the associated air docket 191. This addendum reflects changes in their estimate of the number of covered facilities in each industry sector and changes in the incremental cost to each type of facility. These changes were prompted by "new" information EPA said it received from the affected industry and from consultants (such as the PSM cost survey data in this article which was first presented at the CCPS International PSM Conference and Workshop mentioned earlier). In this addendum, EPA greatly reduced their estimate for the number of facilities with complex process and toxic materials covered by their proposed list/rule, while they increased their estimate for the number of flammable gas production fields covered. EPA now estimates that there is a total of 114,000 facilities covered by their RMP regulation. While reducing the number

of facilities covered (probably due in large part to unannounced changes in the list of regulated substances), their estimate for the cost of RMP implementation increased substantially. They now estimate that hazard assessments will cost the industry about $1.2 billion and that full implementation of the RMP rule will cost industry about $3.7 billion. EPA says this is the first-year cost, but their calculation method indicates that this is the cost to reach compliance, which will probably take at least 3 years. With an estimate of only $2.1 billion, EPA has still grossly underestimated the cost of compliance with PSM requirements in the RMP rule (as shown below). The greatest single deficiency is the failure to account for capital improvements and other costs related to responding to recommendations from PHAs, incident investigations, etc.

Previously, EPA estimated that the OSHA regulation covered 88,000 facilities. However, a comparison of the number of facilities in each industry sector covered by each regulation indicates that EPA now believes about 30,000 facilities are covered by OSHA's PSM regulation, a number that more closely agrees with OSHA's estimate of 25,000 facilities 121. Based on those estimates, about 85,000 facilities will be covered by EPA's RMP regulation that was not covered by OSHA's regulation. Most of these additional facilities are either gas field operations or non-manufacturers-these types of facilities are much less complex and employ less people than the average facility covered by the PSM regulation. Assuming each of these facilities on average has only 10 employees, then the cost of compliance with the PSM-type requirements of EPA's RMP regulation will be over $13 billion during the first 10 years (using the cost factor presented in this paper for PSM implementation per employee). In addition, EPA has probably underestimated the additional cost to those facilities which are currently covered by the OSHA PSM regulation or similar state regulations. Furthermore, we estimate that performing, documenting, and communicating the initial hazard assessment for a single chemical at a site will cost about $15,000 to $40,000, depending on the complexity of the facility (this includes consequence modeling of the worst case scenario and three other more probable scenarios). Therefore, using EPA's estimate of an average of about two listed chemicals per covered site, the hazard assessment requirements alone will cost the U.S. industry over $6 billion (for a 3-year implementation period). Plus, these hazard assessments must be updated periodically or for major changes to the boundary conditions of the assessments. The cost of developing summary risk management plans will also be substantial. When all the other incremental costs related to RMP are combined, the total cost to industry will probably exceed $30 billion (over a 10-year period). Though these numbers are admittedly rough, they probably provide a more realistic characterization of the costs than EPA's estimates. (EPA did not provide a revised estimate for ongoing cost or costs for a 10-year period, so a direct comparison of estimates is not possible at this time.) While industry will see benefits from implementing the PSM-type requirements within the RMP rule, it is difficult to identify any additional, significant benefit from performing hazard assessments, developing the "summary" risk management plans, and then documenting both of these in a fashion suitable for effective communication to the public. EPA is currently holding hearings on the proposed rule; perhaps it is not too late to scale back the cost impact of EPA's RMP regulation to provide equitable safety and environmental improvement benefits.

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