CHRONIC BERYLLIUM DISEASE PREVENTION PROGRAM FINAL RULE:

ECONOMIC ANALYSIS

U.S. Department of Energy
Office of Environment, Safety and Health
Office of Worker Health and Safety

November 19, 1999

TABLE OF CONTENTS

EXECUTIVE SUMMARY ES-1

CHAPTER ONE: INTRODUCTION 1-1
1.1 Health-Related Justification for the CBDPP Rule 1-2
1.2 Beryllium Exposure and Market Failure 1-6
1.3 Overview of the Economic Analysis 1-8
1.3.1 Executive Order 12866 1-8
1.3.2 Small Business Analysis 1-9
1.3.3 Unfunded Mandates Analysis 1-9
1.3.4 Summary 1-9

CHAPTER TWO: PROFILE OF AFFECTED DOE FACILITIES AND ACTIVITIES .. 2-1
2.1 Scope of the Rule 2-1
2.2 Affected Activities 2-2
2.2.1 Research and Development Activities 2-3
2.2.2 Production Activities 2-4
2.2.3 Decontamination and Decommissioning Activities 2-5
2.2.4 Maintenance Activities 2-6
2.2.5 Detonating and Dismantling Weapons 2-7
2.2.6 Industrial Hygiene Tasks 2-8
2.2.7 Non-Beryllium Work Where Exposure is Possible 2-8
2.3 Affected Facilities and Number of Affected Workers 2-9

CHAPTER THREE: ESTIMATED COMPLIANCE COSTS 3-1
3.1 Cost Estimation Methodology 3-1
3.1.1 Relationship Between the CBDPP Rule and DOE N 440.1 3-1
3.1.2 Estimating Incremental Compliance Costs 3-2
3.1.3 Wage Rates and Unit Costs Applied in the Cost Estimation 3-6
3.1.4 Using The 1999 EH Cost Impact Survey (EH, 1999) To Provide Conservative Cost Estimates 3-8
3.2 Estimated Compliance Costs 3-9
3.2.1 850.10 Chronic Beryllium Disease Prevention Program (CBDPP) 3-9
3.2.1.1 Submitting Initial Versions of the CBDPP Plans Under DOE N 440.1 3-10
3.2.1.2 Revising the CBDPP Plan to Comply with the CBDPP Rule 3-13
3.2.1.3 Annual Revisions to the Plan 3-13
3.2.1.4 Responding to Requests for Copies of the Plan 3-16
3.2.2 850.20 Baseline Beryllium Inventory 3-16
3.2.3 850.21 Hazard Assessment 3-21
3.2.4 850.24 Exposure Monitoring 3-23
3.2.4.1 Baseline Exposure Monitoring 3-23
3.2.4.2 Periodic Exposure Monitoring 3-24
3.2.4.3 Exposure Monitoring During Operational Changes 3-26
3.2.4.4 Notification of Exposure Monitoring Results 3-26
3.2.5 850.25 Exposure Reduction and Minimization 3-29

3.2.6 850.26 Regulated Areas 3-29
3.2.7 850.27 Hygiene Facilities and Practices 3-30
3.2.8 850.28 Respiratory Protection 3-30
3.2.9 850.29 Protective Clothing and Equipment 3-31
3.2.10 850.30 Housekeeping 3-31
3.2.11 850.31 Release Criteria 3-33
3.2.12 850.32 Waste Disposal 3-38
3.2.13 850.33 Beryllium Emergencies 3-38
3.2.14 850.34, 850.35, 850.36 Medical Surveillance, Removal and Consent 3-39
3.2.14.1 Medical Evaluations 3-40
3.2.14.2 Beryllium Registry 3-43
3.2.14.3 Medical Data Analysis 3-45
3.2.14.4 Worker Removal 3-47
3.2.14.5 Inform Workers 3-50
3.2.14.6 Signed Consent Forms 3-51
3.2.15 850.37 Training and Counseling 3-52
3.2.15.1 Adapt ORISE Program 3-52
3.2.15.2 Annual Training Costs 3-54
3.2.15.3 General Awareness Training 3-57
3.2.16 850.38 Warning Signs and Labels 3-59
3.2.17 850.39 Recordkeeping 3-59
3.2.17.1 Develop a Recordkeeping System 3-59
3.2.17.2 Annual Recordkeeping Cost 3-61
3.2.18 850.40 Performance Feedback 3-62
3.3 Summary of Compliance Cost Estimates 3-63

CHAPTER FOUR: BENEFITS OF REDUCING BERYLLIUM EXPOSURE 4-1
4.1 Health Effects of Beryllium Exposure 4-3
4.2 Reduced Medical Costs 4-5
4.2.1 Costs Associated with Additional Testing for Workers with Positive Be-LPT Tests 4-5
4.2.2 Costs Associated with Monitoring and Treating Cases of Beryllium Sensitization 4-6
4.2.3 Medical Costs Savings Per Avoided Case of Beryllium Sensitization and CBD 4-7
4.3 Reduced Mortality 4-8
4.4 Increased Quality of Life 4-9
4.5 Increased Medical Surveillance for Workers at Risk 4-9
4.6 Increased Work-Life and Opportunities 4-11
4.6.1 Increased Work-Life 4-11
4.6.2 Increased Opportunities 4-12
4.7 Increased Productivity 4-12
4.8 Reduced Legal Liability for DOE and DOE Contractors 4-13
4.9 Reducing the Externality Associated With Beryllium Exposure Through a Transfer of Medical Costs 4-14
4.10 Summary 4-14

CHAPTER FIVE: MARKET IMPACTS OF THE CBDPP RULE 5-1
5.1 Provision of Public Goods 5-1
5.2 Impact on the Market for Beryllium 5-5
5.3 Summary 5-8

CHAPTER SIX: SMALL BUSINESS AND UNFUNDED MANDATES ANALYSIS 6-1
6.1 Small Business Analysis 6-1
6.2 Unfunded Mandates Analysis 6-3

CHAPTER SEVEN: SUMMARY 7-1

CHAPTER EIGHT: REFERENCES 8-1

APPENDIX A: UNIT COSTS OF MEDICAL EVALUATIONS B-1

EXECUTIVE SUMMARY

Beryllium is a silver-gray metal that is characterized by high tensile strength, light weight, and high resistance to corrosion. Because of these properties, the U.S. Department of Energy (DOE) and its contractors use beryllium metal and ceramics in nuclear weapons, as nuclear reactor moderators or reflectors, and as nuclear reactor fuel element cladding. In addition to these applications, DOE and its contractors conduct a number of beryllium-related research and development projects.

The use of beryllium is also associated with potential health problems in workers exposed to beryllium dust. Specifically, inhalation of beryllium dust can lead to beryllium sensitization (an allergic reaction to beryllium in the blood) which may progress to Chronic Beryllium Disease (CBD), a chronic lung disease. To protect workers from the dangers of beryllium exposure, the Atomic Energy Commission (AEC) set an 8-hour time-weighted average (TWA) exposure limit of 2 $\mu g/m^3$ in 1949. Between the 1970s and 1984, cases of CBD all but disappeared, and reported cases were attributed to exposures over the 2 $\mu g/m^3$ standard (Eisenbud and Lisson, 1983; Stange et al., 1996). However, in 1984, DOE identified a case of CBD that resulted from exposure thought to be below this standard.

As of June 1999, 119 confirmed cases of CBD and 258 cases of beryllium sensitization have been identified among approximately 10,000 current and former DOE workers screened for beryllium disease. In addition to the workers who have been diagnosed with CBD and beryllium sensitization, DOE is concerned with the nature of some of these cases:

- A number of the cases are among workers whose exposure is believed to have been below the 2 $\mu g/m^3$ workplace standard (Kreiss, et al., 1996; Stange, et al., 1996).
- A number of the cases are among workers not directly involved in beryllium-related work (e.g., clerical workers, secretaries, security guards), whose exposure to beryllium should only have been incidental (Kreiss et al., 1993a, 1996; Stange et al., 1996).

DOE believes that these two observations, along with the recent increased incidence of beryllium sensitization and CBD, represent an unacceptable trend and is therefore issuing the Chronic Beryllium Disease Prevention Program (CBDPP).

The CBDPP rule is designed to minimize the number of workers exposed to beryllium and reduce worker exposures in the DOE complex, thereby reducing the incidence of beryllium sensitization and CBD. This report constitutes the economic analysis for this rule, fulfilling three requirements:

- *Executive Order (EO) 12866*—EO 12866 requires federal agencies issuing rules to evaluate the costs, benefits, and economic impacts of the rule.
- *The Regulatory Flexibility Act, as amended by the Small Business Regulatory Enforcement Act (SBREFA)*—Federal agencies are required to review rules for potentially significant impacts on small entities.
- *The Unfunded Mandates Reform Act*—Federal agencies are required to determine if rules will impose unfunded mandates on state and local governments.

Before conducting these analyses, DOE profiled the sites and activities that will be affected by the CBDPP rule and estimated the number of workers that will be affected by the rule (Chapter 2). DOE estimates that 1,634 workers may be exposed or potentially exposed in the DOE complex. Furthermore, DOE estimates that 1,236 of these workers (75.6 percent) are potentially exposed above the action level or PEL prescribed in the CBDPP rule.

DOE estimated the compliance costs of the CBDPP rule (Chapter 3). The rule is estimated to impose a $8.54 million annualized cost on DOE contractors between July 1997 and December 1999 and a $31.55 million annualized cost on DOE contractors between December 1999 and December 2009. This includes an initial (i.e., startup) cost of $9.02 million incurred in July 1997 and another initial cost of $2.22 million incurred in December 1999.

The CBDPP rule will result in substantial benefits for DOE, DOE contractors, and workers. DOE assessed six benefits anticipated for the CBDPP rule (Chapter 4):

- Reduced medical costs;
- Reduced mortality;
- Increased quality of life;
- Increased medical surveillance for workers at risk;
- Increased work-life for beryllium workers;

- Increased productivity;
- Reduced legal liability for DOE and DOE contractors; and
- A reduction in the externality associated with beryllium exposure through a transfer of the medical costs from workers to DOE contractors.

Because sufficient information on the dose-response relationship for beryllium is not available within the scientific community, DOE could not relate reduced levels of exposure to a specific reduction in CBD and beryllium sensitization. Nevertheless, DOE estimates that the monetary benefits from reduced lifetime medical costs could range from $10,100 to $16,093 for each avoided case of beryllium sensitization or CBD.[1] Although not quantified, DOE also expects that the other categories may also produce substantial benefits to DOE, DOE contractors, and affected workers.

DOE also assessed the potential economic impacts of the CBDPP rule (Chapter 5). Two potential impacts were discussed:

- The impact on the provision of public goods that contain beryllium; and
- The impact on the market for beryllium.

DOE assessed each of these potential impacts and determined none of them will impose a significant economic impact. For the provision of public goods and the impact on the beryllium market, DOE determined that the potential reduction in the provision of beryllium-containing public goods will be minimal and consequently the reduction in demand for beryllium will also be small.

DOE assessed the small business impacts of the CBDPP rule pursuant to the Regulatory Flexibility Act and the Small Business Regulatory Enforcement Fairness Act (Chapter 6, Section 6.1). Information collected regarding all affected sites indicates that no small businesses are performing beryllium-related work at the affected sites. Thus, no small businesses would be impacted by the CBDPP rule. DOE also reviewed the CBDPP rule for unfunded mandates that

[1] These estimates assume that workers are diagnosed at age 40 and die at age 70. See Chapter 4, Section 4.2.3 for details of the estimates.

may be imposed on state and local government (Chapter 6, Section 6.2). This review indicates that no unfunded mandates will be imposed on state or local governments.

CHAPTER ONE
INTRODUCTION

Beryllium is a silver-gray metal that is characterized by high tensile strength, light weight, and high resistance to corrosion. Because of these properties, the U.S. Department of Energy (DOE) and its contractors use beryllium metal and ceramics in weapons, as nuclear reactor moderators or reflectors, and as nuclear reactor fuel element cladding. In addition to these applications, DOE and its contractors conduct a number of beryllium-related research and development projects.

The use of beryllium is also associated with potential health problems in workers exposed to beryllium dust. Inhalation of beryllium dust has been associated with both acute and chronic lung diseases. In response to these potential health effects, in 1949 the Atomic Energy Commission (AEC), DOE's predecessor, set an occupational exposure limit of 2 micrograms per cubic meter ($\mu g/m^3$), measured as an 8-hour time-weighted average (TWA). The Occupational Safety and Health Administration (OSHA) adopted that standard in 1971 as the Permissible Exposure Limit (PEL) for beryllium under the OSHA Air Contaminants Standard, 29 CFR 1900.1000. The American Conference of Governmental Industrial Hygienists (ACGIH) has identified beryllium as a known human carcinogen, and the National Institute of Occupational Safety and Health (NIOSH) has labeled beryllium an occupational carcinogen.[2]

While the number of reported cases of beryllium-related disease declined after the AEC set its exposure limit, recent data and events suggest that beryllium exposure may still pose a threat to worker health at DOE facilities (Kreiss et al., 1993a; Stange et al., 1996; Barnard et al., 1996). In response to these concerns, DOE is issuing this rule to further protect workers from beryllium exposure at DOE facilities. This report provides an economic analysis of the CBDPP rule.

The next two sections of this chapter discuss the justification for issuing the CBDPP rule in terms of protecting worker health and correcting a market failure. Chapter 2 discusses the scope of the rule and profiles the affected activities, facilities, and sites. Chapter 3 estimates the compliance costs associated with the rule. Chapter 4 discusses the benefits of reducing

[2] ACGIH notes that the weight of the evidence supports this classification, but that beryllium is of such low potency that only individuals exposed above 100 micrograms per cubic meter face a significant risk of developing lung cancer.

beryllium exposure at DOE facilities, and Chapter 5 discusses the market impacts of the rule. Chapter 6 looks at the potential small business and unfunded mandates impacts associated with the rule. Chapter 7 concludes the report.

1.1 HEALTH-RELATED JUSTIFICATION FOR THE CBDPP RULE

DOE is issuing this rule to protect the health of workers involved in beryllium-related work in the DOE complex. Beryllium is a toxic chemical that is associated with a number of adverse health effects:

- *Acute Beryllium Disease*—An acute, beryllium-induced, pulmonary disorder caused by exposure to high levels of soluble forms of beryllium.
- *Beryllium sensitivity*—An allergic reaction caused by exposure to insoluble forms of beryllium.
- *Chronic Beryllium Disease (CBD)*—A granulamatous lung disease caused by a delayed hypersensitivity response to beryllium in the lung.
- *Lung cancer*—A cancerous growth in the lungs caused by high levels of exposure to beryllium (e.g., above 100 $\mu g/m^3$).
- *Skin lesions*—Lesions that form on the skin after beryllium becomes deposited in open wounds.

Of the five preceding adverse health effects, CBD currently poses the greatest risk to workers in the DOE complex (Kreiss et al., 1993a; Stange et al., 1996; Barnard et al., 1996). Acute Beryllium Disease and lung cancer are caused by high exposures which have become less common in industry since the implementation of the OSHA PEL in 1971. Also, Acute Beryllium Disease is caused by exposure to *soluble* forms of beryllium, which are not common in DOE facilities. Skin lesions, while a legitimate health concern of beryllium exposure, are a less serious concern than others.[3] Therefore, the following discussion focuses on CBD.

Exposure to beryllium dust and fibers can occur in a number of activities in the DOE complex. Processing beryllium into useful products usually creates dust or particles that can

[3] Nevertheless, the rule imposes requirements that protect against dermal exposure to reduce the incidence of skin lesions.

become suspended in the air and inhaled by workers. A number of DOE operations create beryllium dust:

- Machining beryllium or beryllium objects;
- Manufacturing beryllium objects;
- Processing beryllium objects;
- Laboratory use of beryllium;
- Industrial hygiene work related to beryllium monitoring (e.g., taking area or swipe samples in beryllium-contaminated areas);
- Decontamination and decommissioning beryllium-contaminated workplaces; and
- Maintenance or housekeeping in beryllium-contaminated areas.

Workers involved in these operations are at risk of inhaling beryllium. Additionally, beryllium dust can settle on objects such as table surfaces, equipment, clothing, paper, and ventilation filters. If disturbed, these fibers can become reentrained and potentially inhaled by workers or other exposed individuals.

Inhalation of beryllium dust and fibers can lead to the development of CBD. Before the onset of CBD, workers generally become sensitized to beryllium (Eisenbud and Lisson, 1983; Newman et al., 1992, 1996). Sensitization is characterized by an allergic reaction to beryllium in the worker's blood. While some research has shown that approximately 1 to 16 percent of workers exposed to beryllium become sensitized (Newman et al., 1996), most studies estimate the prevalence at 1 to 3 percent (NJMRC, 1993; ES&H, 1995; Eisenbud and Lisson, 1983; Kreiss et al., 1993a,b; Stange et al., 1996). Workers who are sensitized to beryllium are at greater risk of developing CBD (Eisenbud and Lisson, 1983; Kreiss et al. 1993a,b; Newman et al., 1992, 1996). Symptoms of CBD include:

- Shortness of breath;
- Multiple lung scars that appear on chest X-rays;
- Granulomous scars found through a lung biopsy;
- Abnormalities in pulmonary function tests; and

- Abnormal lung sounds heard with a stethoscope.

The time from first beryllium exposure to the development of CBD symptoms averages ten years, although this time may be as short as a few months or close to 40 years. There is no cure for CBD, and workers who experience its symptoms are normally treated with steroids. Some individuals that contract CBD may require oxygen support to sustain pulmonary function. Steenland and Ward (1991) report that 57 percent of workers with CBD die of beryllium-related diseases.

The Atomic Energy Commission (AEC) set the 8-hour TWA (2 $\mu g/m^3$) in 1949 to protect workers from the dangers of beryllium exposure. OSHA adopted the standard in 1970 for private industry. Between the 1970s and 1984, cases of CBD all but disappeared, and reported cases were attributed to exposures over the 2 $\mu g/m^3$ standard (Eisenbud and Lisson, 1983; Stange et al., 1996). However, in 1984, DOE identified a case of CBD that resulted from exposure thought to be below this standard.

In 1987, the National Jewish Center and DOE began to screen workers for beryllium sensitization with a new test: the beryllium-induced lymphocyte proliferation test (Be-LPT). The Be-LPT enables health professionals to make subclinical diagnoses of beryllium sensitization, thereby increasing the accuracy and timeliness of diagnosing beryllium sensitization (Newman et al. 1996; Rossman, 1996). The Be-LPT can be either performed on *in vitro* blood samples or through bronchoalveolar lavage (BAL). The BAL and blood Be-LPT have both been shown to accurately identify beryllium sensitization in clinical trials (Rossman et al., 1988; Newman et al., 1989; Rossman, 1996), but the *in vitro* blood test is less intrusive, and has therefore proven to be a more effective screening tool (Kreiss et al., 1989; Newman et al., 1991; Newman, 1996; Rossman, 1996). Individuals who are identified as beryllium-sensitized can undergo more extensive clinical evaluation, including the BAL Be-LPT. Thus, instead of waiting until workers develop CBD symptoms, the Be-LPT enables health professionals to determine which workers are sensitized to beryllium and are therefore, at greater risk of developing CBD.

As of June 1999, 119 confirmed cases of CBD and 258 cases of beryllium sensitization have been identified among approximately 10,000 current and former DOE workers screened for beryllium disease. DOE believes these numbers represent an unacceptable trend and is therefore issuing this rule to curb the incidence of CBD and beryllium sensitization. In addition to the

workers who have been diagnosed with CBD and beryllium sensitization, DOE is concerned with the nature of some of these cases:

- A number of the cases are among workers whose exposure is believed to have been below the 2 $\mu g/m^3$ workplace standard (Kreiss, et al., 1996; Stange, et al., 1996).
- A number of the cases are among workers not directly involved in beryllium-related work (e.g., clerical workers, secretaries, security guards), whose exposure to beryllium should only have been incidental (Kreiss et al., 1993a, 1996; Stange et al., 1996).

These two observations, combined with the increased incidence of CBD and beryllium sensitization, have led DOE to believe that the current standard may not be protective enough and that further controls are necessary.

Although DOE is de-emphasizing the nuclear weapons program, the major source of beryllium use, the Department expects the pace of beryllium-related work to *increase* in the near future. First, DOE expects to continue using beryllium in its industrial, aerospace, and research and development projects because the combination of properties beryllium offers in these applications is not easily replaced by other metals or materials. Second, DOE has begun to decommission facilities that are no longer needed to support the Department's mission. Facilities that are decommissioned must also be decontaminated before they are demolished or converted to other uses. These projects, called decontamination and decommissioning (D&D) projects, will increase in the near future as surplus facilities are taken off-line (Office of Environmental Management, 1996). Several of the facilities slated for D&D are contaminated with beryllium, creating the potential for harmful exposures among D&D workers. The continued use of beryllium in industrial and aerospace applications, combined with the increased pace of D&D work, will increase the number of operations that present the potential for worker exposure to beryllium in the near future.

In summary, beryllium poses a significant health threat, and recent health monitoring has shown that CBD and beryllium sensitization continue to occur in the DOE workforce. A number of recently identified cases of CBD and beryllium sensitization are believed to have resulted from incidental exposures thought to be well below the current standard. Based on these observations, DOE is issuing this rule to prevent the occurrence of CBD among the Department's workforce through aggressive exposure reduction and minimization efforts.

1.2 BERYLLIUM EXPOSURE AND MARKET FAILURE

The U.S. Office of Management and Budget (OMB) (1996) states that federal agency actions such as rules should be taken only in the case of significant market failures. A market failure occurs when the results of a free market (e.g., the working conditions at DOE facilities) can be improved.[4] A market failure is *significant* when non-government mechanisms (e.g., negotiation among interested parties) cannot ameliorate the failure. OMB (1996) identifies four possible market failures: externalities, natural monopolies, excessive market power, and inadequate or asymmetric information. Beryllium exposure in the DOE workplace is an example of the fourth: exposure to beryllium and the consequent risk of disease is characterized by a lack of information. The lack of information leads to an inefficient allocation of the risk associated with beryllium-related disease.

Additionally, this is not a case of asymmetric information, but rather a case of an absence of information. In a case of asymmetric information, one party (e.g., DOE contracters) has the information while the other (e.g., workers) does not have the information. If this were the case, then the efficient solution to this market failure would be to provide workers with the information that they are lacking. As will be discussed below, however, the market fails to allocate compensation for beryllium-related risk because neither workers or their employers have the necessary information. Thus, the absence of information creates a market failure in the market for beryllium-related workers. The remainder of this section elaborate this point.

Workers performing beryllium-related work risk developing CBD. If workers and their employers had complete and accurate information about (1) the risk of developing CBD and (2) each other's preferences, then wages would act as an efficient allocation mechanism. Given a wage rate and a risk of developing CBD, only the workers who are willing to accept the risk at the given wage rate would elect to perform beryllium-related work. Clearly, this places a strong informational requirement on the market. First, workers and employers must know with certainty the risk and costs of developing CBD. Second, workers and employers must be able to tell what the other is willing to accept in terms of wages and risk. Although neither is likely to be satisfied, recent evidence suggests that the first is very unlikely to be satisfied at present.

[4] An improvement can occur if the result can be changed to make at least one market participant better off, while making no one else worse off. In economics, a market result is said to be *Pareto optimal* if no one can be made better off without making someone else worse off. Market failures result in situations that are not Pareto optimal.

Although the adverse health effects of beryllium have been recognized since the early 1940s (Eisenbud and Lisson, 1983), CBD is still not well understood by the medical community, and much less so by the average worker (Jameson, 1996). Several studies have been conducted on the health effects of beryllium exposure, but a definitive dose-response relationship has not yet been established (Kreiss et al., 1993a,b, 1996; Stange et al., 1996; Barnard et al., 1996). Furthermore, a number of cases of CBD and beryllium sensitization have occurred in workers believed to have been exposed at levels below the OSHA 8-hour TWA PEL (2 $\mu g/m^3$). Finally, the effect of particle size on the risk of CBD is only now being addressed in research, so no definitive results are available. Thus, from a medical perspective, the risk of performing a specific beryllium-related job or task may not be well-defined.

Another necessary condition for wages to act as an efficient allocation mechanism is for the set of workers that will incur risk to be well defined. In other words, all workers who risk developing CBD must know they face that risk. Given the recent cases of CBD and beryllium sensitization among individuals thought to have had only incidental contact with beryllium (e.g., secretaries, clerical staff), this condition may not be met. Before these cases were identified, only workers who were directly involved in beryllium-related work were believed to risk developing CBD, and that the risk was believed to be small. Such cases imply that more workers may be at risk than was originally perceived.

While wages are generally the preferred allocation mechanism in the labor market, other mechanisms can allocate the risk of CBD. The tort system is one such mechanism. Monetary losses stemming from lawsuits for worker exposure to beryllium may act as an incentive to provide a safe and healthful working environment. As with wages, however, the lack of perfect knowledge regarding the risk of developing CBD implies that the tort system may not be an efficient allocation mechanism for beryllium-related risk.

Another possible allocation mechanism is the use of insurance to hedge against the possibility of developing CBD in the future.[5] In this situation, workers would buy insurance against contracting CBD. Theoretically, workers would buy enough coverage so that if they contracted CBD, the compensation from the insurance provider would render them no worse off than if they had not contracted CBD.[6] Like the tort system, insurance against CBD is an unlikely

[5] This potential allocation mechanism may be more of a theoretical construction than a real-life possibility.

[6] Insurance of this type is different than health insurance that covers the medical costs of illness. This type of insurance would provide a payment to the worker to compensate him/her for contracting CBD.

mechanism to allocate CBD risk. The primary reason being that this type of insurance is not available. Also, a market for CBD insurance is not likely to develop because of the uncertainties surrounding the risk of developing CBD and because the value of avoiding CBD (i.e., payments to workers who develop CBD) cannot be calculated with any accuracy.

Based on the preceding considerations, beryllium exposure at DOE facilities can be considered a market failure. The failure occurs because both workers and employers lack information about the risk of developing CBD. This lack of information cannot be resolved through simple negotiation or other non-government allocation mechanisms. DOE believes this rule will alleviate this market failure by protecting workers exposed to beryllium at DOE facilities.

1.3 OVERVIEW OF THE ECONOMIC ANALYSIS

This section provides an overview of the analyses contained in this report. This report fulfills the requirements of a number of Executive Orders and public laws, including:

- Executive Order (EO) 12866, *Regulatory Planning and Review*;
- The Regulatory Flexibility Act (RFA), as amended by the Small Business Regulatory Enforcement Fairness Act (SBREFA);
- The Unfunded Mandates Reform Act.

The remainder of this section discusses both the analyses required by each of the above orders and laws and the manner in which this report fulfills these requirements.

1.3.1 Executive Order 12866

EO 12866 requires federal agencies to conduct economic analyses of significant regulatory actions. DOE has determined that the CBDPP rule constitutes a regulatory action that should be subject to review under EO 12866. Pursuant to this, DOE conducted the following analyses:

- Estimated the incremental compliance costs (Chapter 3);

- Evaluated the benefits of reducing beryllium exposure (Chapter 4); and
- Evaluated the market impacts of the CBDPP rule (Chapter 5).

Before presenting these analyses, DOE provides a profile of the affected sites and activities in Chapter 2.

1.3.2 Small Business Analysis

The purpose of the RFA and its subsequent amendment in SBREFA is to ensure that federal regulations do not unduly burden small entities, including small businesses, small governments, and small nonprofit organizations.[7] Federal departments or agencies issuing rules are required to assess the likely effect of the rule on small entities. If the rule is deemed to have a *significant* effect on a *substantial* number of small entities, then the department or agency must conduct further analyses that identify alternative, less-costly approaches to the requirements of the rule. DOE conducted an analysis of the impacts that the CBDPP rule will have on small businesses. This analysis is contained in Chapter 6, Section 6.1.

1.3.3 Unfunded Mandates Analysis

The purpose of the Unfunded Mandates Reform Act is to reduce the incidences of federal agencies imposing unfunded requirements on state and local governments. To fulfill this law, DOE reviewed the CBDPP rule to determine if any of the requirements impose an unfunded mandate on state or local governments. This analysis is contained in Section 6.2 of Chapter 6.

1.3.4 Summary

In summary, DOE will perform three analyses in this report:

- *Review under EO 12866 (Chapters 2 to 5)*—DOE will profile the affected activities, estimate compliance costs, evaluate benefits, and considers the market impacts of the CBDPP rule;
- *Small business analysis pursuant to the Regulatory Flexibility Act, as amended by the SBREFA (Chapter 6, Section 6.1)*—DOE will assess the impact of the CBDPP rule on small businesses.

[7] The CBDPP rule will only have an effect on small businesses and not small governments or small non-profit organizations.

- *Unfunded mandates analysis pursuant to the Unfunded Mandates Reform Act (Chapter 6, Section 6.2)*—DOE will determine if the CBDPP rule imposes any unfunded mandates on state or local governments.

CHAPTER TWO
PROFILE OF AFFECTED DOE FACILITIES AND ACTIVITIES

DOE's past and current uses of beryllium create the potential for harmful exposures to beryllium within the DOE complex. Past uses of beryllium include a number of manufacturing and research projects, most of which were associated with nuclear weapon production and maintenance. These past uses present the potential for worker to be exposed to beryllium during the performance of environmental restoration projects at beryllium-contaminated sites. Beryllium is still used in manufacturing and research projects, but, in recognition of the health hazards associated with inhaling beryllium particles, today's operations are performed under far more stringent controls than those of the past. Despite these controls, these operations continue to potentially expose workers to beryllium, and affected workers continue to become sensitized to beryllium or to develop CBD.

This chapter profiles DOE activities and facilities that are associated with the potential for worker exposure to beryllium. The chapter begins by explaining the scope of the rule (Section 2.1). Section 2.2 discusses DOE activities that may result in worker exposure to beryllium. Section 2.3 discusses DOE facilities at which these activities take place and presents quantitative estimates of the number of workers involved in the activities.

2.1 SCOPE OF THE RULE

The Chronic Beryllium Disease Prevention Program (CBDPP) rule would apply to DOE offices and contractors whose employees are exposed or potentially exposed to beryllium at DOE-owned or -leased facilities (850.2 (a)). The rule does not apply to DOE laboratory operations that are subject to the requirements of 29 CFR 1910.1450, "Occupational Exposure to Hazardous Chemicals in Laboratories" (the laboratory standard). OSHA's laboratory standard (29 CFR 1910.1450(a)) covers all employers using hazardous chemicals when:

- Chemical manipulations are carried out on a "laboratory scale";
- Multiple chemical procedures or chemicals are used;
- The procedures are not part of a production process nor in any way simulate a production process; and
- Protective laboratory practices and equipment are available and in common sense use to minimize the potential for employee exposure to hazardous chemicals.

The Navy Nuclear Propulsion Program (NNPP) was exempted from DOE N 440.1. The current version of the CBDPP rule does not contain this exemption. DOE's Office of Nuclear Reactors requested that the NNPP not be excluded from requirements of the rule (Office of Naval Reactors, 1998a). Although the NNPP is no longer excluded from the rule, DOE has not included costs associated with NNPP in this analysis. Contact with the Office of Naval Reactors indicates that only one current worker and one former worker may be affected by the CBDPP rule (Office of Naval Reactors, 1998b). Thus, any potential cost to the NNPP may be minimal and therefore DOE has decided not to estimate compliance costs for the NNPP.

2.2 AFFECTED ACTIVITIES

Workers can be exposed to beryllium when beryllium particulate enters a worker's breathing zone. A number of beryllium-related activities at DOE facilities can involve such exposures. These activities are grouped into seven general categories:

- Research and development (R&D) projects involving beryllium;
- Current production and maintenance of beryllium-containing products;
- Decontamination and decommissioning (D&D) of beryllium-contaminated facilities;
- Maintenance (e.g., janitorial work) in beryllium-contaminated facilities;
- Detonating and dismantling of weapons with beryllium components;
- Industrial hygiene tasks associated with beryllium-related work; and
- Non-beryllium work in areas where beryllium contamination has spread.

This section profiles these activities at DOE facilities, describing the nature of each activity and its potential for exposing workers to beryllium.

2.2.1 Research and Development Activities

DOE funds a number of R&D projects that directly (i.e., the project focuses on a particular beryllium application) or indirectly (i.e., the project uses beryllium or beryllium components to study another product or application) involve beryllium. A search of the DOE R&D Project Summaries database found eight projects involving beryllium in fiscal year (FY)

1995 with total funding of $4.9 million, and eight more projects in FY 1996 with total funding of $2.4 million (Office of Scientific & Technical Information, 1997).

The quantities of beryllium in R&D projects are substantially smaller than those in production operations, however, harmful exposures still threaten researchers. Projects that involve the machining of beryllium or other processes that create beryllium dust or fumes may expose researchers to airborne beryllium particulates. In the 1996 survey of beryllium use in the DOE complex, six DOE facilities listed R&D-related job categories that involved the potential for worker exposure to beryllium (Office of Worker Health and Safety, 1996) (job categories appear in parentheses):

- Fermilab (lab supervisor);
- Lawrence Berkeley National Laboratory (researcher);
- Los Alamos National Laboratory (researcher);
- Oak Ridge National Laboratory (lab technician);
- Y-12 Plant (lab supervisor, lab technician, R&D group leader); and
- Sandia National Laboratory (researcher).

These facilities reported that 51 workers in these job categories may be exposed to beryllium while performing their work duties. These workers represent approximately 9.7 percent of the total number of workers reported to be potentially exposed to beryllium within the DOE complex in the 1996 survey (Office of Worker Health and Safety, 1996).

Although these R&D activities occur in DOE facilities and involve the potential to expose workers to beryllium, they may not be covered by the CBDPP rule. The CBDPP rule specifies in Section 850.2 (b)(2) that it excludes activities that are subject to OSHA's laboratory standard. Section 2.1 of this economic analysis discusses the scope of OSHA's laboratory standard. DOE expects that most laboratory research involving beryllium will be subject to the OSHA Laboratory standard.

2.2.2 Production Activities

Beryllium is an essential component in a number of DOE production applications, including nuclear weapons, nuclear reactor moderators and reflectors, and nuclear reactor fuel element cladding. With the end of the Cold War, DOE reduced its production of nuclear weapons, thereby also reducing the need for large-scale production of some beryllium-containing components. As a result, DOE is now consolidating its beryllium production operations in a new production facility: The Beryllium Technology Facility at LANL. This new facility will support weapons-related and scientific development of beryllium metal, alloys, and products. Its research will include energy and weapons-related use of beryllium metal and beryllium oxide (LANL, 1997).

Weapons-related production operations at the LANL Beryllium Technology Facility will include the following processes:

- *Machining*—Beryllium blanks are machined into usable shapes. Machining operations include the preparation of tensile bars, chemical and metallography samples, and the development of tooling and fixtures. The machining process removes about 50 percent of the original material.

- *Grinding and polishing*—Small specimens of beryllium and alloys are cut, ground, and polished in preparation for microstructural examination.

- *Inspection*—Machinists inspect beryllium-containing weapons components for defects using nondestructive processes. All weapons-related products are inspected, but, only about half of development products, like tools and fixtures, are inspected.

- *Foundry operations*—During foundry operations scraps of beryllium and alloy compositions are recycled. The material is melted and cast into reusable components. The foundry operation system includes a melt/cast chamber, vacuum system, power supply, and glove box for cleaning and preparing molds.

LANL has experience in machining, grinding and polishing, and inspection operations, but foundry operations have not been performed at the facility in the past (LANL, 1997).

2.2.3 Decontamination and Decommissioning Activities

The reduced emphasis on nuclear weapons in the post-Cold War era has eliminated the need for a number of DOE facilities.[8] Consequently, several DOE facilities have been slated for decontamination and decommissioning (D&D). DOE expects the rate of D&D activities within the DOE complex to increase in near term and increase the opportunities and potential for worker exposure to beryllium.

D&D activities are generally tailored to the facility being decommissioned, but D&D activities in beryllium-contaminated areas have several common aspects:

- *Cleaning*—Most beryllium-contaminated facilities contain equipment (e.g., machinery, tools) that can be reused in other applications.[9] For this equipment to be applied in other uses, the rule would require beryllium surface contamination to be below 3 $\mu g/100cm^2$ (850.30 (a)). The rule would further require that beryllium dust be removed from surfaces and floors through HEPA vacuuming or wet cleaning methods. Additionally, a strippable coating may be applied to flat, smooth surfaces (e.g., floors, countertops). Once dry, the coating is removed from the surface from the surface (i.e., stripped), taking the beryllium contamination with it.

- *Removal and disposal*—Contaminated equipment and building components that are not salvageable must be removed and disposed of properly. Beryllium-contaminated equipment that cannot be cleaned to less than the 0.2 $\mu g/100cm^2$ standard (850.31 (b)(1)) must be disposed of properly. The rule requires that smaller items (e.g., hand tools) be disposed in sealed impermeable bags or other closed impermeable containers. Larger items that may not be covered easily with plastic and may require extra attention to reduce potential exposure. Consequently, the rule requires that contractors use a tailored (i.e., risk-based) approach to dispose of such items. This approach may include breaking the equipment[10] or cleaning the equipment to the extent possible, and then sealing smaller portions of the equipment that may be the sources of potential exposure (e.g., crevices). Once they are cleaned and sealed properly, the beryllium-contaminated objects are sent to a landfill.

- *Demolition*—Buildings and other structures that are not being considered for future use may be slated for demolition. In such cases, D&D involves removing most of the

[8] DOE refers to facilities that are no longer needed as surplus facilities.

[9] One factor that may limit the use of beryllium-contaminated equipment in other applications is radiological contamination.

[10] This may not be an option for some beryllium-contaminated equipment because beryllium dust may be lodged inside the machinery. Thus, breaking the machinery apart may result in harmful exposures.

beryllium contamination (through cleaning and disposing of contaminated equipment and areas) before demolition to avoid releasing beryllium dust into the ambient air.

In addition to these generic activities, the D&D of beryllium-contaminated facilities may involve facility-specific activities that do not fall under the three preceding categories.

D&D activities pose significant challenges to protecting worker health and safety for at least three reasons. First, the nature of the activities (i.e., decontamination) require direct contact with hazardous substances like beryllium (U.S. DOE, 1997). Second, records of the nature of the work performed at the facility and the extent of beryllium contamination in the facility may not correlate well with potential exposures during D&D activities (U.S. DOE, 1997). Third, records, if they are available, may not accurately reflect the nature of the work that was performed in the facility or the extent of beryllium contamination in the facility (U.S. DOE, 1997). The CBDPP rule addresses each of these points by requiring a baseline inventory and sampling (850.20) and hazard assessments (850.21) before D&D activities begin.

A D&D project associated with the reconfiguration of the beryllium processing area at LANL (Area TA-3-141) exemplifies the extent of contamination that may be found in D&D projects at other beryllium processing areas. Before the project began, LANL characterized the facility to determine the nature and extent of the contamination (LANL, 1996). The beryllium processing area showed a substantially high level of contamination. The characterization specified a "level of concern" (LOC) contamination level of 1.9 $\mu g/ft^2$ (i.e., 0.21 $\mu g/100\ cm^2$). LANL used the LOC to determine if the potential for beryllium exposure would exist during facility reconfiguration. Several of the areas characterized in the report had contamination levels more than 100 times greater than the LOC. Additionally, significant beryllium contamination was found in areas where it was not expected, such as office areas (LANL, 1996).

2.2.4 Maintenance Activities

Like the activities they support, a number of maintenance activities may result in harmful exposures to beryllium dust (Stange et al., 1996). Maintenance activities are undertaken to support other activities, such as production of beryllium-containing parts. The 1996 DOE Beryllium Survey (Office of Worker Health and Safety, 1996) identified four job categories of maintenance work:

- Air conditioning and refrigeration mechanic (one worker at Y-12);

- Cleaner (two workers at Y-12);
- Custodian (three workers at LANL); and
- Maintenance mechanic (five workers at LLNL).

The 1996 survey indicated that at least 11 maintenance workers in the DOE complex may have been exposed to beryllium during their work.

The maintenance activity that may pose the greatest potential for workers exposing to beryllium is cleaning and replacing air filters in the exhaust ventilation system for beryllium processing areas. The site characterization at LANL's beryllium processing facility found a contamination level of 5,156 μg/100 cm^2 in the exhaust ventilation system (LANL, 1996). Furthermore, the air filter itself contains significant amounts of beryllium removed from the air.

In addition to air filter cleaning and replacement, a number of other maintenance jobs, such as housekeeping in beryllium production areas and laundering beryllium-contaminated protective clothing, may expose workers to beryllium dust. For example, contractors who are hired to fix building-related problems (e.g., HVAC malfunctions) may be exposed to beryllium.

2.2.5 Detonating and Dismantling Weapons

The de-emphasis of nuclear weapon production in the post-Cold-War era was accompanied by a reduction in the stock of weapons, while DOE dismantles and destroys weapons. Workers may be exposed to beryllium dust while disassembling and removing beryllium-containing parts and detonating of non-nuclear explosive weapon components. During detonation, beryllium parts are destroyed with the explosive weapon components, and beryllium dust may become suspended in the air and create a potential inhalation hazard for workers.

The Pantex plant in North Central Texas engages in several activities of this nature that may expose worker to beryllium, including (Office of Worker Health and Safety, 1996):

- Weapon disassembly;
- Weapon component separating, crushing, shredding, and detonating;
- Weapon shield removal; and

- Weapon materials management.

Pantex employs seven weapons engineers to perform some of these activities (Office of Worker Health and Safety, 1996).

2.2.6 Industrial Hygiene Tasks

The hazardous nature of beryllium requires DOE to undertake a number of industrial hygiene (IH) related tasks, such as:

- Installing and maintaining air monitors and personal breathing zone samplers;
- Collecting swipe samples; and
- Performing hazard analyses.

Generally, any task that brings the industrial hygienist into beryllium-contaminated areas poses the potential for beryllium exposure. Therefore, industrial hygienists performing IH tasks in beryllium-contaminated areas should receive the same level of protection as workers in other job categories who have the same exposure. LANL reported that they have five workers who are potentially exposed to beryllium while performing routine IH tasks (Office of Worker Health and Safety, 1996).

2.2.7 Non-Beryllium Work Where Exposure is Possible

In addition to the beryllium-related work described in the previous six categories (Sections 2.2.1 to 2.2.6), other activities that are not directly associated with beryllium use may have the potential for exposure. The potential for exposure in these other activities results not from the tasks that are performed, but from the proximity of their work areas to designated beryllium areas and from the potential for the contamination to spread from the beryllium areas to adjacent work areas. Therefore, diverse activities that do not involve beryllium, such as clerical, secretarial, janitorial, and production operations, may have indirect potential for exposure if they are near beryllium areas. While these activities are intended to be free of contamination, experience has shown that individuals performing them have been exposed at levels high enough to induce sensitization and disease (Kreiss, et al., 1993a, 1996; Stange, et al., 1996).

2.3 AFFECTED FACILITIES AND NUMBERS OF AFFECTED WORKERS

This section lists the affected sites for which cost estimates are made and provides an estimate of the number of workers affected by the CBDPP rule. These data items are used in the cost estimation (Chapter 3).

A number of sites use beryllium across the DOE complex and thus will be affected by the CBDPP rule. For this analysis, DOE has identified 14 such sites. These sites, which appear in Table 2-1, were identified through the CBDPP plans submitted under DOE Notice 440.1, contact with DOE field offices and sites, and through the 1999 Environment, Safety and Health (EH) Cost Impact Survey (1999 EH Cost Impact Survey) (EH, 1999). Any site that submitted either an interim or a final plan under DOE Notice 440.1 was considered affected by the rule.

Table 2-2 provides estimates of the number of workers affected by this rule. This information was gathered primarily from the 1999 EH Cost Impact Survey (EH, 1999). This information indicates that 1,634 workers are currently exposed or potentially exposed to beryllium. Of these workers, 1,236 (75.6 percent) are exposed or potentially exposed to beryllium above action level or PEL. Furthermore, DOE sites have indicated that a total of 8,113 current workers are or were exposed or potentially exposed to beryllium.

Table 2-1
Affected Sites

Site	Location	Mission	Approximate Total Number of Workers
Argonne East	Chicago, IL	Research and development to support development of energy-related technologies	4,500 [a]
Argonne West	Idaho Falls, ID	Technology development for spent nuclear fuel and waste treatment, reactor and fuel cycle safety, and facility decommissioning	-
ETTP (K-25)	Oak Ridge, TN	Environmental restoration, waste management, technology development and demonstration, education and training, and technology transfer	6,200
Hanford	Richland, WA	The site originally produced plutonium for U.S. nuclear weapons. The site is currently involved in environmental restoration.	10,500
Kansas City	Kansas City, MO	Manufacturing nonnuclear components for nuclear weapons	3,300
LANL	Los Alamos, NM	National security focus combined with several areas of high-tech research (e.g., space nuclear systems, controlled thermonuclear fission, lasers, biomedicine, environmental management)	10,000
LBL	Berkeley, CA	Energy-related reset activities	3,400
LLNL	Livermore, CA	Research, testing, and development that focus on national defense and security, energy, the environment, and biomedicine	9,700
Mound	Miamisburg, OH	Environmental restoration for conversion to commercial industrial site	5,100
ORNL	Oak Ridge, TN	Basic and applied research in numerous scientific fields	5,000
Pantex	Amarillo, TX	Fabricating high explosives for nuclear weapons, assembling and disassembling nuclear weapons	2,400
Stanford	Menlo Park, CA	High-energy accelerator research	1,400
Rocky Flats	Rocky Flats, CO	Cleanup and restoration	4,000
Y-12	Oak Ridge, TN	Nuclear weapons processing technologies	4,000

Source: Office of Environmental Management, 1996.
[a] Includes workers at the Argonne-West site.

Table 2-2
Numbers of Affected Workers

Site	Beryllium-Exposed Workers that are Currently Exposed or Potentially to Beryllium [a]	Beryllium-Exposed Workers that are Currently Exposed or Potentially to Beryllium Above the Action Level or PEL [b]	Total Number of Beryllium-Exposed Workers [c]
Argonne East	4	4	419
Argonne West	34	0	283
ETTP (K-25)	12	0	350
Hanford	50 [d]	0	205
Kansas City	50	0	40
LANL	200	200	3,000
LBL	17 [e]	0	18
LLNL	20 [e]	0	914
Mound	69	69	38
ORNL	26	0	85
Pantex	300	119	1,000
Stanford	8	0	17
Rocky Flats	228	228	500
Y-12	616	616	1,244
Totals	**1,634**	**1,236**	**8,113**

[a] EH, 1999, except where noted. The rule defines beryllium-exposed workers as any current (i.e., still employed at the site) worker that *is* or *was* exposed or potentially exposed to beryllium. This is the number of workers that currently is exposed to beryllium. This is used as an input in a number of the compliance requirements.
[b] EH, 1999. This number is a subset of the previous column.
[c] EH, 1999. This is the total number of beryllium-exposed workers. The rule defines beryllium-exposed workers as any current (i.e., still employed at the site) worker that *is* or *was* exposed or potentially exposed to beryllium. This number of workers is used exclusively in the medical-related compliance requirements (850.34, 850.35, and 850.36) as an input. The first column is a subset of this column.
[d] Morris, 1998.
[e] Office of Worker Health and Safety, 1996.

CHAPTER THREE
ESTIMATED COMPLIANCE COSTS

This chapter estimates the compliance costs of the Chronic Beryllium Disease Prevention Program (CBDPP) rule. The chapter begins with a general discussion of the cost estimation methodology (Section 3.1) and then presents the estimated costs (Section 3.2). Section 3.3 summarizes the estimates.

3.1 COST ESTIMATION METHODOLOGY

This section presents the methodology used in estimating the incremental compliance costs for the CBDPP rule. This section begins with a discussion of the relationship between the CBDPP rule and DOE's previous beryllium policy (DOE Notice 440.1) and discusses the timetable of costs incurred by affected facilities (Section 3.1.1). Section 3.1.2 discusses DOE's process in estimating compliance costs for the rule. Finally, Section 3.1.3 presents the wage rates and unit costs used in estimating compliance costs for the rule. Finally, Section 3.1.4 discusses the use of data collected from the 1999 EH Cost Impact Survey (EH, 1999) to provide conservative cost estimates for some of the compliance requirements.

3.1.1 Relationship Between the CBDPP Rule and DOE Notice 440.1

On July 15, 1997, Secretary PeÔa signed DOE Notice 440.1 (DOE N 440.1), *Interim Chronic Beryllium Disease Prevention Program* (the Notice) as an interim measure to provide protection of workers engaged in beryllium-related activities in the DOE complex. The CBDPP rule incorporates many of the requirements of DOE N 440.1 and adds some new requirements. Contact with sites during this analysis, as well as review of the CBDPP plans submitted under DOE N 440.1, indicates that sites have begun to implement several of the Notice's requirements. Based on discussions with the Office of Management and Budget (OMB), DOE has decided that costs incurred in response to DOE N 440.1 are incremental to the CBDPP rule. This determination is based on the fact that DOE N 440.1 was issued as an interim, short-term measure to protect workers from beryllium exposure while the Department continued with formal rule-making activities.

DOE N 440.1 and the CBDPP rule are not identical. Thus, the estimated compliance costs will differ between the time period that DOE N 440.1 is effective and the time that the rule becomes effective. DOE N 440.1 was signed on July 15, 1997 and then extended at the time of its expiration (July 15, 1998). DOE expects DOE N 440.1 to be effective until issuance of the

final version of this rule. Furthermore, DOE expects to publish the final version of this rule in December 1999.[11] Thus, from July 1997 until December 1999, affected entities will incur the costs of complying with DOE N 440.1. From December 1999 until the end of the rule's effective period, affected entities will incur the costs associated with the CBDPP rule.[12] DOE accounts for this change in costs in estimating the compliance costs of the CBDPP rule.

3.1.2 Estimating Incremental Compliance Costs

This chapter presents estimates of the incremental compliance costs for the requirements contained in the CBDPP rule. The method used to calculate these costs varies between the requirements, and therefore detailed methods are presented along with the cost estimates in Section 3.2. In general, however, costs are estimated by determining the incremental amount that DOE contractors must spend to comply with the rule. Excluded from these costs are the costs that either would (a) be incurred in the absence of the rule (i.e., as part of current operating procedures) or (b) are attributable to other regulations.[13] In this analysis, DOE estimates the costs of compliance with the CBDPP rule using the following five steps:

- *Step 1*—DOE developed compliance profiles for each requirement of the rule. These compliance profiles identify controls that need to be implemented for DOE contractors to be in compliance with the rule.

- *Step 2*—DOE compared the compliance profiles to current operating procedures at DOE sites to determine which of the controls in the profile are incremental (i.e., new) to DOE facilities. DOE then adjusted the compliance profiles to reflect only the new controls that DOE contractors will have to implement to be in compliance with the rule.

- *Step 3*—DOE developed cost estimates for each of the compliance profiles.

- *Step 4*—DOE generated total cost estimates for each requirement by multiplying the cost for each compliance profile by the number of relevant units (e.g., workers, sites)

[11] Although the rule is expected to be published in December 1999, the rule allows sites and contractors two years to reach full compliance with the requirements. In terms of estimating compliance costs, DOE assumes that affected entities will begin to incur compliance costs at the time the final rule is published.

[12] It should be noted that a number of the requirements of DOE N 440.1 are repeated in the proposed rule. Thus, the costs of DOE N 440.1 and the proposed rule are not unrelated.

[13] This includes regulations issued by other federal agencies such as the Environmental Protection Agency (EPA) or the Occupational Health and Safety Administration (OSHA), or DOE orders and notices that are not associated with this rulemaking.

that are affected by the requirement. The number of affected units were taken from the profile of affected sites and activities in Chapter 2.

- *Step 5*—DOE converted the costs for each requirement into an annualized cost using a 7 percent discount rate (OMB, 1992). For initial requirements (i.e., those incurred in the first year of the rule), DOE annualized the cost the requirement over the life of the requirement.

Before discussing each of the steps in more detail below, this section briefly discusses DOE's choice of discount rate, expected life of the rule, and method for annualizing initial costs. Included in the discussion of the method of annualizing initial costs is a discussion of the possible lifetimes for initial requirements of the rule and DOE N 440.1.

Discount rates are used to translate costs (and benefits) that are incurred in future years into a present value. Following OMB (1992) guidance, DOE chose a 7 percent discount rate. In the analysis, DOE uses the 7 percent discount rate for three purposes: (1) to annualize the costs of equipment or other program elements that have a lifetime of more than one year, (2) to translate the costs incurred in future years into a present value, and (3) to calculate the annualized cost of initial requirements of DOE N 440.1 and the CBDPP rule.

DOE chose a 10 year expected life for the CBDPP rule. This follows DOE's Office of Organization and Management (1996) guidance on estimating the impact of DOE orders. Thus, initial requirements that are only incurred in the first year of the rule are annualized over 10 years using a 7 percent discount rate.

In order to annualize initial costs, DOE assumes that initial costs can be treated as an annuity that is owed where the total value of the annuity is the initial cost. To calculate the annual cost associated with an initial cost, a lifetime and a discount rate are required. The lifetime of the annuity will depend on the assumed lifetime of the initial requirement. Specifically, there are three possible lifetimes for initial requirements in this analysis:

- *Initial requirements of DOE N 440.1 that are superseded in the CBDPP rule*—These requirements have a lifetime equal to the time between the signing of DOE N 440.1 and the promulgation of the final version of this CBDPP rule. DOE N 440.1 was issued in July 1997 and the final rule is expected to be promulgated in December 1999. Thus, these requirements have a lifetime of 29 months (2.42 years).[14]

[14] Although this is a possibility, there are no requirements that fit into this category.

- *Initial requirements of DOE N 440.1 that are continued in the CBDPP rule*—These requirements have a lifetime that begins with the signing of the Notice (July 1997) and lasts until the end of the rule. The rule is expected to be effective until December 2009 (i.e., 10 years beginning in December 1999). Thus, these requirements will have a lifetime of 12.42 years (i.e., from July 1997 until December 2009).

- *Initial requirements of the CBDPP rule that are not contained in DOE N 440.1*—These requirements have a lifetime equal to the lifetime of the rule: 10 years.

The formula for estimating the annual cost of an annuity for a given total annuity cost (i.e., initial cost), discount rate, and lifetime is (Brealey and Myers, 1984):

$$\text{Annual Cost} = [\text{Initial Cost}] \times \left[\frac{1}{r} - \frac{1}{r(1+r)^t}\right]^{-1}$$

where r is the discount rate (i.e., 7 percent) and t is the annualization period (lifetime).

DOE's cost estimation began by reviewing the rule to determine which requirements of the rule will impose costs on affected entities. DOE then determined the controls (e.g., implementation of procedures, purchase of equipment) necessary for affected entities to be in compliance with each requirement. DOE refers to these determinations as *compliance profiles*. The profiles are designed to reflect the full opportunity cost of compliance.[15] To develop these profiles, DOE reviewed CBDPP plans submitted under DOE Notice 440.1, contacted DOE facilities that are affected by the rule, reviewed the results of the 1999 EH Cost Impact Survey (EH, 1999), and reviewed other economic analyses of worker health regulations (e.g., economic analyses developed by the Occupational Safety and Health Administration (OSHA) in support of OSHA regulations).

The goal of the compliance cost estimation is to determine the *incremental* costs of compliance (OMB, 1996). To accomplish this, the compliance profiles were compared to the procedures and controls (i.e., current practices) that are currently in place at DOE facilities affected by the rule (i.e., the baseline). Procedures and controls contained in the CBDPP rule that are not currently in place at DOE facilities were considered new to the facilities, and thus will

[15] For example, the compliance profile for performing a blood beryllium lymphocyte proliferation (Be-LPT) test includes not only the test itself, but also the labor time for the worker and physician to conduct the test, shipping the sample to a lab, and analyzing and interpreting the results of the test.

impose incremental costs on the affected entities. The compliance profiles were then adjusted to reflect only the required incremental controls.

The next step was to estimate the costs for each compliance profile. DOE collected data on the cost of each element contained in the compliance profiles, including the cost of any required equipment, labor costs, medical tests, or procedures. The cost data was obtained from a variety of sources, including CBDPP plans submitted under DOE Notice 440.1, the 1999 EH Cost Impact Survey (EH, 1999), contact with DOE facilities subject to the CBDPP rule, trade publications; the U.S. Office of Personnel Management (OPM) (e.g., for wage rates), and previous economic analyses of other regulations (e.g., regulatory impact analyses of OSHA health standards). This cost data was then applied to the compliance profiles to determine the costs associated with each profile, providing an estimate of the incremental cost for each requirement.

DOE-wide cost estimates for each requirement were generated by multiplying the number of units affected by each requirement by the incremental cost for each requirement. The number of units affected by each requirement was taken from Chapter 2 (Profile of Affected Activities and Sites). Costs estimated in this step were then annualized using a 7 percent discount rate. Initial costs were annualized using the method discussed above. Recurring costs with a life of more than one year (e.g., a biennial requirement) were annualized over the life of the requirement.

3.1.3 Labor Costs and Other Unit Costs Applied in the Cost Estimation.

A number of unit costs will be needed in providing cost estimates for the CBDPP rule. Many of the requirements involve labor time. Table 3-1 provides hourly labor costs for both workers and industrial hygienists at each site. These labor costs are fully loaded (i.e., they reflect the hourly wage for these workers marked up by a factor to account for overhead and benefits) and were provided by the affected sites in the 1999 EH Cost Impact Survey (EH, 1999). The worker labor costs represent the weighted average of labor costs for the different types of workers that the site employs. Table 3-1 also provides the labor cost (fully loaded) for industrial hygienists. This labor cost was also provided by the affected sites in the 1999 EH Cost Impact Survey (EH, 1999).

Table 3-1 also provides the four other unit costs for each site: (1) the sample analysis cost, (2) the cost of initial medical evaluations, (3) the cost of annual medical evaluations, and

(4) the cost of medically-indicated referral evaluations. The sample analysis costs are used in providing costs for the baseline inventory requirement (850.20), the exposure monitoring requirement (850.24), and the swipe sampling requirement (850.30). These unit cost estimates were provided by the affected sites in the 1999 EH Cost Impact Survey (EH, 1999). The unit costs of the three medical evaluations were estimated in Appendix A and encompass a number of labor costs, medical procedures, and medical tests.

Finally, DOE used two other labor costs that were assumed to be constant across sites. DOE assumed that a physician's labor time could be valued at $59.53 and that a clerical workers time could be valued at $11.50. Both of these reflect fully loaded hourly labor costs. (Both of these labor costs were derived in Appendix A of the Economic Analysis of the *proposed* CBDPP rule).

Table 3-1
Hourly Labor Costs and Other Unit Costs

Site	Hourly Labor Costs [a]		Sample Analysis Cost [a]	Medical Evaluations		
	Workers	Industrial Hygienists		Initial [b]	Annual [c]	Referral [d]
Argonne East	$51.38	$64.90	$120	$693.42	$539.81	$8,752.17
Argonne West	$141.58	$67.31	$310	$873.82	$675.10	$10,916.91
ETTP (K-25)	$45.97	$50.00	$60	$682.61	$531.69	$8,622.37
Hanford	$65.90	$50.48	$235	$722.45	$561.58	$9,100.49
Kansas City	$46.73	$54.09	$250	$684.12	$532.83	$8,640.54
LANL	$71.39	$86.54	$250	$733.45	$569.83	$9,232.46
LBL	$112.50	$86.54	$275	$815.66	$631.48	$10,219.00
LLNL	$65.90	$112.50	$200	$722.45	$561.58	$9,100.49
Mound	$81.05	$112.50	$75	$752.76	$584.31	$9,464.20
ORNL	$52.71	$58.41	$80	$696.09	$541.80	$8,784.13
Pantex	$65.90	$74.64	$54	$722.45	$561.58	$9,100.49
Stanford	$65.90	$70.31	$55	$722.45	$561.58	$9,100.49
Rocky Flats	$69.08	$75.72	$275	$728.82	$566.36	$9,176.94
Y-12	$50.40	$54.06	$83	$691.45	$538.33	$8,728.52

Source: EH, 1999.
[a] EH, 1999.
[b] See Appendix A, Section A.2.1 and Table A-2.
[c] See Appendix A, Section A.2.2 and Table A-4.
[d] See Appendix A, Section A.2.3 and Table A-6.

3.1.4 Using the 1999 EH Cost Survey to Provide Conservative Estimates

The 1999 EH Cost Impact Survey (EH, 1999) provided inputs to the cost estimates for a number of the requirements in the CBDPP rule. A number of the questions in the Survey asked sites to provide two data elements for specific requirements: (1) the number of labor hours it would take to fulfill the requirement and (2) the monetary resources it would take to fulfill the requirement. Specifically, the Survey generated these two data elements for ten requirements:

- Submitting initial CBDPP plans under DOE N 440.1 (850.10);
- Revising the initial CBDPP plans submitted under DOE N 440.1 to comply with 10 CFR 850 (850.10);
- Submitting annual revisions to the CBDPP plans (850.10);
- Baseline inventory (850.20);
- Hazard assessment (850.21);
- Regulated areas (850.26);
- Hygiene Facilities and Practices (850.27);
- Develop a recordkeeping system (850.39);
- Maintain the recordkeeping system (850.39); and
- Provide performance feedback (850.40).

In order to provide a conservative estimate of the costs of these requirements, DOE developed a cost estimate from each data element separately. DOE used the second data element (i.e., the monetary resources needed to comply with the requirement) directly. Thus, DOE's first estimate of the cost of these requirements was the monetary cost needed to comply reported by the site in the 1999 EH Cost Impact Survey.

DOE then used the reported labor time (i.e., the first data element) to provide an additional cost estimate. Depending on the requirement, DOE valued the reported labor time at either the industrial hygienist's labor cost or the clerical worker labor cost. In some cases where the reported labor time was assumed to be an industrial hygienist's time, DOE added some time for clerical labor. The exact methods used for each requirement are delineated in the discussion

for each requirement in Section 3.2. This method provided a second cost estimate for each the above requirements.

DOE then provided a cost estimate for each site by taking the larger of the two estimates. Using this procedure, DOE believes that it has provided a conservative estimate of the cost for each of the ten requirements listed above.

3.2 ESTIMATED COMPLIANCE COSTS

This section provides estimates of the incremental compliance costs of the CBDPP rule for each section of the rule that imposes an incremental requirement. As described in Section 3.1.1, DOE estimated the costs of the CBDPP rule by first identifying requirements of the rule that will impose new costs on DOE contractors (Steps 1 and 2). DOE then estimated the costs of these new requirements (Step 3) and provided annualized compliance costs for implementing the requirements across the DOE complex (Steps 4 and 5). This section reflects the results of this analysis. Section 3.3 summarizes the estimates of this section.

3.2.1 850.10, 850.11 Chronic Beryllium Disease Prevention Program (CBDPP)

The CBDPP rule requires affected DOE sites to submit written Chronic Beryllium Disease Prevention Programs (CBDPPs) within 90 days of the effective date of the rule. The CBDPP must cover all of the requirements of Subpart C (Program Requirements) of the rule (850.11 (b)(2)). All DOE activities must, henceforth, be conducted in compliance with the CBDPP and the CBDPP must identify all activities within the scope of the CBDPP. An update of the CBDPP must be submitted to DOE when the CBDPP is altered or whenever there is a change in contractor or subcontractor (850.10 (c)).

DOE N 440.1 also required submission of a CBDPP. The final versions of these plans were due to DOE on January 15, 1998. Thus, sites that are subject to this rule have already begun incurring the time and effort to submit *initial* versions of these plans to DOE. The CBDPP rule and DOE N 440.1 have a number of differences and therefore the CBDPPs submitted under the Notice may not fully comply with the requirements of the rule. Therefore, sites will generally require additional time and effort to update the CBDPPs submitted under the Notice to comply with the requirements of the rule. In addition, sites will incur costs associated with updating the programs on a recurring basis.

DOE expects this section of the rule to impose at least four incremental requirements on DOE contractors:

- *Time to submit initial versions of the CBDPP Plan under DOE N 440.1*—Sites have already incurred the time and effort to submit initial version of the plans. Final versions of the plans were submitted to DOE in January 1998.

- *Time to update the CBDPP submitted under the DOE N 440.1*—Sites will incur a cost to revise the plan submitted under the Notice. Although DOE N 440.1 and the CBDPP rule contain a number of similarities, they are not identical. Thus, in order to ensure that the CBDPP is in compliance with the rule, sites are assumed to revise the plan as necessary.

- *Time to periodically revise the plan*—The rule requires the CBDPP to be revised and resubmitted to the DOE Field Organization whenever a significant change occurs in the site's CBDPP or whenever a change in contractor occurs. Site will also be required to review the CBDPP annually and make necessary changes. Thus, sites will incur time to revise and resubmit the plan when any of these situations arise.

- *Time to respond to requests for copies of the CBDPP*—The rule requires DOE contractors to furnish copies of the CBDPP to interested parties. If the time to respond to these requests is substantial, then sites will incur costs to respond to these requests.

The cost of each of these requirements are estimated in the Sections that follow.

3.2.1.1 Submitting Initial Versions of the CBDPP Plan Under DOE N 440.1

The 1999 EH Cost Impact Survey (EH, 1999) contains information on the labor time and the monetary resources that sites expended in submitting initial CBDPP plans under DOE N 440.1. This information is presented in Table 3-2 along with an estimated value of the labor time using the fully loaded labor costs from Table 3-1. DOE followed the methodology described in Section 3.1.4 to provide an estimate from the combined labor time and resource expenditure data provided by the affected sites. Thus, the estimated cost for each site the maximum of the total labor time valued at the fully loaded labor cost for each site and the reported costs expended by the site.

In estimating the labor cost of this requirement, DOE added the time and cost associated with clerical labor. Thus, the labor cost for this requirement includes the cost of the reported

professional labor plus time for clerical support. DOE assumed that for every four hours of professional labor, one hour of clerical labor would be required.

DOE estimates that submitting the initial CBDPP plans under DOE N 440.1 cost a total of $958,096. This cost was incurred in July 1997 and represents an initial cost that can be annualized over the lifetime of DOE N 440.1 and the rule (i.e., 12.42 years). Thus, the annualized cost of this requirement, assuming a 7 percent discount rate is $118,007.

Table 3-2
Estimated Cost of Submitting Initial CBDPP Plans Under DOE N 440.1

Site	Labor Time		Estimated Labor Cost [c]			Reported Monetary Cost [d]	DOE Cost Estimate [e]
	Professional [a]	Clerical [b]	Professional	Clerical	Total		
Argonne-East	160	40	$10,385	$460	$10,845	$9,600	$10,845
Argonne-West	200	50	$13,462	$575	$14,037	$13,400	$14,037
ETTP (K-25)	160	40	$8,000	$460	$8,460	$15,000	$15,000
Hanford	650	160.5	$32,813	$1,869	$34,681	$41,200	$41,200
Kansas City	160	40	$8,654	$460	$9,114	$8,800	$9,114
LANL	1,400	350	$121,154	$4,025	$125,179	$90,000	$125,179
LBL	160	40	$13,846	$460	$14,306	$15,000	$15,000
LLNL	720	180	$81,000	$2,070	$83,070	$35,000	$83,070
Mound	160	40	$18,000	$460	$18,460	$12,000	$18,460
ORNL	320	80	$18,692	$920	$19,612	$8,000	$19,612
Pantex	222	55.5	$16,570	$638	$17,208	$8,600	$17,208
Stanford	70	17.5	$4,922	$201	$5,123	$2,150	$5,123
Rocky Flats	2,500	625	$189,303	$7,188	$196,490	$153,000	$196,490
Y-12	3,584	896	$193,738	$10,304	$204,042	$387,758	$387,758
Totals	**10,466**	**2,616.5**	**$730,537**	**$30,090**	**$760,627**	**$799,508**	**$958,096**
Annualized Cost Estimate [f]							**$118,007**

Note: Totals may contain some rounding error.
[a] EH, 1999.
[b] Clerical labor time is assumed to be one quarter (0.25) of the professional time.
[c] The estimated labor cost for professional and clerical labor is calculated by multiplying the fully loaded wage rates in Table 3-1 by the labor times in this table.
[d] EH, 1999.
[e] Following the discussion in Section 3.1.4, this is assumed to be the maximum of the "total estimated labor cost" and the "reported monetary cost".
[f] Calculated by annualizing the total DOE cost estimate over 12.42 years assuming a 7 percent discount rate.

3.2.1.2 Revising the CBDPP Plan to Comply with the CBDPP Rule

The 1999 EH Cost Impact Survey (EH, 1999) also contained information on the labor time and resources that would need to be expended to revise the plan to comply with the final rule. These estimate appear in Table 3-3. DOE followed the same method used in estimating the cost of submitting initial plans under DOE N 440.1 to provide a cost estimate for this requirement (see Section 3.2.1.1). DOE estimates that revising the plans submitted under DOE N 440.1 to comply with the final version of this rule will impose $330,305 in costs. This represents an initial cost of the rule that would be incurred in December 1999. Annualizing the cost over the life of the rule (10 years) and assuming a 7 percent discount rate results in a $47,028 annual cost.

3.2.1.3 Annual Revisions to the Plan

The CBDPP rule requires DOE contractors to revise the plan whenever there is a change in the plan and whenever there is change in contractors (850.10 (a)(3)). Furthermore, the CBDPP rule requires DOE contractors to review the CBDPP plan on an annual basis (850.10 (a)(3)). Table 3-4 contains information on the labor time and monetary resources that DOE sites reported in the 1999 EH Cost Impact Survey (EH, 1999) to make annual revisions. DOE followed the same method used in estimating the cost of submitting initial plans under DOE N 440.1 to provide a cost estimate for this requirement (see Section 3.2.1.1). However, this is a recurring requirement and not an initial one. Thus, the estimated cost does not require annualization. DOE estimates that the affected DOE sites will incur a total of $182,434 annually to make revisions to the CBDPP plans.

Table 3-3
Estimated Cost of Revising CBDPP Plans to Comply with 10 CFR 850

Site	Labor Time		Estimated Labor Cost [c]			Reported Monetary Cost [d]	DOE Cost Estimate [e]
	Professional [a]	Clerical [b]	Professional	Clerical	Total		
Argonne-East	32	8	$2,077	$92	$2,169	$1,900	$2,169
Argonne-West	120	30	$8,077	$345	$8,422	$8,040	$8,422
ETTP (K-25)	40	10	$2,000	$115	$2,115	$3,000	$3,000
Hanford	325	81.25	$16,406	$934	$17,341	$20,600	$20,600
Kansas City	80	20	$4,327	$230	$4,557	$4,400	$4,557
LANL	700	175	$60,577	$2,013	$62,589	$45,000	$62,589
LBL	80	20	$6,923	$230	$7,153	-	$7,153
LLNL	160	40	$18,000	$460	$18,460	$11,600	$18,460
Mound	50	12.5	$5,625	$144	$5,769	$6,500	$6,500
ORNL	960	240	$56,077	$2,760	$58,837	$78,000	$78,000
Pantex	30	7.5	$2,239	$86	$2,325	$1,250	$2,325
Stanford	30	7.5	$2,109	$86	$2,196	$920	$2,196
Rocky Flats	1,000	250	$75,721	$2,875	$78,596	$65,000	$78,596
Y-12	462	115.5	$24,974	$1,328	$26,302	$35,738	$35,738
Totals	**4,069**	**1,017.25**	**$285,133**	**$11,698**	**$296,831**	**$281,948**	**$330,305**
Annualized Cost Estimate [f]							**$47,028**

Note: Totals may contain some rounding error.
[a] EH, 1999.
[b] Clerical labor time is assumed to be one quarter (0.25) of the professional time.
[c] The estimated labor cost for professional and clerical labor is calculated by multiplying the fully loaded wage rates in Table 3-1 by the labor times in this table.
[d] EH, 1999.
[e] Following the discussion in Section 3.1.4, this is assumed to be the maximum of the "total estimated labor cost" and the "reported monetary cost".
[f] Calculated by annualizing the total DOE cost estimate over 10 years assuming a 7 percent discount rate.

Table 3-4
Estimated Cost of Making Annual (Periodic) Revisions to CBDPP Plans

Site	Labor Time		Estimated Labor Cost [c]			Reported Monetary Cost [d]	DOE Cost Estimate [e]
	Professional [a]	Clerical [b]	Professional	Clerical	Total		
Argonne-East	24	6	$1,558	$69	$1,627	$1,440	$1,627
Argonne-West	80	20	$5,385	$230	$5,615	$5,360	$5,615
ETTP (K-25)	8	2	$400	$23	$423	$600	$600
Hanford	65	16.25	$3,281	$187	$3,468	$4,550	$4,550
Kansas City	40	10	$2,163	$115	$2,278	$2,200	$2,278
LANL	350	87.5	$30,288	$1006	$31,295	$22,000	$31,295
LBL	40	10	$3,462	$115	$3,577	-	$3,577
LLNL	80	20	$9,000	$230	$9,230	$5,800	$9,230
Mound	40	10	$4,500	$115	$4,615	$6,000	$6,000
ORNL	640	160	$37,385	$1,840	$39,225	$52,000	$52,000
Pantex	30	7.5	$2,239	$86	$2,325	$1,250	$2,325
Stanford	30	7.5	$2,109	$86	$2,196	$920	$2,196
Rocky Flats	400	100	$30,288	$1,150	$31,438	$26,000	$31,438
Y-12	384	96	$20,758	$1,104	$21,862	$29,703	$29,703
Totals	**2,211**	**522.75**	**$152,816**	**$6,357**	**$159,173**	**$157,823**	**$182,434**

Note: Totals may contain some rounding error.
[a] EH, 1999.
[b] Clerical labor time is assumed to be one quarter (0.25) of the professional time.
[c] The estimated labor cost for professional and clerical labor is calculated by multiplying the fully loaded wage rates in Table 3-1 by the labor times in this table.
[d] EH, 1999.
[e] Following the discussion in Section 3.1.4, this is assumed to be the maximum of the "total estimated labor cost" and the "reported monetary cost".

3.2.1.4 Responding to Requests for Copies of the Plan

Although some effort will be required to respond to requests for copies of the plan, DOE expects that this requirement will not result in substantial costs for DOE contractors. First, many requests can be handled through electronic dissemination of the plan, especially through Internet delivery mechanisms (e.g., World Wide Web, e-mail). Second, most sites have public reading rooms or libraries where copies of the plan can be placed for public use. Thus, DOE expects that DOE contractors will spend an insignificant amount of time responding to requests and therefore costs are not estimated for this requirement.

3.2.2 850.20 Baseline Beryllium Inventory

The rule requires DOE contractors to conduct a baseline inventory of beryllium locations and operations, identify exposed and potentially exposed workers by location, and conduct sampling (850.20). In developing the inventory, DOE contractors are required to perform a records review and employee interviews, as well as a document the presence and location of beryllium on site (850.20 (b)). DOE N 440.1 also required sites to conduct an equivalent level of baseline inventory and sampling. A review of CBDPP plans submitted under DOE N 440.1, as well as contact with some affected sites, indicates that baseline inventory and sampling efforts are well underway.

DOE assumes that compliance with the baseline inventory and sampling requirement will require both labor time (to perform records reviews and interview employees) and analysis of monitoring samples. Furthermore, DOE assumes that three types of labor will be required. First, industrial hygienists will be required to review records and interview employees. Affected DOE sites provided estimates for this labor time in the 1999 EH Cost Impact Survey (EH, 1999). These estimates appear in Table 3-5. Second, workers will be the subject of interviews which DOE assumes will be accomplished during work time. DOE assumes that all affected sites will interview the current set of exposed of potentially exposed workers. An estimate of this number for each site appears in Table 2-2 of Chapter 2. DOE further assumes that each worker interview will last one hour. Finally, clerical labor will be required to support the industrial hygienist's efforts (e.g., searching for old files). DOE assumes that one hour of clerical labor will be required for every four hours of professional labor.

Table 3-5 presents DOE's estimate of the labor costs associated with this requirement. The labor time associated with each labor category (e.g., industrial hygienist) is valued at the

loaded labor costs that appear in Table 3-1. DOE estimates that the baseline inventory and sampling requirement will require $2.4 million in labor costs.

Table 3-6 presents DOE's estimates of the cost of analyzing the baseline samples. The affected site's responses to the 1999 EH Cost Impact Survey (EH, 1999) provided information on the incremental number of samples that would be required to fulfill this requirement plus the fully loaded cost per sample to perform analysis of the sample. The number of incremental samples is multiplied by the fully loaded sample analysis cost which appears in Table 3-1. DOE estimates that analysis of baseline samples will impose a total cost of $1.4 million on affected sites.

Table 3-7 summarizes the estimated labor costs and sample analysis costs and provides an estimate of the total cost of this requirement. Also included in Table 3-7 is the reported monetary cost of this requirement reported by each site in the 1999 EH Cost Impact Survey (EH, 1999). Following the procedure outlined in Section 3.1.4, DOE's cost estimate for each site is the maximum of (a) the total labor and sample analysis cost estimate (i.e., Table 3-5 and Table 3-6) and (b) the reported cost. DOE estimates that the baseline inventory and sampling requirement will impose a cost of $4.5 million on affected sites. This cost represents an initial cost of DOE N 440.1. Thus, this cost can be annualized over the lives of DOE N 440.1 and the final rule (i.e., 12.42 years). Assuming a 7 percent discount rate, the annualized cost of this requirement is $553,818.

Table 3-5
Labor Costs for Baseline Inventory and Sampling

Site	Hours			Cost [d]			Total Labor Cost
	Industrial Hygienist [a]	Clerical [b]	Worker Interviews [c]	Industrial Hygienist	Clerical	Worker Interviews	
Argonne-East	150	37.5	4	$9,736	$431	$206	$10,372
Argonne-West	600	150	34	$40,385	$1,725	$4,814	$46,923
ETTP (K-25)	100	25	12	$5,000	$288	$552	$5,839
Hanford	244	61	50	$12,317	$702	$3,295	$16,314
Kansas City	360	90	50	$19,471	$1,035	$2,337	$22,843
LANL	4,172	1,043	200	$361,038	$11,995	$14,279	$387,312
LBL	150	37.5	17	$12,981	$431	$1,913	$15,325
LLNL	761	190	20	$85,651	$2,189	$1,318	$89,158
Mound	650	162.5	69	$73,125	$1,869	$5,592	$80,586
ORNL	300	75	26	$17,524	$863	$1,371	$19,757
Pantex	1,540	385	300	$114,945	$4,428	$19,769	$139,141
Stanford	120	30	8	$8,438	$345	$527	$9,310
Rocky Flats	2,500	625	228	$189,303	$7,188	$15,750	$212,241
Y-12	23,701	5,925.25	616	$1,281,187	$68,140	$31,044	$1,380,372
Totals	**35,348**	**8,837**	**1,634**	**$2,231,100**	**$101,626**	**$102,765**	**$2,435,492**

[a] EH, 1999.
[b] Assumed to be 0.25 of the industrial hygienist's time.
[c] Assumed to require one hour per exposed or potentially exposed worker.
[d] Calculated by multiplying the labor hours by the fully loaded wage rates in Table 3-1.

Table 3-6
Sample Analysis Cost of the Baseline Inventory and Sampling Requirement

Site	Number of Incremental Samples [a]	Cost Per Sample [b]	Total Sampling Cost
Argonne-East	30	$120	$3,600
Argonne-West	69	$310	$21,390
ETTP (K-25)	50	$60	$3,000
Hanford	1,704	$235	$400,440
Kansas City	30	$250	$7,500
LANL	1,000	$250	$250,000
LBL	6	$275	$1,626
LLNL	30	$200	$6,000
Mound	85	$75	$6,375
ORNL	51	$80	$4,101
Pantex	591	$54	$32,097
Stanford	8	$55	$440
Rocky Flats	700	$275	$192,500
Y-12	6,000	$83	$498,000
Totals	**10,355**	**-**	**$1,427,069**

[a] The number of incremental samples was derived from the 1999 EH Cost Impact Survey (EH, 1999). Each site was asked to provide an estimate of the number of samples they would need to take to comply with this requirement (i.e., the total number of samples). Each was also asked how many of those samples would have been collected in the absence of DOE N 440.1 and 10 CFR 850 (i.e., the "baseline" number of samples). The difference between these two numbers represent the number of incremental samples.
[b] EH, 1999.

Table 3-7
Total Cost Estimate for Baseline Inventory and Sampling

Site	Estimated Costs			Reported Cost [c]	DOE's Estimate [d]
	Labor [a]	Sampling [b]	Total		
Argonne-East	$10,372	$3,600	$13,972	$9,060	$13,972
Argonne-West	$46,923	$21,390	$68,313	$40,200	$68,313
ETTP (K-25)	$5,839	$3,000	$8,839	$10,000	$10,000
Hanford	$16,314	$400,440	$416,754	$351,400	$416,754
Kansas City	$22,843	$7,500	$30,343	$12,100	$30,343
LANL	$387,312	$250,000	$637,312	$425,000	$637,312
LBL	$15,325	$1,626	$16,951	$34,000	$34,000
LLNL	$89,158	$6,000	$65,158	$38,067	$65,158
Mound	$80,586	$6,375	$86,961	$19,000	$86,961
ORNL	$19,757	$4,101	$23,858	$13,000	$23,858
Pantex	$139,141	$32,097	$171,238	$172,000	$172,000
Stanford	$9,310	$440	$9,750	$3,700	$9,750
Rocky Flats	$212,241	$192,500	$404,741	$361,500	$404,741
Y-12	$1,380,372	$498,000	$1,878,372	$2,542,775	$2,542,775
Totals	**$2,435,492**	**$1,427,069**	**$3,862,561**	**$4,031,802**	**$4,545,936**
Annualized Cost Estimate [e]					**$553,818**

[a] Table 3-5.
[b] Table 3-6.
[c] EH, 1999.
[d] Represents the maximum of the total estimated costs and the reported cost.
[e] Calculated by annualizing the total DOE cost estimate over 12.42 years assuming a 7 percent discount rate.

3.2.3 850.21 Hazard Assessment

DOE N 440.1 and Section 850.21 of the CBDPP rule require DOE contractors to conduct beryllium hazard assessments based on the results of the baseline inventory, and, if warranted, conduct an in-depth analysis to assess the extent of exposure risk. The hazard assessments focus on beryllium-related activities must include an analysis of existing conditions, review and collection of exposure data, review of medical surveillance data and trends, and analysis of exposure potential for planned activities.

DOE does not expect the inclusion of the hazard assessment provision in DOE N 440.1 and the CBDPP rule to have a substantial impact on affected sites. DOE Order 440.1A (*Worker Protection Management for DOE Federal and Contractor Employees*) requires hazard assessments for chemical hazards (DOE O 440.1A (4)(i)(2)) and, pursuant to this, sites should have already conducted hazard assessments for beryllium. In fact, two sites (ETTP and ORNL) indicated that no incremental labor time or resources would be required in their responses to the 1999 EH Cost Survey. However, the hazard assessments requirement of DOE O 440.1A does not include the in-depth analysis requirement contained in the CBDPP rule (850.21). Contact with affected sites, as well as review of the CBDPP plans submitted under DOE N 440.1 and responses to the 1999 EH Cost Survey, has indicated that most sites have either conducted these hazards assessments or are in the process of conducting them. Thus, DOE assumes that for all but ETTP and ORNL the cost of performing hazard assessments will be attributable to the CBDPP rule.

The 1999 EH Cost Impact Survey (EH, 1999) contains information on the labor time and monetary resources that affected sites expect to use (or have used) in complying with this requirement. DOE's estimate for this requirement follows the procedure outlined in Section 3.1.4: for each site the estimated cost of the requirement is the maximum of the labor time valued at the fully loaded wage rate and the reported monetary cost from the 1999 EH Cost Survey. Table 3-8 provides estimates for this requirement using the 1999 EH Cost Survey data and the procedure of Section 3.1.4. DOE estimates that the hazard assessment requirement will impose a total cost of $618,014. This cost represents an initial cost of DOE N 440.1 and can therefore be annualized over 12.42 years. Assuming a 7 percent discount rate, the annualized cost of this requirement is $76,119.

Table 3-8
Cost Estimate for the Hazard Assessment Requirement

Site	Labor Time		Estimated Labor Cost [c]			Reported Monetary Cost [d]	DOE Cost Estimate [e]
	Professional [a]	Clerical [b]	Professional	Clerical	Total		
Argonne-East	40	10	$2,596	$115	$2,711	$2,400	$2,711
Argonne-West	160	40	$10,769	$460	$11,229	$10,720	$11,229
ETTP (K-25) [g]	0	0	$0	$0	$0	$0	$0
Hanford	260	65	$13,125	$748	$13,873	$25,200	$25,200
Kansas City	40	10	$2,163	$115	$2,278	$2,200	$2,278
LANL	640	160	$55,385	$1,840	$57,225	$40,000	$57,225
LBL	100	25	$8,654	$288	$8,941	$10,000	$10,000
LLNL	234	59	$26,354	$673	$27,028	$11,713	$27,028
Mound	400	100	$45,000	$1,150	$46,150	$8,000	$46,150
ORNL [g]	0	0	$0	$0	$0	$0	$0
Pantex	363	90.75	$27,094	$1,044	$28,138	$14,233	$28,138
Stanford	40	10	$2,813	$1,15	$2,928	$1,230	$2,928
Rocky Flats	1,500	375	$113,582	$4,313	$117,894	$98,000	$117,894
Y-12	3,862	965.5	$208,765	$11,103	$219,868	$287,233	$287,233
Totals	**7,839**	**1,910**	**$516,300**	**$21,963**	**$538,263**	**$510,929**	**$618,014**
Annualized Cost Estimate [f]							**$76,119**

Note: Totals may contain some rounding error.
[a] EH, 1999.
[b] Clerical labor time is assumed to be one quarter (0.25) of the professional time.
[c] The estimated labor cost for professional and clerical labor is calculated by multiplying the fully loaded wage rates in Table 3-1 by the labor times in this table.
[d] EH, 1999.
[e] Following the discussion in Section 3.1.4, this is assumed to be the maximum of the "total estimated labor cost" and the "reported monetary cost".
[f] Calculated by annualizing the total DOE cost estimate over 12.42 years assuming a 7 percent discount rate.
[g] Both ETTP (K-25) and ORNL reported that the hazard assessment requirement of DOE N 440.1 and 10 CFR 850 would impose no new requirements.

3.2.4 850.24 Exposure Monitoring

The CBDPP rule requires DOE contractors to perform exposure monitoring to determine worker exposure to beryllium. In order to perform the monitoring, DOE contractors must first identify the operations and areas where monitoring is required (850.24 (b)). The rule imposes four requirements that may impose costs on DOE contractors:

- Perform baseline monitoring (850.24 (b));
- Perform periodic monitoring for all workers that are exposed or potentially above the action level at least quarterly (850.24 (c));
- Perform monitoring each time there is a change in the operation or process (850.24 (d)); and
- Notify workers of the monitoring results (850.24 (g)).

The general requirement to identify operations and areas where monitoring is required will also impose a cost on DOE contractors, but DOE assumes that this will be accomplished during the development of the CBDPP plan (850.10) and in the performance of the baseline inventory and sampling (850.20) and hazard assessment (850.21). The four provisions listed above and their potential incremental costs are discussed in the following sections.

3.2.4.1 Baseline Exposure Monitoring

DOE N 440.1 and the rule require DOE contractors to conduct baseline exposure monitoring to determine the extent to which workers are currently exposed to beryllium. A review of CBDPP plans submitted under DOE N 440.1, as well as contact with some affected sites, and a review of the results of the 1999 EH Cost Impact Survey (EH, 1999), indicates that baseline exposure monitoring is well under way. Furthermore, the results of the 1999 EH Cost Survey indicates that baseline exposure monitoring that would satisfy the requirements of this section has been performed during the satisfaction of the baseline inventory and sampling requirement (850.20). In fact, most sites indicated in their responses to the 1999 EH Cost Survey that costs for this requirement were not separable from the requirements for baseline inventory and sampling. Thus, DOE does not provide an estimate for initial exposure monitoring and

assumes that these costs have been included in the estimate for baseline inventory and sampling requirement (850.20).[16]

3.2.4.2 Periodic Exposure Monitoring

The final rule require DOE sites to conduct periodic exposure monitoring for workers that are exposed or potentially exposed to beryllium at or above the action level (850.24 (c)). DOE estimates that 1,236 workers across six DOE sites (ANL-E, LANL, Mound, Pantex, RF, and Y-12) are exposed or potentially exposed to beryllium above the action level (see Chapter 2, Section 2.3 and Table 2-2). Table 3-9 provides DOE's estimates for the number of workers that will be subject to periodic exposure monitoring at each of the seven sites.

DOE estimates the cost of periodic exposure monitoring by multiplying the number of incremental samples needed to comply by the fully loaded analysis cost per sample. The fully loaded analysis cost per sample was reported by each site in the 1999 EH Cost Impact Survey (EH, 1999) and is reported in Table 3-1 and repeated in Table 3-6. The annual number of incremental samples is calculated by subtracting the current number of annual samples collected from the number of annual samples needed to comply with the rule. Both of these numbers were provided by sites in the 1999 EH Cost Survey. Table 3-9 summarizes the estimated cost to conduct periodic exposure monitoring. DOE estimates that affected sites will spend $2.0 million annually in performing periodic exposure monitoring.

[16] In the few case that sites provided separate estimates for this requirement, DOE combined the separate estimate with the baseline inventory estimate.

Table 3-9
Estimated Cost of Periodic Exposure Monitoring

Site	Number of Affected Workers [a]	Annual Samples Needed to Comply [a]	Annual Number of Samples Currently Collected [a]	Annual Number of Incremental Samples [b]	Total Cost [c]
Argonne-East	4	16 [d]	8	8	$960
LANL	200	1,000	0	1,000	$250,000
Mound	69	3,588 [e]	1,435	2,153	$161,460
Pantex	119	5,200	260	4,940	$395,200
Rocky Flats	228	30,000	9,000	21,000	$1,155,000
Y-12	616	10,580	10,580	0	$0
Totals	**1,236**	**50,384**	**21,283**	**29,101**	**$1,962,620**

Note: Column totals may contain some rounding error.
[a] Except where noted, the numbers are taken from the 1999 EH Cost Impact Survey (EH, 1999).
[b] Calculated as the difference between the annual number of samples needed to comply and the annual number of samples currently collected.
[c] Calculated by multiplying the annual number of incremental samples by the (site-specific) cost per sample from Table 3-6.
[d] Argonne-East reported only 10 samples would need to be collected to comply. However, the rule requires at least quarterly monitoring. Thus, DOE assumes that Argonne-East will collect one sample per quarter per worker, or 16 sample annually ([4 workers]*[4 samples annually]).
[e] Mound did not provide an estimate of the number of samples needed to comply. DOE assumed that Mound would collect one sample per worker per week, or 52 samples annually from each worker. DOE assumed this high rate of monitoring based on the type of work that will be performed at Mound (i.e., D&D).

3.2.4.3 Exposure Monitoring During Operational Changes

The CBDPP rule requires sites to conduct exposure monitoring during operational changes to ensure that exposure reduction and minimization goals are met (850.24 (d)). Contact with sites during this rulemaking has indicated that the number of operational changes that may require additional exposure monitoring is not easily predictable. D&D operations are likely to incur the largest number of process changes. DOE expects that this was reflected in the increased monitoring frequency for D&D activities at Mound and Rocky Flats in Section 3.2.4.2 above. For example, the annual number of samples per worker at Mound is 52 (assumed, see notes to Table 3-9) and at Rocky Flats is 132. The number of samples per workers at other sites is much lower. [17]Thus, given the uncertainty regarding the number of annual operation changes during non-D&D work and the fact that it appears the periodic exposure monitoring estimates for D&D operations encompass operational changes, DOE has not provided estimates for these costs and has assumed they are contained in the estimates for periodic exposure monitoring.

3.2.4.4 Notification of Exposure Monitoring Results

The rule requires sites to make exposure monitoring results available to affected workers in a manner that ensures the privacy of the worker (850.24 (g)). OSHA (1986), in estimating the costs for a similar notification requirement in its Asbestos Worker Protection Rule (29 CFR 1926.1101), assumes that 0.2 hours of clerical time per sample is required to perform the notification. This estimate includes the time to enter the records into a database and post the notification in a place where workers can access the results. From section 3.2.4.2, a total of 29,101 incremental samples are collected on an annual basis (see Table 3-9). From Section 3.1.3, clerical time is valued at $11.50 per hour. This implies that the cost of notifying workers of exposure monitoring results is $66,932 annually ([$11.50]*[29,101 samples]*[0.2 hours per sample]). The notification requirement is imposed in the rule and not the Notice, thus, affected sites would begin to incur these costs in December 1999 (the expected publication date of the final rule).

[17] Pantex estimates the need to collected 44 samples per worker annually, but this may also reflect the nature of the work at that facility (i.e., detonation and dismantling of weapons).

3.2.5 850.25 Exposure Reduction and Minimization

DOE contractors are required by the rule to manage and control exposures to beryllium by reducing airborne levels of beryllium to the permissible exposure limit, minimizing the number of current workers that are exposed and potentially exposed to beryllium, minimizing the number of opportunities to be exposed, and setting reasonable exposure reduction and minimization goals using a risk-based approach (850.25 (b)). These requirements encompass two distinct elements of the rule:

- Minimizing the number of workers that are exposed or potentially exposed to beryllium; and
- Reducing the exposure of those that must be exposed or potentially exposed to beryllium during the course of their work.

DOE expects that a variety of methods and controls will be used to comply with this requirement, including local exhaust ventilation (LEV) systems, high-efficiency particulate air (HEPA) vacuums, negative pressure systems, and gloveboxes.

DOE reviewed information from the 1999 EH Cost Impact Survey (EH, 1999) to determine the types and costs of controls that would be needed under both DOE N 440.1 and 10 CFR 850. Table 3-10 summarizes the reported start-up (procurement, purchase, and installation) and operational costs for controls required to obtain compliance with DOE N 440.1 and 10 CFR 850.

Controls acquired to comply with DOE N 440.1 result in $2.2 million in start-up costs and $2.0 million in annual operational costs. Annualizing the start-up costs over 12.42 years using a 7 percent discount rate results in a total annual cost of $2.3 million. Controls acquired to comply with the final rule impose $137,770 in start-up costs and $414,500 in annual operational costs. Annualizing the start-up costs over 10 years using a 7 percent discount rate results in a total annual cost of $434,115. Thus, the total annual cost of engineering controls under the rule is $2.7 million ($2.3 million for DOE N 440.1 and $0.4 million for 10 CFR 850).

Table 3-10
Estimated Costs of Engineering Controls

Site	DOE N 440.1		10 CFR 850	
	Start-Up Costs [a]	Annual Operational Costs [a]	Start-Up Costs [a]	Annual Operational Costs [a]
Argonne-East	$0	$0	$0	$0
Argonne-West	$0	$0	$7,000	$4,000
ETTP (K-25)	$0	$0	$0	$0
Hanford	$0	$0	$0	$0
Kansas City	$2,000	$200	$2,770	$100
LANL	$2,015,475	$2,000,000	$125,000	$310,000
LBL	$0	$0	$0	$0
LLNL	$0	$0	$0	$0
Mound	$0	$0	$0	$0
ORNL	$0	$0	$0	$0
Pantex	$200,000	$200	$0	$0
Stanford	$0	$0	$3,000	$400
Rocky Flats	$0	$0	$0	$0
Y-12	$0	$0	$0	$0
Totals	**$2,217,475**	**$2,000,400**	**$137,770**	**$414,500**
Annualized Costs [b]	**$273,121**	**$2,000,400**	**$19,615**	**$414,500**
Total Annual Costs [c]	**$2,273,521**		**$434,115**	

[a] EH, 1999.
[b] Start-up costs are annualized using a 7 percent discount rate and a 12.42 time frame for DOE N 440.1 and a 10 year time frame for 10 CFR 850. Annual operational costs are not annualized since they are already an annual estimate by definition.
[c] Calculated as the sum of the annualized costs.

3.2.6 850.26 Regulated Areas

The rule requires DOE contractors to establish regulated areas wherever airborne concentrations of beryllium are measured at or above the action level (850.26 (a)). The area must be demarcated from the rest of the workplace in a manner that ensures workers will be alerted to the presence of beryllium hazards (850.26 (b)). In addition to these requirements, DOE contractors are required to limit access to the regulated area (850.26 (c)) and keep a record of all persons who enter the regulated areas (850.26 (e)).

DOE expects that only one of these requirements will impose incremental costs on DOE contractors: demarcating the regulated area. DOE does not believe that limiting access to the regulated areas will impose costs on regulated entities since only workers that are *engaged in* beryllium-related operations will be allowed in the beryllium areas, and worker who are *not* engaged in beryllium-related operations will be restricted from entering the area. Thus, by eliminating the presence of *unnecessary* workers in the beryllium areas, the requirement will not decrease productivity.

As part of establishing regulated areas, the CBDPP rule requires DOE contractors to demarcate regulated areas in a manner that adequately alerts workers to the boundaries of the areas (850.26 (b)). In order to assess the current compliance with this requirement, DOE contacted sites potentially affected by the CBDPP rule. Sites where beryllium exposure may exceed the action level indicated that beryllium operation areas are currently operated as regulated areas. Thus, there may be close to 100 percent current compliance with this requirement given that most sites use beryllium infrequently and thus may not have the potential for exceeding the action level. Furthermore, in the 1999 EH Cost Impact Survey (EH, 1999), all sites that reported workers potentially exposed above the action level also reported no incremental costs associated with establishing regulated areas.[18] Thus, DOE estimates that the establishment of regulated areas will not impose incremental costs on the affected sites.

[18] ETTP (K-25) reported incremental costs and labor time associated with establishing regulated areas in the 1999 EH Cost Impact Survey (EH, 1999). However, ETTP (K-25) also reported that no workers are exposed above the action level at the site. Thus, no incremental costs are estimated for ETTP (K-25) since no workers are exposed above the action level.

3.2.7 850.27 Hygiene Facilities and Practices

The CBDPP rule requires sites to establish change rooms or areas (850.27 (b)) and shower facilities (850.27 (c)) for workers that may be exposed at or above the action level. DOE estimates that a total of 1,236 workers may be exposed above the action level (see Chapter 2, Section 2.3 and Table 2-2). Only two sites (Rocky Flats and Y-12) reported incremental costs to establish change rooms and shower facilities in the 1999 EH Cost Impact Survey (EH, 1999). Rocky Flats reported that each change room and shower facility would cost $350,000 to establish and that multiple facilities may be required. Rocky Flats did not provide an estimate of the number of facilities. DOE assumes that Rocky Flats will need to establish 5 facilities over the course of the rule. Thus, DOE estimates that Rocky Flats will incur an initial cost of $1,750,000 to comply with this requirement. Y-12 reported that it will incur a total of $4,000 to comply with this requirement. Thus, the two sites will incur a total initial cost of $1,754,000. This cost is incurred at the beginning of the final rule and can be annualized over the life of the rule (10 years). Assuming a 7 percent discount rate, the annualized cost of this requirement is $249,730.

3.2.8 850.28 Respiratory Protection

The CBDPP rule requires DOE contractors to develop and implement a respiratory protection program in accordance with 29 CFR 1910.134, Respiratory Protection (850.28 (a)). Respirators that are used by DOE contractors must be either approved by NIOSH or accepted for use by DOE (850.28 (c)). Respirators are required for all workers who are exposed or potentially exposed to beryllium at or above the action level (850.28 (b)).

DOE expects that this requirement will not impose substantial costs on affected sites because current practices require respirator use in operations where exposures are likely to exceed the action level. First, contact with sites affected by this rulemaking indicated that respirators are currently required for operations where potential exposures are above the PEL (Creek, 1998; Hargis, 1998; Torma-Krajewski, 1998a; Uelen, 1998a). Second, data collected for the 1996 DOE Beryllium Use Information Report (Office of Worker Health and Safety, 1996) also indicates that operations where exposures are likely to exceed 2.0 $\mu g/m^3$ are always conducted with respirators. Finally, in the 1999 EH Cost Impact Survey (EH, 1999) all affected sites except one (Hanford) reported that no incremental costs would be incurred to comply with this requirement.

Hanford reported that each worker would need to spend 10 additional days each year wearing a respirator. DOE conservatively assumes that this would result in the need for one additional respirator cartridge each year for each affected worker. Respirator cartridges cost $181.70 (Lab Safety Supply, 1998) and there are 50 affected workers at Hanford. Thus, the incremental cost of respiratory protection at Hanford is $9,085 annually. Since Hanford is the only site that reported incremental costs, then $9,085 also represents that annual respiratory protection cost for the final rule.

3.2.9 850.29 Protective Clothing and Equipment

The rule requires DOE contractors to provide protective clothing to workers that are exposed or potentially exposed to beryllium at levels above the action level (850.29 (a)(1) or who work in areas where surface contamination exceeds the level prescribed in Section 850.30 of the rule (3 $\mu g/100cm^2$) (850.29 (a)(2),(3)). Contaminated work clothes must be removed from the workplace in sealed, marked containers (850.29 (d)). Reusable protective clothing and equipment must be laundered prior to reuse, and the personnel responsible for laundering the clothes must be informed of the potentially harmful effects of beryllium exposure (850.29 (f)). Disposable protective clothing must be disposed of in accordance with the waste disposal requirements of the CBDPP rule.

The 1999 EH Cost Impact Survey (EH, 1999) contains information on implementation of this requirement. In the survey, no sites reported incremental costs associated with this requirement. All sites claimed either (a) that the requirement did not impose any new requirements on practices at the site or (b) the protective clothing requirement did not apply to the site (e.g., no exposures above the action level or surface contamination above the surface contamination limit). Thus, DOE estimates that no costs are incurred to comply with this requirement.

3.2.10 850.30 Housekeeping

Beryllium that settles on surface areas may become entrained in the air and inhaled by workers. In order to avoid this potential hazard, the CBDPP rule sets requirements for housekeeping in beryllium work areas. The CBDPP rule requires DOE contractors to conduct surface sampling and to clean surface areas to 3 $\mu g/100cm^2$ (850.30 (a)). The rule requires the use of wet methods or HEPA vacuuming to clean surfaces, and prohibits the use of compressed

air or dry methods of cleaning (850.30 (b)). The rule also forbids the use of cleaning equipment in areas outside of the regulated areas (850.30 (d)).

DOE expects that this provision will impose only one new requirement on affected sites: conducting surface sampling (i.e., swipe samples). DOE's contact with sites during this rulemaking indicated that swipe sampling programs were not common prior to DOE N 440.1. The 1999 EH Cost Impact Survey (EH, 1999) contains information on the current levels of swipe sampling at the affected sites and the level that sites expect to need to comply with the rule. Table 3-11 summarizes this information. DOE estimates the cost of this requirement by multiplying the number of incremental samples needed to comply by the cost per sample (from Table 3-1) for each site. The number of incremental samples is calculated by subtracting the number of currently collected samples from the total number of samples needed to comply.

Table 3-11
Cost Estimate for Swipe Sampling

Site	Total Annual Number of Samples Needed to Comply [a]	Annual Number of Samples Currently Collected [b]	Incremental Annual Number of Samples [c]	Total Annual Cost [d]
Argonne-East	20	20	0	$0
Argonne-West	0	0	0	$0
ETTP (K-25)	0	0	0	$0
Hanford	124	0	124	$31,000
Kansas City	50	25	25	$6,250
LANL	10,000	5,000	5,000	$1,375,000
LBL	240	24	215	$43,000
LLNL	1,764	1,764	0	$0
Mound	0	0	0	$0
ORNL	120	0	120	$6,512
Pantex	4,600	230	4,370	$237,160
Stanford	20	0	20	$1,100
Rocky Flats	0	0	0	$0
Y-12	25,776	25,776	0	$0
Totals	**42,714**	**32,839**	**9,874**	**$1,700,022**

Note: Column totals may contain some rounding error.
[a] EH, 1999.
[b] Calculated from data provided in EH (1999). Sites were asked to provide the total number of samples they needed to comply with this requirement (see note [a]) and the percentage of those samples that are currently collected. This column was calculated by multiplying the total number of samples needed to comply by the percentage that are currently collected.
[c] Calculated by subtracting the annual number of samples currently collected from the total annual number of samples needed to comply.
[d] Calculated by multiplying the incremental number of samples by cost per sample from Table 3-6.

3.2.11 850.31 Release Criteria

The CBDPP rule requires the responsible employers to clean and label beryllium-contaminated equipment and other items to the lowest extent practicable (850.31 (a)), but not to exceed the levels established in the rule. Specifically, the rule requires that equipment or items that will be released to the general public (i.e., non-DOE) be cleaned to 0.2 $\mu g/100cm^2$ (850.31 (b)(1). Equipment or items that will be released to another DOE facility performing beryllium-related work must be cleaned to 3 $\mu g/100cm^2$ (850.31 (c)(1)). The rule also sets requirements for labeling of the equipment or item (850.31 (b)(2) and (c)(2)).

DOE expects that this requirement of the proposed rule will impose two types of costs on affected DOE sites. First, DOE sites will be required to clean the equipment to the levels proscribed in the rule. Second, DOE sites may incur losses in revenues and costs of disposal if equipment cannot be cleaned to the levels proscribed in the rule.

3.2.11.1 Cleaning Equipment to Levels Proscribed in the Rule

To provide estimate of the cost of cleaning equipment to the levels proscribed in the rule, DOE contacted Rocky Flats which is involved in decontamination and decommissioning (D&D) activities. The Rocky Flats site is slated for closure and therefore several hundred pieces of equipment may be released to either other DOE sites or the general public. From the information provided by Rocky Flats, DOE calculated an annual cost of cleaning equipment to the prescibed release criteria in the standard for Rocky Flats. DOE then estimated the cleaning cost for the other 13 affected sites by assuming that the annual cost at other sites is proportional to the costs at Rocky Flats using the number of affected workers as the proportionality factor. This section provides DOE's estimates for this requirement and discusses the possibility that the estimated cost is an overestimate of the actual cost.

Rocky Flats reported that several types of equipment may need to be cleaned prior to release to the public or other DOE sites (Hiebert, 1999b). Included among this equipment would be industrial lathes, mills, and machine and drill presses. Rocky Flats estimates that, on average, a piece of equipment of this type located in the former beryllium processing area (the area of the site with the most beryllium contamination) could be cleaned by a five person crew over a one month time frame (Hiebert, 1999b). Thus, cleaning a piece of this equipment would require 800 worker-hours ([5 workers] × [8 hours per day] × [20 days per month]).

DOE assumes that 12 pieces of equipment will be cleaned annually at the site. This assumption can be interpreted in two ways: (a) only one crew will be involved in cleaning equipment at the site or (b) only 12 pieces of equipment will be targeted for release to the public or to other DOE sites annually. DOE expects that the second of these interpretations represents a realistic assumption based on conversations with Rocky Flats (Hiebert, 1999a,b) and on comments received on the proposed rule. Hiebert (1999a,b) indicated that much of the equipment may to be too contaminated to clean, posing an undue risk to workers. Wynveen (1999) indicated that the standard proposed in the rule may result in some equipment being disposed of rather than being cleaned.Thus, DOE estimates that Rocky Flats will incur 9,600 worker-hours ([12 pieces of equipment] × [800 worker-hours per piece]) to clean equipment annually.

In addition to cleaning the equipment, the sites will need to collect samples to determine if the level of contamination before, during, and after cleaning. Rocky Flats reports that the typical piece of equipment would require about 50 samples. Thus, assuming that 12 pieces are cleaned annually implies 600 samples would be taken. In the the 1999 EH Cost Impact Survey (EH, 1999), Rocky Flats indicated that the fully loaded cost of analyzing a swipe sample is $275. This results in a total annual sampling cost of $165,000.[19]

The total cost estimate for Rocky Flats appears in Table 3-12. The release criteria compliance costs for the other sites are estimated by assuming that the number of labor hours and the number of samples will be proportional to the estimates for Rocky Flats where the number of affected workers is used as the proportionality factor (from Table 2-2). These estimate are also presented in Table 3-12. DOE estimates that cleaning equipment for release under the rule will impose $4.9 million in annual costs across the DOE complex. Sites will begin incurring this cost in December 1999.

[19] Hiebert (1999a) indicated that Rocky Flats has budgeted $50,000 for swipe sampling for FY 2000. Thus, the cost estimated here exceeds the budgeted amount at Rocky Flats. This is further evidence that the number of pieces of equipment that would be cleaned will be small.

Table 3-12
Cost Estimate for Cleaning Equipment

Site	Labor		Sampling		Total Cost [e]
	Hours [a]	Cost [b]	Number of Samples [c]	Cost [d]	
Argonne-East	168	$8,654	11	$1,263	$9,917
Argonne-West	1,432	$202,682	89	$27,737	$230,419
ETTP (K-25)	505	$23,229	32	$1,895	$25,123
Hanford	2,105	$138,727	132	$30,921	$169,648
Kansas City	2,105	$98,381	132	$32,895	$131,275
LANL	8,421	$601,215	526	$131,579	$732,794
LBL	716	$80,526	45	$12,303	$92,829
LLNL	842	$55,491	53	$10,526	$66,017
Mound	2,905	$235,472	182	$13,618	$249,090
ORNL	1,095	$57,707	68	$5,474	$63,181
Pantex	12,632	$832,363	789	$42,845	$875,208
Stanford	337	$22,196	21	$1,158	$23,354
Rocky Flats	9,600	$663,177	600	$165,000	$828,177
Y-12	25,937	$1,307,135	1,621	$134,547	$1,441,682
Totals	**68,800**	**$4,326,955**	**4,300**	**$611,761**	**$4,938,716**

Note: The column totals may contain some rounding error.
[a] The estimated number of labor hours is based on the information from Rocky Flats. For each site, the estimated number of hours is assumed to be proportional to the number of hours at Rocky Flats (i.e., 9,600) where the number of affected workers (from Table 2-2) is used as the proportionality factor.
[b] Calculated by multiplying the number of labor hours by the worker's hourly labor cost for each site (from Table 3-1).
[c] The estimated number of samples is based on the information from Rocky Flats. For each site, the estimated number of samples is assumed to be proportional to the number of samples at Rocky Flats (i.e., 600) where the number of affected workers (from Table 2-2) is used as the proportionality factor.
[d] Calculated by multiplying the number of samples by the sample analysis cost for each site (from Table 3-1).
[e] Sum of the labor and sampling costs.

DOE expects that this estimate may represent an overestimate of the actual costs that sites will incur for four reasons. First, prudent industrial hygiene practice will require the equipment to be cleaned in the absence of the CBDPP rule. The estimate provided here attributes all cleaning cost to the rule. Thus, the *incremental cost* of cleaning under the rule should be less than the costs discussed here.

Second, some equipment may be too contaminated for release. Hiebert (1999a) noted that some equipment at Rocky Flats may not get cleaned for this reason. Wynveen (1999) also noted that the release criteria contained in the rule may result in disposal rather than cleaning of equipment.

Third, the equipment at Rocky Flats site may be contaminated to a larger degree than equipment at other sites. Thus, other sites may not need to spend as much time and effort for each piece of equipment that need to be cleaned owing to a lesser degree of contamination.

Finally, other sites may not have as much equipment to release. The Rocky Flats plant was involved in a large degree of beryllium processing and thus contains a good deal of equipment that may be useful for beryllium or related processing. Most of the other sites used less beryllium then Rocky Flats. Furthermore, Rocky Flats is slated for shut-down and thus equipment at the site is no longer necessary. Most other affected sites are not in such a phase and thus may need their beryllium-contaminated equipment.

Thus, although DOE has estimated a $4.9 million annual cost, the Department expects that actual costs will be lower. DOE is unable to provide a more accurate estimate of this cost because of a lack of sufficient data. In particular, DOE was unable to find data on:

- The number of pieces of equipment that will need cleaning;
- The decision criteria that sites will employ to determine which pieces will be cleaned and which will be disposed;
- The level of cleaning that would occur in the absence of the rule; and
- The labor time and samples that would be needed to clean equipment at the various sites besides Rocky Flats.

Therefore, DOE expects that the $4.9 million annual cost represents a useful, conservative estimate of the cost for this requirement.

3.2.11.2 Revenue Losses and Disposal Costs Associated with Non-Release of Equipment and Items

The release criteria requirement of the rule may result in some equipment or items that would have been released in the absence to the rule to not be released under the rule. This would result in both losses of revenue (or use of the equipment by other DOE sites) and disposal costs.

Equipment that is sold to the general public generate revenues for DOE and its contractors. If the rule results in some equipment not being released (e.g., the site cannot demonstrate that the equipment or item is cleaned to the proscribed level), then DOE and its

contractors will lose the revenues associated with the sale of that equipment. In this situation, DOE incurs the cost of losing the revenue from these sales.

Equipment that is transferred to other DOE sites performing beryllium-related operations save the time and cost of purchasing new equipment. If the rule results in some equipment not being released (e.g., the site cannot demonstrate that the equipment or item is cleaned to the proscribed level), then other DOE sites that need this equipment will have to purchase new equipment. In this situation, DOE and its contractors incur an incremental cost equal to the differnce between the cost of purchasing new equipment and the book value of the equipment that would have been transferred.[20]

Equipment or other items that cannot be cleaned to the levels proscribed in the rule must be disposed of in accordance with the waste disposal requirements of the rule (850.32). Thus, in addition to incurring the revenue losses discussed above, DOE contractors would incur the cost of disposing of the equipment that cannot be released.

DOE has not estimated the cost associated with revenue losses and disposal costs associated with the release criteria requirement for three data-related reasons: it may be impossible for sites to predict (a) the number of pieces of equipment that will be considered for release, (b) the types of equipment that may be considered for release, and (c) the number (or percentage) or pieces that would no pass the release criteria after cleaning.

[20] However, new equipment may provide superior performance and may need less repair or maintenance over the short term.

3.2.12 850.32 Waste Disposal

Beryllium waste can pose potential hazards if proper waste handling procedures are not followed. The CBDPP rule sets requirements for the handling of beryllium-contaminated waste. Specifically, the rule requires beryllium waste (i.e., waste, scrap, debris, bags, containers, equipment, and clothing) to be collected and disposed of in sealed impermeable bags or other impermeable containers (850.32 (b)). These impermeable containers must then be labeled in accordance with Section 850.38 Warning Signs and Labels.

DOE expects that this requirement will not impose incremental requirements on affected entities. The provisions contained in the CBDPP rule are also contained in EPA's hazardous waste regulations (40 CFR 260 to 262). Under these regulations, a waste is considered hazardous if (a) it is listed as a hazardous waste at 40 CFR 261 Subpart D or (b) it exhibits one of the four characteristics of hazardous waste: ignitability, corrosivity, reactivity, and toxicity. DOE expects that most beryllium waste generated in the DOE complex will exhibit the characteristic of toxicity and therefore be subject to EPA hazardous waste regulations. Thus, DOE considers costs for waste disposal to be attributable to EPA hazardous waste regulations and to the CBDPP rule.

3.2.13 850.33 Beryllium Emergencies

During the course of beryllium-related work, emergency situations may arise as the result of fires, spills, or other unexpected events. The rule requires DOE contractors to comply with 29 CFR 1910.120 (l) for D&D activities and to comply with 29 CFR 1910.120 (q) for all other non-D&D beryllium-related activities.

DOE does not expect this requirement to impose incremental costs on affected sites. DOE has instituted a number of general emergency situation requirements in accordance with OSHA's HAZWOPER standard (29 CFR 1910.120) that are applicable to beryllium work. The requirements of the CBDPP rule are all contained in DOE's guidance for preparing health and safety plans (Office of Environment, Safety, and Health, 1998). Thus, this requirement does not impose incremental costs on affected DOE sites.

3.2.14 850.34, 850.35, and 850.36 Medical Surveillance, Removal, and Consent

The CBDPP rule contains a number of requirements for medical surveillance of workers who may be at risk of developing CBD. DOE contractors are required to establish and implement a medical surveillance program for all *current* workers that are or were exposed or potentially exposed to beryllium in the DOE workplace (850.34 (a)(1)). In order to accomplish this, the CBDPP rule sets a number of specific requirements for DOE contractors, including:

- Develop and maintain a registry of beryllium-exposed workers (850.34 (a));
- Providing medical evaluations for workers covered by the medical surveillance requirements (850.34 (b)-(c));
- Performing data analysis to identify workers that are at risk and identify work practices that pose undue risk (850.34 (d));
- Developing a plan for the removal of workers from beryllium-related work based on the findings of the medical evaluations (850.35);
- Protecting the benefits of workers that are removed from beryllium work for medical reasons, and providing alternative employment without occupational beryllium exposure for the workers who are permanently removed (850.35);
- Inform workers of the benefits and risk of medical tests and procedures used in the diagnosis and treatment of beryllium-related health effects (850.36 (a)-(b)); and
- Obtain signed consent forms from workers prior to medical evaluations (850.36 (c)).

This section estimates the costs for seven requirements: (1) medical evaluation (Section 3.2.14.1) (2) develop a registry of beryllium-exposed workers (Section 3.2.14.2), (3) maintain the registry of beryllium-exposed workers (Section 3.2.14.2), (4) analysis of medical data (Section 3.2.14.3), (5) worker removal (Section 3.2.14.4), (6) inform workers about tests and procedures (Section 3.2.14.5), and (7) obtain signed consent forms from workers (Section 3.2.14.6).

3.2.14.1 Medical Evaluations

The CBDPP rule requires DOE contractors to provide medical evaluations for workers covered by the medical surveillance requirements. All current workers that are or were exposed to beryllium at the DOE site are eligible for coverage under the medical surveillance requirements of the rule. The rule requires the following types of medical evaluations:

- *Initial medical evaluations*—DOE contractors are required to offer each beryllium workers a medical evaluation prior to placement in beryllium-related work (850.34 (b)(1)).

- *Annual evaluations*—DOE contractors are required to provide annual medical evaluations for all beryllium workers that are currently exposed or potentially exposed to beryllium (850.34 (b)(2)).

- *Medically-Indicated Referrals*—In the event that workers are found to be sensitized to beryllium, a more extensive medical evaluation would be required. Thus, DOE has included costs associated with conducting these more extensive evaluations.

Appendix A provides a more detailed discussion of these requirements as well the contents of the evaluations.

DOE contacted National Jewish Medical Center (NJMC) regarding the standard procedures and costs associated with performance of these evaluations. Appendix A provides a discussion of the components of these exams and derives unit costs for each type of exam. The unit costs for all three types of evaluations involve the labor time of affected workers. Thus, the unit costs vary by site based on the labor cost at each site. Tables A-2, A-4, and A-6 of Appendix A summarizes the site-specific unit costs for each type of evaluation.

Sites provided information on the number of workers that would be covered by the medical surveillance requirement in the 1999 EH Cost Survey. This information is provided in the first numeric column of Table 3-13. Table 3-13 also provides estimates of the annual numbers of each type of exam that will be performed at each site. The number of initial exams is assumed to represent 5 percent of the current number of exposed or potentially exposed workers. In other words, DOE assumes a five percent annual turnover rate among these workers and thus, a number

equal to five percent of these workers must take initial evaluations.[21] Given that the number of initial evaluations is based on an annual rate (i.e., the turnover rate), the number presented in Table 3-13 should also be interpreted as an annual rate. The number of annual evaluations is assumed to equal the number of affected workers since all affected workers must have an annual evaluation. The number of annual referrals is assumed to equal 6.2 percent of the number of affected workers (see note [e] in Table 3-13 for the derivation of this number). As with the number of initial evaluations, the number of referrals should be interpreted as an annual rate.

DOE estimates that medical evaluations will impose an annual cost of $9.2 million on the affected sites. Both referral evaluations and annual evaluations are estimated to cost approximately $4.6 million annually. Initial evaluations are estimated to impose $58,533. DOE assumes that sites will begin incurring these costs in December, 1999.

[21] The number of currently exposed or potentially exposed workers does not appear in Table 3-13, but is presented in Table 2-2 of Chapter 2. The number of affected workers in Table 3-13 is the total number of workers who are or were exposed or potentially exposed. Thus, the number of affected workers reported in Table 3-13 encompasses both currently and previously exposed or potentially exposed workers. Since the initial evaluation is required prior to placement in beryllium-related work, DOE based the estimated number of evaluations on the number of currently exposed or potentially exposed workers.

Table 3-13
Cost Estimate for Medical Evaluations

Site	Number of Affected Workers [a]	Annual Initial Exams		Annual Periodic Evaluations		Annual Referral Evaluations		Total Cost
		Number [b]	Cost [c]	Number [d]	Cost [c]	Number [e]	Cost [c]	
Argonne-East	419	0.2	$139	419	$226,179	25.98	$227,364	$453,682
Argonne-West	283	1.7	$1,485	283	$191,054	17.55	$191,548	$384,088
ETTP (K-25)	350	0.6	$410	350	$186,093	21.70	$187,105	$373,608
Hanford	205	2.5	$1,806	205	$115,123	12.71	$115,667	$232,597
Kansas City	40	2.5	$1,710	40	$21,313	2.48	$21,429	$44,452
LANL	3,000	10	$7,334	3,000	$1,709,476	186	$1,717,238	$3,434,048
LBL	18	0.85	$693	18	$11,367	1.12	$11,404	$23,464
LLNL	914	1	$722	914	$513,281	56.67	$515,707	$1,029,711
Mound	38	3.45	$2,597	38	$22,204	2.36	$22,298	$47,098
ORNL	85	1.3	$905	85	$46,053	5.27	$46,292	$93,251
Pantex	1,000	15	$10,387	1,000	$56,1577	62	$564,230	$1,136,644
Stanford	17	0.4	$289	17	$9,547	1.05	$9,592	$19,428
Rocky Flats	500	11.4	$8,309	500	$283,178	31	$284,485	$575,971
Y-12	1,244	30.8	$21,297	1,244	$669,682	77.13	$673,214	$1,364,192
Totals [f]	**8,113**	**82**	**$58,533**	**8,113**	**$4,566,127**	**503**	**$4,587,573**	**$9,212,234**

Source: Appendix A; DOE estimates.
Note: Estimates may contain some rounding error.
[a] EH, 1999.
[b] Initial exams are only required upon placement into beryllium-related work. Thus, the number in this column should reflect replacement of currently exposed or potentially exposed workers. DOE assumes a 5 percent turnover rate for workers who are *currently* exposed or potentially exposed. Thus, the number of workers listed as currently exposed or potentially exposed in Table 2-2 of Chapter 2 is multiplied by 0.05 to derive this number for each site.
[c] The cost estimate for each site is derived my multiplying the number of evaluations by the site-specific unit cost for each type of evaluation from Tables A-2, A-4, and A-6 in Appendix A.
[d] This is the total number workers that the sites reported as being covered by the medical surveillance program in EH (1999).
[e] This number is calculated by assuming that (a) 2 percent of all workers exposed or potentially exposed will have true positive Be-LPT tests in the next ten years (i.e., an annual rate of 0.2 percent), (b) 6 percent of all workers have a false positive Be-LPT test each year and (c) workers taking initial exams have had no prior beryllium exposure and thus are excluded from the risk group. These assumptions, derived from the medical literature on CBD, are discussed in more detail in Appendix A. Combined, the assumptions imply that 0.062 percent of all workers covered by medical surveillance will need medical referrals.
[f] The number of evaluations reported in this row are rounded to the nearest whole integer.

3.2.14.2 Beryllium Registry

The rule requires DOE contractors to establish and maintain an electronic beryllium registry to serve as a roster for all workers covered by the CBDPP rule's medical surveillance requirement (850.34 (a)(4)). DOE expects the registry to include a number of data item for each worker such as name, social security number, date of birth, gender, site, job history, medical screening test results, and results of referrals for specialized medical evaluations. This provision will impose two requirements on affected DOE sites: (1) develop a beryllium registry and (2) maintain the beryllium registry.

Develop the Beryllium Registry

The cost of developing the beryllium registry at each site will depend on the number of workers that must be entered into the registry and the number of data items that must be entered for each worker. The relevant number of workers for this requirement will be the number of workers that are covered by the medical surveillance program (see Table 3-13). Many of the data items would be entered during initial development of the registry, such as name, social security number, date of birth, and gender. Information on the time required to enter this initial information is not available, but DOE assumes that 15 minutes (0.25 hours) will be spent entering the initial information for each worker. DOE further assumes that clerical staff will be used to enter the data. Thus, the cost of developing beryllium registries is estimated by multiplying the number of affected workers by 0.25 hours and the hourly labor cost for clerical workers ($11.50 per hour). Table 3-14 presents these estimates. The initial cost of developing beryllium registries is estimated to be $3,039. Sites are assumed to have begun incurring this cost in July 1997. Annualizing this cost over 12.42 years using a seven percent discount rate, the annual cost is $374.

Table 3-14
Cost of Developing a Beryllium Registry

Site	Number of Affected Workers [a]	Estimated Number of Hours to Develop Beryllium Registry [b]	Cost Estimate [c]
Argonne-East	419	104.75	$1,205
Argonne-West	283	70.75	$814
ETTP (K-25)	350	87.5	$1,006
Fermilab	205	51.25	$589
Hanford	40	10	$115
Kansas City	3,000	750	$8,625
LANL	18	4.5	$52
LBL	914	228.5	$2,628
LLNL	38	9.5	$109
Mound	85	21.25	$244
Pantex	1,000	250	$2,875
Stanford	17	4.25	$49
Rocky Flats	500	125	$1,438
Y-12	1,244	311	$3,577
Totals	**8,113**	**2028.25**	**$23,325**
Annualized Cost Estimate [d]			**$2,873**

Note: Column totals may contain some rounding error.
[a] EH, 1999.
[b] Calculated by assuming that fifteen minutes (0.25 hours) is spent to enter the relevant initial data for each covered worker.
[c] Calculated by multiplying the estimated number of hours by the clerical worker's hourly labor cost of $11.50.
[d] Annualized over a 12.42 year time frame using a 7 percent discount rate.

Maintain the Beryllium Registry

Sites will be required to update the information in the beryllium registry on an recurring basis. Specifically, after each medical evaluation performed on a worker, new information will be generated. Thus, sites will incur costs each year for updating the registry with the new information from medical evaluations. DOE assumes that this will require 5 minutes (0.083 hours) of a clerical worker's time for each non-referral medical evaluation and 15 minutes (0.25 hours) for each referral. From Table 3-17, there are 8,195 non-referral evaluations and 503 referral evaluations performed annually. Valuing a Clerical worker's time at $11.50 per hour, the cost of maintaining the beryllium registry is estimated to be $9,299 annually ([0.083 hours]*[8,195 non-referral evaluations]*[$11.50 per hour] + [0.25 hours]*[503 referral evaluations]*[$11.50 per hour]). Although the beryllium registry requirement appears in DOE N 440.1, DOE assumes that the medical surveillance program will not be fully in place until December 1999. Thus, DOE assumes that sites will begin incurring these costs in December 1999.

3.2.14.3 Medical Data Analysis

The CBDPP rule also requires the Site Occupational Medical Directors (SOMDs) to conduct analysis of medical data (i.e., test results, exposure conditions) to identify workers at risk of developing CBD and identify working conditions that may pose undue risk (850.34 (k)). Sites contacted during this analysis were unable to provide estimates of the time required to perform such analyses. Therefore, DOE used information provided by Y-12 to develop cost estimates for this requirement (Jenkins, 1998). Y-12 reported that two weeks (i.e., 80 hours) of an industrial hygienist's time would be spent performing this analysis. DOE assumes that the time at all other sites will be proportional to the number of workers at Y-12. However, DOE also assumed that at a minimum, sites would spend 20 hours annually performing this analysis. Table 3-15 provides estimates of the compliance costs of this requirement for each site. Total incremental compliance costs are estimated to be $47,734 annually. Sites will begin to incur these costs beginning in December 1999.

Table 3-15
Estimated Incremental Compliance Costs to Conduct Medical Data Analysis

Site	Number of Affected Workers [a]	Industrial Hygienist's Time (Hours) [b]	Total Compliance Cost
Argonne-East	419	26.95	$1,749
Argonne-West	283	20.00	$1,346
ETTP (K-25)	350	22.51	$1,125
Hanford	205	20.00	$1,010
Kansas City	40	20.00	$1,082
LANL	3,000	192.93	$16,696
LBL	18	20.00	$1,731
LLNL	914	58.78	$6,613
Mound	38	20.00	$2,250
ORNL	85	20.00	$1,168
Pantex	1,000	64.31	$4,800
Stanford	17	20.00	$1,406
Rocky Flats	500	32.15	$2,435
Y-12	1,244	80.00	$4,325
Totals	**8,113**	**617.62**	**$47,734**

[a] This is the number of current workers that are or were exposed or potentially exposed.
[b] The estimates in this column are derived by assuming that Y-12 will spend 80 hours conducting this analysis and that the time spent at all other sites is proportional to the number of workers at the site. For example, the number of hours at Rocky Flats (i.e., 32.15) is estimated as [(500 workers at Rocky Flat)/(1,244 workers at Y-12)]*[80 hours at Y-12]. However, DOE also assumed that the minimum amount of time that would be required would be 20 hours annually. Thus, the estimated number of hours is the larger of the number of hours proportional to Y-12's hours (based on the number of affected workers) and 20 hours.
[c] Calculated by multiplying the industrial hygienist's time by the industrial hygienist's hourly labor cost from Table 3-1.

3.2.14.4 Worker Removal

The CBDPP rule allows for workers to be removed from beryllium exposure or potential beryllium exposure (850.35). The rule also protects the benefits, earnings, and seniority of workers that are permanently removed from beryllium-related work for medical reasons. DOE expects that the worker removal requirement will impose three costs on DOE contractors: (1) the cost of protecting the workers salary and benefits for two years, (2) the cost of retraining workers that are removed, and (3) the cost of additional medical referral evaluations.

The cost of this requirement depends on the number of workers that have been removed from work for medical reasons under the CBDPP rule. An estimate of this number is difficult to make considering a quantitative dose-response relationship does not exist for beryllium and data on worker exposure is also lacking. However, DOE has decided to use a rough estimate of the number of annual removals using information from the medical literature. Newman et al. (1996) note that the medical literature has found incidence rates ranging from 1 to 16 percent. However, most studies have reported incidence rates between 2 and 5 percent (e.g., Kreiss, et al., 1993a, 1996, 1997; Stange et al., 1996a). Furthermore, these rates are not annual rates, but reflect the number of cases that have developed over a longer time frame. Based on this information, DOE has assumed that 2 percent of all workers will be removed over a ten year period. This translates into an average annual rate of 0.2 percent.[22] Table 3-16 provides estimates of the annual removal rates for each affected site. The annual removal rate is calculated by multiplying the number of workers covered by medical surveillance (see Table 3-13) by 0.2 percent.

The CBDPP rule requires DOE contractors to protect the earnings, benefits, and seniority of workers that are removed from work for medical reasons under the rule for two years. DOE estimates this cost by multiplying the two-year present value of a worker's fully loaded annual salary by the removal rate (see notes in Table 3-16 for details of the calculation). The fully loaded annual salary for workers is calculated by multiplying the fully loaded labor cost for workers from Table 3-1 by 2,080 hours (i.e., a full year of employment). In using the fully loaded labor cost, DOE has accounted for the earnings and benefits of workers.[23] The cost estimate for this requirement appears in Table 3-16. DOE estimates that protecting worker's earnings and benefits will impose $4.5 million annually on affected DOE sites.

[22] DOE does not claim that this is a rate of CBD incidence, but only a rate of worker removal.

[23] A cost estimate for protecting seniority is harder to make. However, DOE expects that using the fully loaded labor cost will account for seniority also since compensation is tied to seniority.

DOE also expects that some retraining of removed workers will be required. DOE assumes that worker retraining will cost $6,000 per worker. This assumption is based on the requirements of the proposed version of this rule which set $6,000 as the maximum amount of worker retraining that sites had to provide. DOE assumes that $6,000 will also be a good estimate for the amount that will be required under the final version of this rule. The cost for retraining is estimated by multiplying the removal rate by $6,000 for each site. The cost estimate for this requirement appears in Table 3-16. DOE estimates that worker retraining will impose an annual cost of $97,356 on affected sites.

Finally, DOE assumes that each worker removal will involve another referral evaluation. Thus, DOE adds the cost of performing one more medical referral for each removed worker. This is done by multiplying the removal rate by the unit costs of medical referrals for each site from Table 3-1. The results of this calculation appear in Table 3-16. DOE estimate that medical referrals caused by worker removals will impose $147,986 in annual costs on affected sites.

In total, DOE estimates that worker removals will impose a $4.8 million annual cost on affected DOE sites. This is a requirement of 10 CFR 850 and therefore DOE sites will begin incurring these costs in December 1999.

Table 3-16
Annual Costs Associated With Worker Removal

Site	Annual Removal Rate [a]	Salary/Benefit Protection Costs [b]	Retraining Costs [c]	Medical Referral Costs [d]	Total Costs [e]
Argonne-East	0.838	$173,263	$5,028	$7,334	$185,626
Argonne-West	0.566	$322,453	$3,396	$6,179	$332,028
ETTP (K-25)	0.700	$129,496	$4,200	$6,036	$139,732
Hanford	0.410	$108,715	$2,460	$3,731	$114,906
Kansas City	0.080	$15,043	$480	$691	$16,215
LANL	6.000	$1,723,710	$36,000	$55,395	$1,815,105
LBL	0.036	$16,297	$216	$368	$16,881
LLNL	1.828	$484,709	$10,968	$16,636	$512,313
Mound	0.076	$24,787	$456	$719	$25,962
ORNL	0.170	$36,060	$1,020	$1,493	$38,573
Pantex	2.000	$530,317	$12,000	$18,201	$560,518
Stanford	0.034	$9,015	$204	$309	$9,529
Rocky Flats	1.000	$265,158	$6,000	$9,177	$280,335
Y-12	2.488	$691,605	$14,928	$21,717	$728,250
Totals	**16.226**	**$4,530,629**	**$97,356**	**$147,986**	**$4,775,971**

[a] To calculate this number, DOE multiplied the number of workers eligible for medical surveillance (see Table 3-21) by 0.2 percent. DOE assumes that only those workers with true positive Be-LPT tests will be removed. From Section 3.2.14.1, DOE assumed that 0.2 percent of all workers would have such tests annually.
[b] Calculated as the removal rate multiplied by the present value of two years of the fully loaded annual salary of workers. The two year present value was calculated as [$y + y/(1+r)$] where y is the fully loaded annual salary of workers and r is the discount rate (equal to 7 percent (OMB, 1992)). The fully loaded annual salary of the workers for each site was calculated by multiplying the fully loaded labor cost for each site by 2,080 hours (i.e., 40 hours per week multiplied by 52 weeks).
[c] This number was calculated by multiplying the removal rate by $6,000.DOE assumes that each site will spend $6,000 on retraining workers. The $6,000 number was the maximum that sites would of needed to spend under the proposed version of this rule. DOE believes that $6,000 should also provide a good estimate for the amount that sites will spend under the final rule.
[d] Calculated as the removal rate multiplied by the unit cost for referral evaluations (see Table 3-1).
[e] This is the sum of the retraining costs and the referral costs.

3.2.14.5 Inform Workers

The CBDPP rule requires DOE contractors to provide beryllium-exposed workers with information on the benefits and risks of the medical tests and examinations available to them (850.36). DOE assumes that this will be accomplished by a discussion between the attending physician and the worker before each medical evaluation. DOE further assumes that non-referral evaluations will require a 15 minute discussion and referrals will require a 30 minute discussion. The incremental cost for this requirement is calculated as the value of this time for both workers and attending physicians. Table 3-17 summarizes the estimated compliance costs for this requirement. The physician's time is valued at $59.35 per hour and the value of the worker's time at each site is taken from Table 3-1. The total estimated compliance cost for this requirement is $292,111 annually. As with the medical evaluations, sites will begin incurring these costs in December 1999.

Table 3-17
Incremental Compliance Cost of Informing Workers About Medical Tests and Procedures

Site	Non-Referrals [a]		Referrals		Total Compliance Costs
	Number	Total Cost [b]	Number	Total Cost [b]	
Argonne-East	419.2	$11,605	25.98	$1,438	$13,043
Argonne-West	284.7	$14,301	17.55	$1,763	$16,064
ETTP (K-25)	350.6	$9,232	21.70	$1,143	$10,374
Hanford	207.5	$6,497	12.71	$796	$7,293
Kansas City	42.5	$1,127	2.48	$132	$1,259
LANL	3,010	$98,385	186.00	$12,159	$110,544
LBL	18.85	$810	1.12	$96	$906
LLNL	915	$28,650	56.67	$3,549	$32,199
Mound	41.45	$1,455	2.36	$165	$1,620
ORNL	86.3	$2,418	5.27	$295	$2,713
Pantex	1,015	$28,436	62.00	$3,883	$32,319
Stanford	17.4	$545	1.05	$66	$611
Rocky Flats	511.4	$16,013	31.00	$1,991	$18,003
Y-12	1,274.8	$40,931	77.13	$4,232	$45,163
Totals	**8,195**	**$260,404**	**503**	**$31,707**	**$292,111**

Note: The estimated number of referrals and non-referrals for each site should be interpreted as an annual referral rate rather than as the number of referrals each year.
Note: Column totals may contain some rounding error.
[a] Non-referrals are defined as initial and annual evaluations.
[b] Calculated as the attending physician's hourly labor cost plus the worker's hourly labor cost (at each site) from Table 3-1 multiplied by the number of non-referrals and 0.25 hours (i.e., fifteen minutes).
[c] Calculated as the attending physician's hourly labor cost plus the worker's hourly labor cost (at each site) from Table 3-1 multiplied by the number of non-referrals and 0.5 hours (i.e., fifteen minutes).

3.2.14.6 Signed Consent Forms

The CBDPP rule requires DOE contractors to obtain signed consent forms from beryllium-exposed workers prior to the performance of medical examinations (850.36 (c)). The rule contains a sample of the form that is to be used. Workers will incur time to fill out the consent form prior to the medical examination. DOE assumes that this will require 15 minutes of the worker's time. The cost of this requirement is calculated by multiplying the total number of medical evaluations at each site by the worker labor costs presented in Table 3-1 and 0.25 hours. Table 3-18 summarizes these calculations for each site. The total incremental cost of this requirement is thus $147,336 annually. Sites will begin to incur these costs beginning in December 1999.

Table 3-18
Compliance Costs for Signing Consent Forms

Site/Facility	Total Number of Evaluations [a]	Estimated Number of Worker Hours [b]	Total Compliance Cost
Argonne-East	445.18	111.29	$5,719
Argonne-West	302.25	75.56	$10,698
ETTP (K-25)	372.30	93.08	$4,279
Hanford	220.21	55.05	$3,628
Kansas City	44.98	11.25	$525
LANL	3,196	799	$57,044
LBL	19.97	4.99	$562
LLNL	971.67	242.92	$16,007
Mound	43.81	10.95	$888
ORNL	91.57	22.89	$1,207
Pantex	1,077	269.25	$14,193
Stanford	18.45	4.61	$304
Rocky Flats	542.40	135.60	$8,935
Y-12	1,351.93	337.98	$23,348
Totals	**8,698**	**2,174**	**$147,336**

Note: Column totals may contain some rounding error.
[a] Calculated as the sum of non-referrals and referrals from Table 3-17.
[b] Calculated as the total number of evaluations multiplied by 0.25 hours.
[c] Calculated as the estimated number of hours multiplied by the site-specific worker hourly labor cost from Table 3-1.

3.2.15 850.37 Training and Counseling

The CBDPP rule requires DOE contractors to establish training and counseling programs with respect to the hazards of beryllium exposure (850.37). Training must be provided to workers prior to or at the time of initial assignment in an area where the worker may be exposed or potentially exposed to beryllium. The training must cover:

- Beryllium health risk;
- Exposure reduction;
- Safe handling of beryllium; and
- Medical surveillance.

The rule indicates that workers who are exposed or potentially exposed to beryllium are required to take this detailed training every two years. Furthermore, the rule also requires that *all* workers at affected sites take a general awareness training every other year.

Sites contacted during this rulemaking have all indicated that extensive beryllium training is not currently conducted. DOE's Office of Defense Programs and Office of Environment, Safety and Health, in conjunction with the Oak Ridge Institute for Science and Education (ORISE) have formed the Beryllium Risk Communication Task Force, which is in the process of developing a new beryllium training program (the ORISE program). DOE assumes that this project will become the standard for beryllium training under the rule. This requirement will impose two incremental costs on affected sites: (1) time to adapt the ORISE program to the site, (2) time for the currently exposed to potentially exposed affected workers to complete the training every two years, and (3) time for *all* workers at the site to complete a general awareness training every two years.

3.2.15.1 Adapt ORISE Program

Although the ORISE program is expected to provide comprehensive beryllium training, each site will incur time to adapt the program to the conditions and processes at the site. To estimate the cost of adapting the program, DOE assumes that Y-12, the largest site in terms of the number of affected workers (see Table 3-1), will incur 80 hours (i.e., two full-time equivalent weeks) of an industrial hygienist's time to adapt the program. DOE further assumes that the time

incurred by the other sites will be proportional to the time that Y-12 incurs, where the number of affected workers is used as a scaling factor. However, DOE assumes that sites will spend a minimum of 40 hours adapting the ORISE program to the site.

The cost of adapting the program at each site is estimated by multiplying the number of hours for each site by the hourly labor cost for industrial hygienists (Table 3-1). Table 3-19 summarizes the estimated costs. Adapting the ORISE program to each site is estimated to cost a total of $47,882. This is an initial cost of DOE N 440.1 and therefore sites can annualize this cost over 12.42 years. Annualizing the estimate over that time frame with a seven percent discount rate, the annual cost is $5,282.

Table 3-19
Cost Estimate for Adapting Training Programs

Site	Number of Affected Workers [a]	Estimated Number of Hours to Adapt Training [b]	Cost Estimate [c]
Argonne-East	4	40	$2,596
Argonne-West	34	40	$2,692
ETTP (K-25)	12	40	$2,000
Hanford	50	40	$2,019
Kansas City	50	40	$2,163
LANL	200	40	$3,462
LBL	17	40	$3,462
LLNL	20	40	$4,500
ORNL	69	40	$4,500
Mound	26	40	$2,337
Pantex	300	40	$2,986
Stanford	8	40	$2,813
Rocky Flats	228	40	$3,029
Y-12	616	80	$4,325
Totals	**1,634**	**640**	**$42,882**
Annualized Cost [d]			**$5,282**

[a] From Chapter 2, Table 2-2.
[b] Calculated by assuming that Y-12 will spend 80 hours to adapt the program and that the time spent by the other sites is proportional to time spent at Y-12, where the number of affected workers is the scaling factor. However, DOE assumes that sites will spend a minimum of 40 hours adapting the ORISE training program.
[c] Calculated by multiplying the estimated number of hours by the industrial hygienist's hourly labor cost for each site from Table 3-1.
[d] Annualized over a 12.42 year time frame assuming a 7 percent discount rate.

3.2.15.2 Annual Training Costs

Sites will also incur the cost associated with current beryllium workers taking the training course. DOE assumes that workers will be compensated for time spent in training. To estimate the incremental cost of training, DOE used information from the 1999 EH Cost Impact Survey (EH, 1999). In the survey, sites provided information on both current (baseline) beryllium training and training that would be required under 10 CFR 850. Although DOE uses the sites' estimates of current training programs, DOE expects that the sites' estimates of the training needed to comply with the requirements of the rule is too low. Therefore, DOE assumes that this training will be similar in scope and length to EPA's Asbestos Model Accreditation Plan (MAP) training. Specifically, DOE assumes that beryllium training will be similar to Class II Asbestos Worker training, which requires each worker to complete a 24 hour (i.e., three worker days) training course. Following the requirements of the rule, this training will be required every other year.

To estimate the cost of this requirement, DOE estimated the baseline cost of training and subtracted that estimate from an estimate of the costs of training under 10 CFR 850. Table 3-20 provides an estimate of the costs that sites are currently incurring to perform beryllium-related training (i.e., baseline costs). In addition to the time that workers spend in training, DOE assumes that an industrial hygienist at each site will spend the same amount of time as each worker in training related duties (e.g., teaching a training class). Thus, the baseline training cost at each site is the value of all of the worker's time plus the value of an industrial hygienist's time. DOE estimate that baseline training costs for the affected sites total $494,898 annually.

Table 3-21 provides an estimate of the training costs that will be incurred under 10 CFR 850. As discussed above, DOE assumes that workers who are currently exposed or potentially exposed to beryllium will attend a 24 hour (i.e., three work day) training course every two years. DOE also assumes that this course will be taught by an industrial hygienist. Thus, DOE sites will incur the labor cost for each worker to take the 24 hour training course plus 24 hours of an industrial hygienist's time to teach the course. These estimates are provided in Table 3-21. The worker-related training costs total $2.5 million and the industrial hygienist labor costs total $24,432. Since these costs are incurred every other year, DOE annualizes the sum of the worker-related labor costs and the industrial hygienist's costs using a two year time frame and a 7 percent discount rate. This results in a total annualized cost of $1.4 million to conduct training under 10 CFR 850.

Table 3-20
Annual Baseline Costs of Worker Training

Site	Number of Affected Workers [a]	Annual Number of Hours Per Worker [b]	Total Annual Worker-Related Labor Costs [c]	Annual Cost of Industrial Hygienist's Time [d]	Total Annual Baseline Cost [e]
Argonne-East	4	0.00	$0	$0	$0
Argonne-West	34	1.00	$4,814	$67	$4,881
ETTP (K-25)	12	0.50	$276	$25	$301
Hanford	50	0.00	$0	$0	$0
Kansas City	50	0.00	$0	$0	$0
LANL	200	2.00	$28,558	$173	$28,731
LBL	17	0.00	$0	$0	$0
LLNL	20	8.00	$10,543	$900	$11,443
ORNL	69	0.00	$0	$0	$0
Mound	26	1.00	$1,371	$58	$1,429
Pantex	300	0.50	$9,884	$37	$9,922
Stanford	8	1.00	$527	$70	$597
Rocky Flats	228	8.00	$126,004	$606	$126,609
Y-12	616	10.00	$310,445	$541	$310,985
Totals	**1,634**	**32.00**	**$492,421**	**$2,478**	**$494,898**

Note: Column totals may contain some rounding error.
[a] This is the number of workers that are currently exposed or potentially exposed to beryllium.
[b] EH, 1999.
[c] Calculated by multiplying the number of affected workers by the annual number of hours per worker and the worker labor cost from Table 3-1.
[d] Calculated by multiplying the number of affected workers by the annual number of hours per worker and the industrial hygiene labor cost from Table 3-1.
[e] Calculated as the sum of the total annual worker-related labor costs and the annual cost of an industrial hygienist's time.

Table 3-21
Annual Costs of Worker Training Under 10 CFR 850

Site	Number of Affected Workers [a]	Number of Hours Per Worker Incurred Every Other Year [b]	Total Worker-Related Labor Costs [c]	Cost of Industrial Hygienist's Time[d]	Total Annual Cost Under 10 CFR 850 [e]
Argonne-East	4	24	$4,933	$1,558	$3,590
Argonne-West	34	24	$115,529	$1,615	$64,792
ETTP (K-25)	12	24	$13,240	$1,200	$7,987
Hanford	50	24	$79,075	$1,212	$44,406
Kansas City	50	24	$56,077	$1,298	$31,734
LANL	200	24	$342,692	$2,077	$190,689
LBL	17	24	$45,900	$2,077	$26,536
LLNL	20	24	$31,630	$2,700	$18,988
ORNL	69	24	$134,219	$2,700	$75,729
Mound	26	24	$32,893	$1,402	$18,968
Pantex	300	24	$474,447	$1,791	$263,404
Stanford	8	24	$12,652	$1,688	$7,931
Rocky Flats	228	24	$378,011	$1,817	$210,080
Y-12	616	24	$745,067	$1,297	$412,808
Totals	**1,634**	**-**	**$2,466,364**	**$24,432**	**$1,377,639**

Note: Column totals may contain some rounding error.
[a] This is the number of workers that are currently exposed or potentially exposed to beryllium.
[b] DOE assumption.
[c] Calculated by multiplying the number of affected workers by the number of hours per worker incurred every two years and the worker labor cost from Table 3-1. These costs are incurred every two years.
[d] Calculated by multiplying the number of affected workers by the number of hours per worker incurred every two years and the industrial hygiene labor cost from Table 3-1. These costs are incurred every two years.
[e] This number is calculated as the annualized cost of the sum of the worker-related labor costs and the industrial hygienist's cost. DOE annualizes the sum of these two costs over two years (i.e., the life of the training) assuming a 7 percent discount rate. See Section 3.1.2 for details on the annualization calculation.

The incremental cost of annual training for currently exposed or potentially exposed workers is the difference between the annualized cost of training under 10 CFR 850 and the annual baseline costs. Table 3-22 provides estimates of the incremental cost of this requirement for all of the affected sites. DOE estimates that annual training for currently exposed or potentially exposed workers will impose an annual cost of $882,741 on affected sites. DOE sites will begin incurring these costs in July 1997.

Table 3-22
Incremental Costs of Annual Training for Beryllium Workers

Site	Annual Baseline Costs [a]	Annual Costs Under 10 CFR 850 [b]	Annual Incremental Costs [c]
Argonne-East	$0	$3,590	$3,590
Argonne-West	$4,881	$64,792	$59,911
ETTP (K-25)	$301	$7,987	$7,686
Hanford	$0	$44,406	$44,406
Kansas City	$0	$31,734	$31,734
LANL	$28,731	$190,689	$161,958
LBL	$0	$26,536	$26,536
LLNL	$11,443	$18,988	$7,544
ORNL	$0	$75,729	$75,729
Mound	$1,429	$18,968	$17,539
Pantex	$9,922	$263,404	$253,482
Stanford	$597	$7,931	$7,334
Rocky Flats	$126,609	$210,080	$83,470
Y-12	$310,985	$412,808	$101,823
Totals	**$494,898**	**$1,377,639**	**$882,741**

Note: Column totals may contain some rounding error.
[a] From Table 3-20.
[b] From Table 3-21.
[c] Calculated by subtracting the annual baseline costs from the annual costs under 10 CFR 850.

3.2.15.3 General Awareness Training

The final rule requires DOE sites to provide general awareness training to all individuals who work at a site where beryllium activities are conducted (850.37 (a) (3)). This training must consist of general awareness about beryllium hazards and controls (850.37 (c)). DOE assumes that this training can be accomplished in a one hour session. As with the training for beryllium-exposed workers (Section 3.2.15.2), this training is required every other year. DOE obtained information on the total employment at all of the affected sites. This information is provided in

Table 2-1 of Chapter 2, but is repeated in Table 3-23 below.[24] DOE also assumes that the labor costs for beryllium exposed workers (in Table 3-1) can be used to approximate the labor cost of all workers at the site.[25] Thus, the cost of this requirement is calculated by multiplying the labor cost for each site (from Table 3-1) by one hour and the number of affected workers. Since this costs is incurred every other year, DOE annualizes resulting estimate using a two year time frame and a 7 percent discount rate. DOE estimates that general awareness training will cost $2.6 million annually.

Table 3-23
Cost Estimate for General Awareness Training

Site	Number of Affected Workers [a]	Total Cost [b]
Argonne-East	2,250	$63,943
Argonne-West	2,250	$176,189
ETTP (K-25)	6,200	$157,651
Hanford	10,500	$382,685
Kansas City	3,300	$85,293
LANL	10,000	$394,876
LBL	3,400	$211,558
LLNL	9,700	$353,528
ORNL	5,100	$228,624
Mound	5,000	$145,777
Pantex	2,400	$87,471
Stanford	1,400	$51,025
Rocky Flats	4,000	$152,832
Y-12	4,000	$111,496
Totals	**69,500**	**$2,602,949**

Note: Column totals may contain some rounding error.
[a] Chapter 2, Table 2-2.
[b] Calculated by multiplying the labor cost for each site (from Table 3-1) by one hour and the number of affected workers.

[24] Workers that are currently exposed or potentially exposed do not have to participate in the general awareness training. However, in making these estimates, DOE does not subtract off the number of workers that take the more comprehensive training. The data on the number of employees at each site is an approximation. Thus, DOE did not believe that subtracting off the number of workers taking more comprehensive training would improve the estimate.

[25] Thus, to the extent that the labor costs in Table 3-1 overestimate (underestimate) the average labor cost for all workers at the site, the estimated cost for each site will be overestimated (underestimated).

3.2.16 850.38 Warning Signs and Labels

DOE contractors are required to post warning signs demarcating regulated areas to notify workers of the potential for beryllium exposure (850.38). The signs must, at the least, include the phrasing: "danger", "beryllium can cause lung damage", "cancer hazard", and "authorized personnel only" (850.38 (a)). In addition to demarcating regulated areas, DOE contractors are required to affix warning labels to all containers of beryllium, beryllium compounds, or beryllium-contaminated clothing, equipment, waste, scrap, or debris (850.37 (b)). Costs are not estimated for this requirement for two reasons. First, in the 1999 EH Cost Impact Survey (EH, 1999) sites indicated that no incremental costs would be incurred to comply with demarcating regulated areas under 10 CFR 850. Second, labeling of hazardous material including beryllium (850.38 (c)) is already required under both EPA waste disposal regulations (40 CFR 262; see Section 3.2.12) and OSHA's Hazard Communication regulation (29 CFR 1910.1200). DOE assumes that costs for labeling are thus attributable to these regulations, and not to the CBDPP rule.

3.2.17 850.39 Recordkeeping

Both DOE N 440.1 and the CBDPP rule require DOE contractors to keep accurate records of all beryllium inventory information, hazard assessments, exposure measurements, controls, and medical surveillance pursuant to the rule (850.39 (a)). The records must be kept in an electronic, easily retrievable manner for transmittal to DOE Headquarters on request (850.38 (b)). The rule also requires DOE contractors to create links between data sets on working conditions, exposure, and health outcomes to serve as a basis for understanding beryllium's affect on health (850.38 (d)). This provision will impose two requirements on DOE contractors: (1) develop a recordkeeping system to satisfy the requirements of DOE N 440.1 and the CBDPP rule and (2) maintain records on an annual basis.

3.2.17.1 Develop a Recordkeeping System

Establishing a recordkeeping system under the CBDPP rule may require sites to develop procedures and rules for keeping the records, as well as developing electronic databases. DOE expects that the cost of developing a recordkeeping system will not be substantial for affected sites since DOE sites are required to keep records under a number of other Department requirements. Nevertheless, DOE expects that some costs will be incurred by all sites.

The 1999 EH Cost Impact Survey (EH, 1999) contains information regarding the time and resources that sites have used to develop recordkeeping systems. Specifically, affected sites provided information on the labor time and monetary resources used to develop a database to keep records under the rule. DOE used the procedure outlined in Section 3.1.4 to provide an estimate of the cost of this requirement.[26] DOE estimated the value of the reported labor using the fully loaded industrial hygienist labor cost from Table 3-1. Table 3-24 contains the information from EH (1999) as well as DOE's estimates. DOE estimates that developing recordkeeping systems will impose a total cost of $612,141 on affected sites. This was a requirement contained in DOE N 440.1 and thus can be annualized over 12.42 years (i.e., the life of the notice and the rule). Assuming a 7 percent discount rate, the total annualized cost of this requirement is $75,396.

Table 3-24
Cost Estimate for Developing a Recordkeeping System

Site	Labor		Reported Monetary Costs [a]	Total Cost Estimate [c]
	Reported Hours [a]	Cost [b]		
Argonne-East	0	$0	$0	$0
Argonne-West	80	$5,385	$5,385	$5,385
ETTP (K-25)	0	$0	$0	$0
Hanford	55	$2,776	$5,350	$5,350
Kansas City	0	$0	$0	$0
LANL	2,500	$216,346	$250,000	$250,000
LBL	0	$0	$0	$0
LLNL	0	$0	$0	$0
ORNL	80	$9,000	$500	$9,000
Mound	0	$0	$0	$0
Pantex	0	$0	$0	$0
Stanford	20	$1,406	$600	$1,406
Rocky Flats	240	$18,173	$215,000	$215,000
Y-12	1,800	$97,301	$126,000	$126,000
Totals	**4,775**	**$350,388**	**$602,835**	**$612,141**
Total Annualized Cost [d]				**$75,396**

Note: Column total may contain some rounding error.
[a] EH, 1999.
[b] Calculated by multiplying the reported hours by the industrial hygienist labor cost (from Table 3-1) for each site.
[c] Represents the maximum of the labor cost and the reported monetary cost.
[d] Annualized over 12.42 years assuming a 7 percent discount rate.

[26] Specifically, DOE calculated the total labor costs associated with the reported labor time and compared that to the reported monetary expenses from EH (1999). DOE used the larger of the two as an estimate of the cost of this requirement.

3.2.17.2 Annual Recordkeeping Cost

The 1999 EH Cost Impact Survey (EH, 1999) also contains information on the labor time and monetary cost that sites expected to spend annually in maintaining records under the final rule. This information appears in Table 3-25. Once again, DOE follows the procedure outlined in Section 3.1.4 to provide a conservative cost estimate with the available data. DOE assumes that contractors will utilize clerical labor to maintain records. Thus, DOE estimated the value of the reported labor using the fully loaded clerical labor cost of $11.50 per hour. Table 3-25 provides DOE's estimates for maintaining records on an annual basis. DOE estimates that the annual cost for this requirement will be $605,620. This cost will be incurred beginning in July 1997.

Table 3-25
Cost Estimate for Maintaining Records On An Annual Basis

Site	Labor		Reported Monetary Costs [a]	Total Cost Estimate [c]
	Reported Hours [a]	Cost [b]		
Argonne-East	8	$92	$480	$480
Argonne-West	80	$920	$5,385	$5,385
ETTP (K-25)	0	$0	$0	$0
Hanford	305	$3,508	$15,500	$15,500
Kansas City [d]	0	$0	$0	$0
LANL	500	$5,750	$30,000	$30,000
LBL	25	$288	$2,500	$2,500
LLNL [d]	0	$0	$0	$0
ORNL	20	$230	$120	$230
Mound	300	$3,450	$13,000	$13,000
Pantex [d]	0	$0	$0	$0
Stanford	30	$345	$900	$900
Rocky Flats	0 [e]	$0 [e]	$82,000	$82,000
Y-12	15,080	$173,420	$455,625	$455,625
Totals	**16,348**	**$188,002**	**$605,510**	**$605,620**

Note: Column total may contain some rounding error.
[a] EH, 1999.
[b] Calculated by multiplying the reported hours by the clerical worker's labor cost (from Table 3-1).
[c] Represents the maximum of the labor cost and the reported monetary cost.
[d] Kansas City, LLNL, and Pantex all claimed that the costs for this requirement were included with the costs for other requirements and could not be separated out.
[e] Rocky Flats did not provide an estimate for the number of hours.

3.2.18 850.40 Performance Feedback

The CBDPP rule requires DOE contractors to conduct periodic analysis of program elements and communicate the results to affected parties. Specifically, DOE contractors must conduct periodic assessments of monitoring results, identified hazards, medical surveillance results, attainment of exposure minimization and reduction goals, and occurrence reporting data (850.40 (a)). The results of these analyses must be communicated to line managers, planners, worker protection staff, workers, medical staff, and other affected parties (850.40 (b)).

The 1999 EH Cost Impact Survey (EH, 1999) contained information on the labor hours that sites expect to spend annually in fulfilling this requirement.[27] DOE assumes that an industrial hygienist will perform the performance feedback analysis. DOE estimated the value of the reported labor using the fully loaded industrial hygienist labor cost from Table 3-1. Table 3-26 provides a summary of the data from EH (1999) as well as DOE's cost estimate for this requirement. DOE estimates that this requirement will impose a cost of $273,612 annually and that sites will begin to incur this cost in July 1997.

[27] The 1999 EH Cost Survey also contained some information on the monetary resources that sites expect to spend on this requirement. However, many sites did not provide information on monetary resources. Therefore, DOE decided to use only the information on labor hours.

Table 3-26
Cost Estimate for Performance Feedback

Site	Reported Number of Annual Hours [a]	Estimated Cost [b]
Argonne-East	40	$2,596
Argonne-West	40	$2,692
ETTP (K-25)	40	$2,000
Hanford	105	$5,300
Kansas City	40	$2,163
LANL	640	$55,385
LBL	40	$3,462
LLNL	80	$9,000
ORNL	160	$18,000
Mound	80	$4,673
Pantex	450	$33,588
Stanford	40	$2,813
Rocky Flats	1,000	$75,721
Y-12	1,040	$56,219
Totals	**3,795**	**$273,612**

Note: Estimates may contain some rounding error.
[a] EH, 1999.
[b] Calculated by multiplying the reported number of hours by the industrial hygienist's labor cost from Table 3-1.

3.3 SUMMARY OF COMPLIANCE COST ESTIMATES

This chapter estimated the incremental compliance costs of the CBDPP rule and DOE N 440.1. Table 3-27 summarizes the estimates of Section 3.2. The costs reported in Table 3-27 are divided into two categories: those incurred beginning in July 1997 and those incurred beginning in December 1999. This distinction is necessary since DOE N 440.1 became effective in July 1997, thus imposing costs on affected sites. The final version of the CBDPP rule is not expected to be published until December 1999, thus, provisions that are in the CBDPP rule but not in DOE N 440.1 will not take effect until December 1999.

DOE N 440.1 is estimated to impose an initial cost of $9.02 million and a recurring annual cost of $7.43 million. This results in a total annualized cost of $8.54 million.[28] The CBDPP rule imposes an initial cost of $2.22 million and a recurring annual cost of $22.70 million which results in a total annualized cost of $23.02 million.

[28] The annualized cost is calculated as (a) the sum of the initial costs annualized over their lifetimes (using the formula in Section 3.1.2) plus (b) the recurring annual cost.

Table 3-28 summarizes the schedule of these costs. Affected sites are expected to incur the initial cost associated with DOE N 440.1, $9.02 million, in July 1997. From July 1997 to December 1999, sites will incur the recurring annual cost of $7.43 million associated with DOE N 440.1. Combined with the initial cost incurred in July 1997, sites will incur an annualized cost of $8.54 million from July 1997 until December 1999. Assuming that the final version of this rule is published in December 1999, affected sites will incur the initial costs of the CBDPP rule ($2.22 million) in December 1999. Sites will then incur the recurring annual costs of the rule ($22.70 million) in addition to the recurring annual costs of DOE N 440.1 ($7.43 million) from December 1999 until December 2009 (ten years after promulgation of the final version of the rule, the expected life of the rule). This totals $30.12 in recurring annual costs from December 1999 to December 2009. Combined with the annualized initial costs of both DOE N 440.1 and the CBDPP rule, affected sites will incur $31.55 million annually from December 1999 to December 2009.

Table 3-27
Summary of Estimated Compliance Costs

Requirement		Initial Costs: Cost Estimate	Initial Costs: Life	Recurring Cost	Annualized Cost [a]
Provisions Incurred Beginning July 1997					
850.10	Submit CBDPP Plans	$958,096	12.42	$0	$118,007
850.20	Baseline Inventory/Sampling	$4,545,936	12.42	$0	$559,913
850.21	Hazard Assessments	$618,014	12.42	$0	
850.24	Baseline Exposure Monitoring	Included with costs for baseline inventory and sampling (850.20)			
	Periodic Exposure Monitoring	$0	-	$1,962,620	$1,962,620
850.25	Exposure Reduction	$2,217,475	12.42	$2,000,400	$2,273,521
850.30	Swipe Sampling	$0	-	$1,700,022	$1,700,022
850.34	Develop Beryllium Registry	$23,325	12.42	$0	$2,873
850.37	Develop Training Program	$42,882	12.42	$0	$5,282
	Annual Training	$0	-	$882,741	$882,741
850.39	Develop Recordkeeping	$612,141	12.42	$0	$75,396
	Annual Recordkeeping	$0	-	$605,620	$605,620
850.40	Performance Feedback	$0	-	$273,612	
Subtotals		***$9,017,869***	***-***	***$7,425,014***	***$8,535,725***
Provisions Incurred Beginning December 1999					
850.10	Revise CBDPP	$330,305	10.0	$0	$47,028
	Annual Revisions to CDBPP	$0	-	$182,434	$182,434
850.24	Monitoring-Notify Workers	$0	-	$66,932	$66,932
850.25	Exposure Reduction	$137,770	10.0	$414,500	$434,115
850.26	Regulated Areas	$0	-	$0	$0
850.27	Change Rooms/Showers	$1,754,000	10.0	$0	$249,730
850.28	Respirators	$0	-	$9,085	$9,085
850.29	Protective Clothing	$0	-	$0	$0
850.31	Release Criteria	$0	-	$4,938,716	$4,938,716
850.34	Medical-Evaluations	$0	-	$9,212,234	$9,212,234
850.34	Maintain Beryllium Registry	$0		$9,299	$9,299
850.34	Medical-Data Analysis	$0	-	$47,734	$47,734
850.35	Medical-Removal	$0	-	$4,775,971	$4,775,971
850.36	Medical-Inform Workers	$0	-	$292,111	$292,111
850.36	Medical-Consent Forms	$0	-	$147,336	$147,336
850.37	General Awareness Training	$0	-	$2,602,949	$2,602,949
Subtotals		***$2,222,075***	***-***	***$22,699,302***	***$23,015,675***
Grand Totals		**$11,239,944**	**-**	**$30,124,316**	**$31,551,401**

[a] For each requirement, the annualized cost is the sum of (1) the initial cost annualized over its life (assuming a 7 percent discount rate) and (2) the recurring cost.

Table 3-28
Schedule of Costs

Time Period	Initial Cost	Recurring Cost	Annualized Cost
July 1997 to December 1999	$9,017,869 [a]	$7,425,014	$8,535,725
December 1999 to December 2009 [b]	$2,222,075 [a]	$30,124,316	$31,551,401

[a] Initial costs are assumed to be incurred at the beginning of the time period.
[b] For the time period December 1999 to December 2009, the initial costs are the initial costs that are assumed to be incurred beginning December 1999. For recurring and annualized costs, the reported estimates are the sum of the July 1997 costs and December 1999 costs. Each estimate is designed to reflect the costs that will be incurred during the time period.

CHAPTER FOUR
BENEFITS OF REDUCING BERYLLIUM EXPOSURE

The goal of the CBDPP rule is to reduce worker exposure to beryllium and minimize the number of exposed workers at DOE facilities, thereby preventing the occurrence of beryllium sensitization and CBD in the DOE workforce. As of June 1999, 119 confirmed cases of CBD and 258 cases of beryllium sensitization have been identified among approximately 10,000 current and former DOE workers who were screened for beryllium disease. DOE believes this is an unacceptable trend and is therefore issuing the CBDPP rule to reduce both the number of workers who are exposed to beryllium and their levels of exposure. Pursuant to Executive Order (EO) 12866, this chapter evaluates the benefits that are attributable to the CBDPP rule.

In contrast to the compliance cost chapter (Chapter 3), this chapter does not provide monetary estimates of the benefits of the CBDPP rule. To provide quantitative estimates, four pieces of information would be necessary:

- The number of workers affected by the CBDPP rule;
- The reduction in exposure associated with the controls incorporated under the rule (i.e., exposure reduction factors);
- A relationship between exposure and the incidence of disease (i.e., a dose-response relationship); and
- The (monetary) value of reducing the incidence of CBD.

While the first of these is available from the profile of affected activities and sites (see Chapter 2), information on the other three is lacking. Exposure reduction factors are generally only available for respirator use and may not be well-defined for other program requirements such as housekeeping.[29] As discussed in Chapter 1, Section 1.1, no definitive dose-response relationship exists for beryllium. Finally, no studies have been conducted on the monetary benefits of reducing the incidence of beryllium sensitization and CBD.[30] Nevertheless, this chapter provides

[29] Clearly, housekeeping provisions reduce the accumulation of beryllium contamination in the workplace and thus play a role in reducing exposure levels. Developing quantitative estimates of these reduced exposure levels may not be straightforward, however.

[30] In the absence of information on the value of reducing the incidence of CBD it would be possible to assess the cost effectiveness of the rule. This would be done by estimating the number of *avoided cases of CBD* and then comparing that to compliance costs to generate a *cost per case avoided* estimate. As noted, however, the number of

a qualitative discussion of the benefits of reducing the incidence of CBD, including relevant quantitative estimates where available.

Reducing the incidence of beryllium sensitization and CBD benefits DOE, DOE contractors, and workers in a number of ways, including:

- Reduced medical costs;
- Reduced mortality;
- Increased quality of life;
- Increased medical surveillance for workers at risk;
- Increased work-life for beryllium workers;
- Increased productivity;
- Reduced legal liability for the Department and its contractors; and
- A reduction in the externality associated with beryllium exposure through a transfer of the medical costs from workers to DOE contractors.

Each of these categories of benefits are discussed in more detail in the subsequent sections. Quantitative estimates are provided where possible to provide an indication of the potential benefits of reducing beryllium exposure (e.g., costs of drugs used to treat CBD). Before discussing the benefits of reducing the incidence of beryllium disease, this chapter begins with a discussion of the relationship between beryllium exposure and the incidence of CBD.

4.1 HEALTH EFFECTS OF BERYLLIUM EXPOSURE

Exposure to beryllium dust can occur in a number of activities in the DOE complex, including the machining and processing of beryllium metals and decontamination and decommissioning (D&D). Chapter 2, Section 2.2 discusses in detail the activities that may result in worker exposure to beryllium dust.

avoided cases cannot be estimated because of the lack of a dose response relationship. Thus, assessing the cost effectiveness of the rule is also not possible.

Although beryllium exposure has been associated with a number of adverse health effects such as lung cancer and acute beryllium disease, Chronic Beryllium Disease (CBD) poses the greatest risk to the DOE workforce (Kreiss et al., 1993a; Stange et al., 1996; Barnard et al., 1996). CBD is a hypersensitive reaction to beryllium lodged in the lung and is caused by inhalation of beryllium dust. Symptoms of CBD include:

- Shortness of breath;
- Multiple lung scars that appear on chest x-rays;
- Granulomous scars found through lung biopsy;
- Abnormalities in pulmonary function tests; and
- Abnormal lung sounds detected with a stethoscope.

On average, CBD symptoms develop 10 years after first beryllium exposure, but they may develop in a few months or close to 40 years (Newman, 1996). There is no cure for CBD, and workers who experience its symptoms are normally treated with steroids to reduce lung inflammation. Some individuals who contract CBD require oxygen support to sustain pulmonary function. Steenlund and Ward (1991) report that 57 percent of workers with CBD die of beryllium-related diseases.

Prior to the onset of CBD, workers generally become sensitized to beryllium (Eisenbud and Lisson, 1983; Newman et al., 1992, 1996). Sensitization is characterized by an allergic reaction to beryllium in the worker's blood. Studies and research have shown that approximately 1 to 16 percent of workers exposed to beryllium become sensitized (Newman et al., 1996), although most studies estimate the prevalence at 1 to 3 percent (NJMRC, 1993; ES&H, 1995; Eisenbud and Lisson, 1983; Kreiss et al., 1993a,b; Stange et al., 1996). Workers that are sensitized to beryllium are at greater risk of developing CBD (Eisenbud and Lisson, 1983; Kreiss et al. 1993a,b; Newman et al., 1992, 1996).

In 1987, the National Jewish Medical and Research Center (NJMRC) and DOE began to screen workers for beryllium sensitization with a new test: the Beryllium Lymphocyte Proliferation Test (Be-LPT). The Be-LPT enables health professionals to make subclinical diagnoses of beryllium sensitization, increasing the accuracy and timeliness of diagnosing beryllium sensitization (Newman et al. 1996; Rossman, 1996). The test can be either performed on *in vitro* blood samples or through bronchoalveolar lavage (BAL). The BAL and blood Be-

LPT have both been shown to accurately identify beryllium sensitization in clinical trials (Rossman et al., 1988; Newman et al., 1989; Rossman, 1996). The *in vitro* blood test is a less intrusive method than the BAL test, and has therefore proven to be a more effective screening tool (Kreiss et al., 1989; Newman et al., 1991; Newman, 1996; Rossman, 1996). Individuals that are identified as beryllium-sensitized can then be given more extensive clinical evaluation, including BAL Be-LPT tests. Thus, instead of waiting until workers develop symptoms of the disease, the Be-LPT enables health professionals to determine which workers are sensitized to beryllium and, therefore, at greater risk of developing CBD.

As of June 1999, 119 confirmed cases of CBD and 258 cases of beryllium sensitization have been identified among approximately 10,000 current and former DOE workers screened for beryllium disease. In addition to the numbers of workers that have been diagnosed with CBD and beryllium sensitization, DOE is also concerned with the nature of some of these cases:

- A number of the cases occurred among workers whose exposure is believed to have been below the 2 $\mu g/m^3$ workplace standard (Kreiss, et al., 1996; Stange et al., 1996).
- A number of the cases are among workers not directly involved in beryllium-related work (e.g., clerical workers, secretaries, security guards), whose exposure to beryllium should only have been incidental (Kreiss et al., 1993a, 1996; Stange et al., 1996).

These two observations, combined with the increased incidence of CBD and beryllium sensitization, have led DOE to believe that the current standard may not be protective enough and that further controls may be necessary.

The CBDPP rule imposes a number of new requirements on DOE contractors to reduce the levels of beryllium exposure and minimize the number of workers that are exposed to beryllium. DOE believes that this dual objective (i.e., reducing exposure and minimizing the number of exposed workers) will prevent the future occurrence of CBD among the DOE workforce for two reasons. First, DOE expects that reducing *exposure* to beryllium will reduce the risk of developing CBD. Although epidemiological research has not been able to establish a definitive quantitative dose-response relationship, DOE believes that reducing worker exposure to beryllium is the prudent course of action and will reduce the incidence of CBD. Second, reducing the *number* of workers exposed to beryllium will reduce the number of workers at risk of developing beryllium sensitization and CBD.

4.2 REDUCED MEDICAL COSTS

Workers who are sensitized to beryllium or who contract CBD require medical attention and treatment. Reducing the incidence of beryllium sensitization and CBD will reduce the medical costs associated with treating and monitoring workers with these conditions. DOE expects the CBDPP rule to reduce two categories of medical costs: additional testing for workers with positive Be-LPT tests and monitoring and treating cases of beryllium sensitization and CBD.

4.2.1 Costs Associated with Additional Testing for Workers with Positive Be-LPT Tests

The CBDPP rule requires DOE contractors to offer workers with positive Be-LPTs further testing to determine if they are sensitized to beryllium or have contracted CBD. By reducing the incidence of beryllium sensitization and CBD, the CBDPP rule will reduce the number of positive Be-LPT tests. As a result, the number of referrals for further testing will be reduced and, consequently, their associated costs will be reduced.

The incremental benefits for this category would be calculated by multiplying the number of avoided beryllium-related medical referrals by the cost associated with each referral. The number of avoided referrals would be found by first determining the number of referrals that would occur in the absence of the rule (i.e., baseline referrals).[31] The number of avoided referrals is the reduction in the number of baseline referrals associated with the CBDPP rule. Given the lack of a quantitative dose-response relationship, the number of avoided referrals cannot be calculated, and thus an estimate of the incremental benefits for this category is not possible. The cost associated with each referral, however, can be estimated and is presented in Appendix A of this analysis. As discussed in Appendix A, DOE estimates that each referral for beryllium-related heath effects costs, on average, $9,120. Therefore, the CBDPP rule will save $9,120, on average, for each avoided referral.

4.2.2 Costs Associated with Monitoring and Treating Cases of Beryllium Sensitization

[31] Baseline referrals would include the number of referrals that sites would make plus the number of referrals that workers (i.e., self-referrals) and worker's personal physicians would make.

Workers who are sensitized to beryllium or have CBD require both continued monitoring and treatment. Reducing the incidence of beryllium sensitization and CBD will reduce the costs associated with both monitoring and treatment.[32] The incremental benefits for this category can be calculated by multiplying the number of avoided cases by the costs of continued monitoring and treatment. As with the cost savings associated with reducing the number of referrals (Section 4.2.1), the number of avoided cases cannot be calculated because of the lack of a definitive dose-response relationship. Nevertheless, for each avoided case of beryllium sensitization and CBD, the costs associated with continued monitoring and treatment will be avoided.

The treatment of beryllium sensitization and CBD involves a combination of periodic medical exams and possibly steroids. NJMRC recommends biennial medical exams for sensitized workers without symptoms of CBD and, depending on the severity of the symptoms, more frequent exams (e.g., annually or biannually) for workers who have CBD (Smythe, 1998). NJMRC also uses Prednisone, an anti-inflammatory steroid, in severe cases of CBD (Smythe, 1998). From Appendix A, physical exams are estimated to cost $140. Therefore, for each medical exam that is avoided by reducing the incidence of beryllium sensitization and CBD, $140 is saved. NJMRC also estimates that Prednisone costs $20 per month, or $240 annually (Smythe, 1998).[33] Therefore, for each person-year of Prednisone intake that is avoided, $240 is saved.

4.2.3 Medical Costs Savings Per Avoided Case of Beryllium Sensitization and CBD

To provide an indication of the potential cost savings associated with reduced medical costs under the CBDPP rule, DOE developed four hypothetical treatment scenarios and estimated the cost for each. These four scenarios, which are based on conversations with NJMRC, are:

- *Scenario A*—The worker has a positive Be-LPT and, upon referral, is found to be sensitized to beryllium. The worker develops no symptoms and thus requires only biennial medical exams. The worker does not require Prednisone.

[32] Is should be noted that monitoring and treatment costs are usually not incurred by the contractor, but are covered under workman's compensation or are incurred by the affected worker. Nevertheless, these reduced costs represents a benefit of the rule.

[33] NJMRC reports that the cost of Prednisone depends on the dosage, which may vary between 1 and 12 milligrams. Dosage depends on the severity of the patient's symptoms. Given this range of doses, NJMRC estimates that the cost of Prednisone will vary between $15 and $20 per month (Smythe, 1998).

- *Scenario B*—The worker has a positive Be-LPT and, upon referral, is found to have CBD. The worker develops mild symptoms, and requires annual medical exams, but *not* Prednisone.

- *Scenario C*—The worker has a positive Be-LPT and, upon referral, is found to have CBD. The worker develops mild symptoms, and requires annual medical exams as well as Prednisone.

- *Scenario D*—The worker has a positive Be-LPT and, upon referral, is found to have CBD. The worker develops severe symptoms, and requires biannual medical exams and Prednisone.

In reality, CBD may progress in a combination of these scenarios. Table 4-1 summarizes the cost elements of each scenario, as well as the timing of those elements.

Table 4-1
Cost Elements of the Hypothetical Scenarios

Scenario	Referral	Medical Exam	Use of Prednisone
A	Yes—Incurred as an initial cost	Yes—Biennially	No
B	Yes—Incurred as an initial cost	Yes—Annually	No
C	Yes—Incurred as an initial cost	Yes—Annually	Yes
D	Yes—Incurred as an initial cost	Yes—Biannually	Yes

DOE estimated the present value costs of each of the treatment scenarios using the assumptions that workers are first diagnosed with beryllium sensitization (Scenario A) or CBD (Scenarios B, C, and D) at age 40, that workers live to age 70, and that the treatment scenario remains constant for each worker from age 40 to 70. DOE took the cost of referrals from Section 4.2.1 (i.e., $9,120 per referral) and the costs of medical exam ($140 per exam) and Prednisone ($240 annually) from Section 4.2.2. The values of the costs of these scenarios, assuming a 7 percent discount rate (OMB, 1992), are:

- $10,100 for Scenario A;

- $10,998 for Scenario B;
- $14,216 for Scenario C; and
- $16,093 for Scenario D.

These estimates represent the medical cost savings for each case of each scenario that is avoided.[34] For example, for each case of Scenario D that is avoided, a $16,190 savings results.

Although each scenario may not be realistic in its own right, Scenarios A and D may provide useful lower and upper bounds on the medical cost savings per avoided case. Scenario A represents a mild case of sensitization with no progression to CBD. Thus, Scenario A may provide a useful lower bound estimate of the avoided medical costs. Scenario D, in contrast, represents a situation in which a severe case of CBD is present at the first diagnosis, resulting in frequent medical exams (i.e., biennially) and the use Prednisone. Thus, it may represent a useful upper bound estimate.

4.3 REDUCED MORTALITY

Steenlund and Ward (1991) report that 57 percent of workers with CBD die of beryllium-related diseases. By reducing the incidence of CBD, the CBDPP rule will reduce the number of CBD-related deaths. The number of deaths that will be avoided cannot be estimated because of the lack of a quantitative dose-response relationship. Nevertheless, DOE expects the provisions of the CBDPP rule to reduce the number of CBD-related deaths, resulting in substantial benefits for each avoided death.

4.4 INCREASED QUALITY OF LIFE

In addition to posing the risk of death, beryllium sensitization and CBD may also reduce affected worker's quality of life. Beryllium sensitization and CBD are often accompanied by a number of physical impairments, such as a reduction in lung function. These impairments will reduce sensitized and diseased worker's quality of life. The CBDPP rule is expected to reduce the incidence of both beryllium sensitization and disease, reducing the number of workers that will suffer a reduction in their quality of life. Thus, reductions in potentially affected worker's quality of life will be avoided.

[34] Once again, these estimates are based on the assumptions that workers are diagnosed at age 40, die at age 70, and remain within the same scenario from age 40 to age 70.

DOE has not quantified this benefit for a number of reasons. First, a quantitative dose-response relationship for beryllium has not been developed. This implies that the number of workers that become sensitized or diseased cannot be predicted. Second, there is no relationship between the incidence of beryllium sensitization or CBD and a reduction in the quality of life. Finally, studies relating monetary values to a reduction in quality of life associated with beryllium sensitization and CBD do not exist.

4.5 INCREASED MEDICAL SURVEILLANCE FOR WORKERS AT RISK

The CBDPP rule requires DOE contractors to perform medical surveillance for current workers at risk of becoming sensitized to beryllium or developing CBD. Contact with sites during this analysis indicated that a number of sites do not currently perform comprehensive medical surveillance for beryllium-related health effects. The medical surveillance requirements of the CBDPP rule increase the frequency, breadth of coverage, and content of medical evaluations that are currently afforded to affected workers at DOE sites. DOE expects this increased level of medical surveillance for beryllium-related health effects will result in four benefits:

- Improved timeliness in diagnosing cases of beryllium sensitization and CBD;
- Improved accuracy in diagnosing cases of beryllium sensitization and CBD;
- Improved timeliness in removing sensitized or diseased workers from beryllium-related work; and
- Increased information regarding beryllium-related health effects.

To improve the timeliness of beryllium sensitization and CBD case diagnosis, the CBDPP rule requires DOE contractors to provide medical evaluations:

- At initial assignment to beryllium areas; and
- Annually to current workers who are exposed or potentially exposed to beryllium in their work assignments.

This increased frequency of medical surveillance under the CBDPP rule will allow beryllium sensitization and CBD to be diagnosed sooner. More timely diagnosis of beryllium sensitization and CBD will lead to more timely treatment of these conditions. Although beryllium

sensitization and CBD are not curable conditions, a more timely response to these conditions may reduce the severity of the symptoms experienced by workers with these conditions (Newman, 1996).

To improve the accuracy of case diagnosis, the CBDPP rule requires DOE contractors to use the Be-LPT when performing the medical evaluations. DOE expects this test to improve the accuracy of medical evaluations that are conducted. Epidemiological research has shown the Be-LPT to be more accurate than other methods of diagnosing beryllium sensitization and CBD such as chest radiographs and spirometry (Newman, 1996). These other methods will miss some cases, leaving some sensitized or diseased workers untreated. Sites contacted during this rulemaking indicated that the Be-LPT is not in widespread use at affected sites. Thus, the CBDPP rule will lead to more accurate diagnoses of beryllium sensitization and CBD by requiring the use of the Be-LPT.

Early and accurate identification allows removal of workers with CBD patients from activities with beryllium exposure. Although there is no direct evidence that removal from exposure improves the prognosis of CBD patients, beryllium does clear from the lung over time. Reducing the level of beryllium in the lung should reduce the severity of the inflammation and the amount of lung damage (preamble).

Finally, repeated (e.g., annually) and comprehensive medical surveillance will improve the information base for epidemiological research. The CBDPP rule's increased medical surveillance and exposure monitoring requirements may lead to increased understanding of beryllium-related health effects and possibly the derivation of a quantitative dose-response relationship. This increased information base may lead to improved treatment and diagnosis of the beryllium-related health effects as well as improved methods of controlling exposure to beryllium to reduce the risk of disease.

4.6 INCREASED WORK-LIFE AND OPPORTUNITIES

Beryllium sensitization and CBD may shorten the work-life of workers with these conditions, reducing the time those workers may remain employed. Furthermore, beryllium sensitization and CBD may reduce the opportunities workers would have in non-beryllium related occupations. Both of these factors will impose costs on affected workers by reducing their income earning opportunities. By reducing the incidence of these conditions, the CBDPP rule will reduce these costs and result in a benefit to potentially affected workers.

4.6.1 Increased Work-Life

Severe cases of CBD may render afflicted workers unable to continue employment for medical reasons. These workers will lose income between the time they leave employment and the time they would have retired. Workman's compensation may partially offset some of this loss, but may not compensate the worker fully for two reasons. First, workman's compensation does not consider any raises workers would have received had they continued in their positions or occupations.[35] Second, some states place time limits on workman's compensation claims. Therefore, workers who develop CBD after the expiration of their state's time limit may be unable to collect workman's compensation. Given that the average time from exposure to onset of disease is 10 years (Newman, et al., 1996), this scenario is a distinct possibility.

The CBDPP rule will reduce the incidence of beryllium sensitization and CBD, and therefore reduce the number of workers who must retire early for beryllium-related medical reasons. The value of avoiding this income loss can be calculated by determining the number of lost work-years that will be avoided and then determining the income that would have been lost during those years. The avoided lost income cannot be estimated because a number of key inputs are not available, including a quantitative dose-response relationship and a method for determining when workers can no longer work due to beryllium-related medical reasons. Nevertheless, reducing the number of workers who retire early for beryllium-related health effects will reduce the amount of lost wages.

4.6.2 Increased Opportunities

Medical conditions such as beryllium sensitization and CBD may reduce a worker's opportunity for employment in non-beryllium DOE work or in work outside the DOE complex. Employers may not be willing to hire workers with these conditions because of the increased insurance costs and the possibility that CBD may leave the workers unable to work. Reducing the number of workers with beryllium sensitization or CBD implies that fewer workers will have diminished opportunities as a result of these conditions.

4.7 INCREASED PRODUCTIVITY

[35] Although workman's compensation adjusts for inflation, workers may have been eligible for raises exceeding the inflation adjustment (e.g., performance-based raises).

Reducing the incidence of beryllium sensitization and CBD will increase productivity at DOE facilities by keeping more experienced workers on the job. The rule requires that workers who become sensitized to beryllium or who contract CBD be removed from beryllium work. Reducing the incidence of beryllium sensitization and CBD will reduce the number of workers who must be removed from beryllium work, thus keeping more experienced workers in beryllium-related work. Workers who replace more experienced workers must be trained for beryllium-related work. Assuming that more experienced workers are more productive, the rule will increase productivity at DOE facilities.

The extent of the increased productivity, however, will depend on the number of workers who would have been removed in the absence of the CBDPP rule (i.e., avoided removals). The number of avoided removals is the decrease in the number of baseline removals, where the number of baseline removals is defined as the number of removals that would occur in the absence of the CBDPP rule.[36] The increase in productivity can be calculated by subtracting the productivity of the replacement workers (i.e., those who replace workers removed for beryllium-related medical reasons) from the workers who would have been removed in the baseline scenario (i.e., in the absence of the CBDPP rule). In addition to the increased productivity is the value of not having to train replacement workers.

Increased productivity and the reduced training costs are not estimated because a quantitative dose-response relationship is not available. The dose-response relationship would determine the number of baseline removals, as well as the number of avoided removals. Although a quantitative estimate is not available, reducing the incidence of beryllium-related health effects will reduce the number of removals and consequently increase productivity and reduce the need for training new workers under the CBDPP rule.

4.8 REDUCED LEGAL LIABILITY FOR DOE AND DOE CONTRACTORS

As a result of the recent increase in the incidences of beryllium sensitization and CBD, a number of lawsuits have been brought against DOE and its contractors. Although these case have yet to be resolved, DOE or some of its contractors may be held legally liable in some of these cases. Furthermore, DOE expects that, in the absence of the rule, future cases of CBD and beryllium sensitization will also result in lawsuits and potential legal liability. The CBDPP rule will reduce the potential for DOE and DOE contractors to be found legally liable in the future for

[36] Assuming that no worker with a positive Be-LPT test elects to remain in beryllium-related work.

at least two reasons. First, the CBDPP rule will reduce the number of cases of beryllium sensitization and CBD. This, in turn, will reduce the number of future lawsuits that are brought against DOE and its contractors. Second, by taking action to reduce beryllium exposure and minimize the number of workers exposed to beryllium, DOE reduces the possibility that it or its contractors will be found negligent in any future lawsuits. Thus, the CBDPP rule should reduce DOE and DOE contractors potential future liability.

4.9 REDUCING THE EXTERNALITY ASSOCIATED WITH BERYLLIUM EXPOSURE THROUGH A TRANSFER OF MEDICAL COSTS

In addition to the benefits discussed previously, the rule also transfers the burden of medical costs from workers to DOE contractors. This does not, however, directly result in a net benefit because these costs are only transferred and are not reduced or eliminated. Nevertheless, this provision of the rule reduces the burden of the externality (i.e., beryllium sensitization and CBD) placed on workers and places that burden on DOE contractors.[37] Placing this burden on DOE contractors will provide these parties with a monetary incentive (i.e., responsibility for the medical costs) to reduce the incidence of beryllium sensitization and CBD.[38] Therefore, transferring the burden of some medical costs from workers to DOE contractors should indirectly (i.e., through a monetary incentive) reduce the incidence of beryllium sensitization and CBD.

This provision of the rule provides a method of internalizing the externality of beryllium exposure. Economic externalities occur when one party (e.g., contractors) does not take into account the costs it imposes on other parties (e.g., workers). Standard economic theory holds that the optimal method of reducing or eliminating an externality is to have the party imposing the externality (e.g., contractors) include in its decisions all costs, including those it imposes on others (i.e., internalize the costs). This reduces the externality because the party imposing the externality considers the costs it imposes on others. By requiring DOE contractors to internalize the medical costs, the rule provides a monetary incentive for the reduction of both beryllium exposure and the number of workers who may be exposed.

4.10 SUMMARY

[37] DOE contractors, in turn, may pass this burden to DOE in the form of increased funding requests.

[38] In economic terms, this is referred to as internalizing the externality.

The CBDPP rule will minimize the number of exposed workers and reduce the exposure levels of workers who are currently performing beryllium-related work. It will therefore reduce the incidence of beryllium sensitization and CBD among the DOE workforce. Reducing the incidence of beryllium-related health effects will reap substantial benefits for DOE, DOE contractors, and affected workers. This chapter identified and discussed six benefits of the CBDPP rule:

- Reduced medical costs;
- Reduced mortality;
- Increased quality of life;
- Increased medical surveillance workers at risk;
- Increased work-life for beryllium workers;
- Increased productivity;
- Reduced liability for DOE and DOE contractors; and
- A reduction in the externality associated with beryllium exposure through a transfer of medical costs from workers to DOE contractors.

These benefits were primarily given a qualitative discussion due to the lack of information on dose-response relationship for beryllium. Table 4-2 summarizes the discussion provided in this chapter for each of the benefits listed above.

Table 4-2
Benefits of the Chronic Beryllium Disease Prevention Program (CBDPP) Rule

Benefit	Description
Reduced medical costs	By reducing the incidence of beryllium sensitization and CBD, the CBDPP rule will reduce referral and treatment costs associated with beryllium-related health effects. DOE estimates that for each avoided positive Be-LPT, the reduction in lifetime medical costs will range from $10,101 to $16,094 [a].
Reduced mortality	Steenlund and Ward (1991) report that 57 percent of workers with CBD die of beryllium-related diseases. By reducing the incidence of CBD, the CBDPP rule will reduce the number of deaths that are attributable to CBD.
Increased quality of life	Beryllium sensitization and CBD reduce sufferer's quality of life. By reducing the number of cases of beryllium sensitization and CBD, the CBDPP rule will increase the quality of life of workers that would have become sensitized or contracted CBD.
Increased medical surveillance	The CBDPP rule increases the level and frequency of medical surveillance, resulting in several benefits including improvements in the timeliness and accuracy in diagnosing cases of beryllium sensitization and CBD and increasing the information base regarding beryllium-related health effects.
Increased work-life for beryllium workers	Beryllium-related health effects may reduce the work-life of affected workers (e.g., medically-related early retirement) and may also reduce other employment opportunities. By reducing the incidence of beryllium-related health effects, the CBDPP rule will reduce the incidence of medically-related early retirement. Furthermore, workers who are not sensitized or diseased will not have diminished employment opportunities.
Increased productivity	Reducing the incidence of beryllium-related health effects will reduce the number of workers removed from work for beryllium-related health effects. Assuming that current beryllium workers are more productive than those who would replace them, reducing the number of beryllium-related removals will avoid reductions in productivity.
Reduced legal liability for DOE and DOE contractors	Reducing the incidence of beryllium-related health effects will reduce the potential future legal liability for DOE and its contractors.
Reduced externality	Transferring the responsibility for some medical costs from workers to DOE contractors will provide DOE contractors with a monetary incentive to reduce the incidence of beryllium-related health effects. This consequence of the CBDPP rule effective reduces the externality faced by the DOE workforce.

[a] These estimates assume that a worker receives a positive blood Be-LPT at age 40 and then dies at age 70. The range is generated by varying the severity of the medical condition.

CHAPTER FIVE
MARKET IMPACTS OF THE CBDPP RULE

This chapter explores the potential economic impacts of the CBDPP rule on markets that are associated with beryllium work at DOE facilities. Section 5.1 discusses the effect of the rule on the provision of public goods. Section 5.2 analyzes the effect on the supply of beryllium. A brief summary of impacts is presented in Section 5.3.

5.1 PROVISION OF PUBLIC GOODS

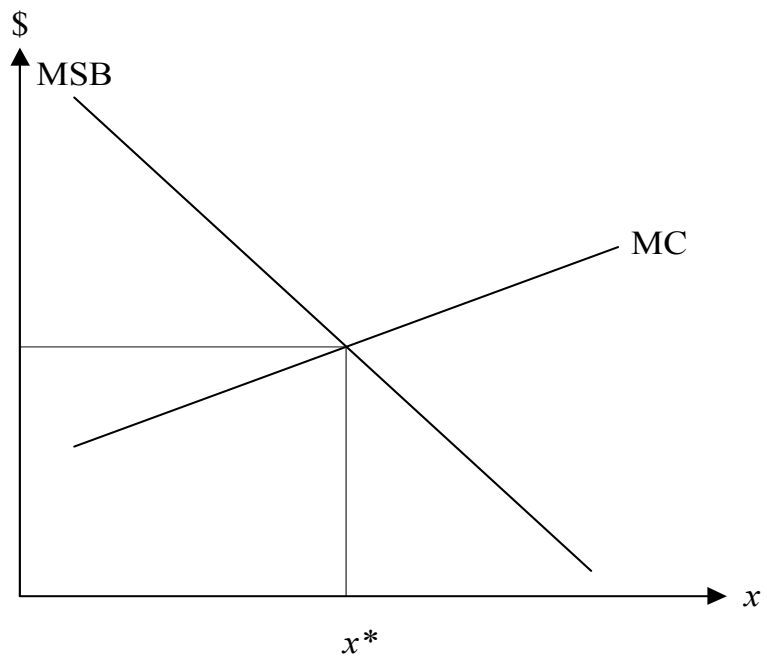
Due to its high tensile strength, light weight, and high resistance to corrosion, beryllium is used in the production of a number of defense-related goods such as nuclear weapon components. Defense-related goods such as nuclear weapons are typically considered *public goods* by economists, as are activities such as environmental restorations projects (e.g., decontamination and decommissioning of facilities). The CBDPP rule will increase the costs associated with providing these public goods and thus, may have an effect on the level of their provision.

In economic theory, public goods are those goods and services that can be consumed by several individuals simultaneously without diminishing the value of consumption for any one of the individuals. This key characteristic of public goods is referred to as *nonrivalry*. Another important feature of most public goods is their *nonexcludability*. Nonexcludability refers to the absence of a mechanism (e.g., price) that would allow the producer of the public good to prevent some individuals from consuming the good. In other words, because of the nature of public goods, some consumers may be able to consume them without paying. This nonexcludability dissuades private firms from providing public goods, leading to a less than socially optimal level of provision.

Since private markets fail to provide efficient (i.e., socially optimal) levels of public goods, these goods are usually provided by governments. Economic theory assumes that governments will provide levels of public goods which maximize total welfare, where total welfare is defined as the difference between total benefits (TB) and total costs (TC) associated with a given level of the public good. This is accomplished by equating the marginal social benefits (MSB) of the public good with the marginal cost (MC) of providing the good. The marginal social benefit of a public good is defined as the change in total benefits for a given change in the amount of the public good. Marginal costs are similarly defined for the total costs

of providing the public good. Figure 5-1 demonstrates how the socially optimal level of a public good is determined.[39] The x-axis measures the quantity of the public good (e.g., the number of beryllium-related research projects or the number of nuclear weapons) and the y-axis measures value in dollars. The intersection of the marginal social benefit (MSB) curve and the marginal cost (MC) curve yields the socially optimal level of the public good, x^*.

Figure 5-1
Socially Optimal Level of a Nonexcludable Public Good



The incremental costs that will be imposed by the CBDPP rule (see Chapter 3) will increase the marginal cost of producing beryllium-related public goods. More specifically, the marginal cost of producing the beryllium-related public good will increase. In terms of Figure 5-1, this will lead to an upward shift in the MC curve for each level of x. Assuming that

[39] It should be noted that although the graph is a useful theoretical construct for economic analysis, determination of the exact positions of the curves requires detailed data on consumer preferences and opportunity costs which are not readily available. Also, Figure 5-1 represents the typical depiction of MSB and MC curves where the MSB curve is decreasing in the level of the public good (i.e., downward sloping) and MC curves is increasing the level of the public good (i.e., upward sloping).

governments always opt to provide the socially optimal level of the public good (i.e. where MSB = MC), the increase in the marginal cost of production will necessitate a subsequent change in the level of provision of the public good.

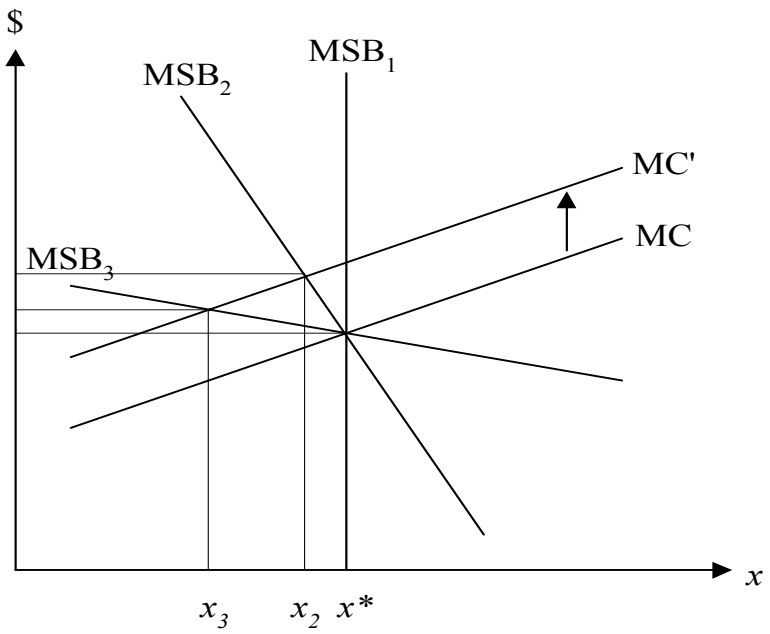
Figure 5-2 presents three marginal social benefit curves and two marginal cost curves. [40] Figure 5-2 assumes that marginal social benefits are given by MSB_2 (i.e., ignoring MSB_1 and MSB_3 for the moment) and that marginal costs prior to the implementation of the rule are given by MC. Prior to the rule, the government will provide x^* of the public good (i.e., the level where MSB_2 = MC). Now, suppose the rule causes an increase in marginal costs to MC', where the new optimal level of the public good is given by x_2, which is less than the original amount, x^*. Thus, an increase in marginal costs (from MC to MC') will lead to a reduction in the amount of the public good provided.[41] In terms of beryllium-containing public goods, the increase in costs associated with the CBDPP rule will decrease the socially optimum amount of beryllium-containing public goods that are provided.

The extent of this effect will partially depend on the shape and slope of the MSB curve. In Figure 5-2, three MSB curves are drawn to demonstrate this. The curves are drawn to represent different elasticity coefficients for the MSB curve. The *elasticity coefficient* measures the responsiveness of quantity to changes in price. If the absolute value of the elasticity coefficient is between zero and one, the curve is labeled inelastic, while elasticity coefficients that exceed one (in absolute value) are considered elastic. On an elastic (inelastic) curve, a one percent increase in price generates a more (less) than one percent increase in quantity. In Figure 5-2, MSB_3 represents an elastic curve and MSB_2 represents an inelastic one. For any given increase in marginal costs (e.g., MC to MC'), the more elastic the curve, the larger will be the reduction in the provision of the public good. Thus, the reduction in the provision of beryllium-containing goods will be greater if that actual MSB curve resembles MSB_3 than if it resembles MSB_2. In the extreme case, a perfectly inelastic curve such as MSB_1 in Figure 5-2 will result in no decrease in the provision of the public good for any increase in marginal costs.

[40] Although the increase in MC is depicted as a parallel upward shift, in reality, the slope of the MC curve may also be effected. Incorporating a change in the slope of the MC curve in addition to the upward shift of the curve would not significantly alter this analysis, thus, a parallel shift is examined solely for ease of exposition.

[41] In Figure 5-2, the reduction is given by ($x^* - x_2$).

Figure 5-2
Change in the Socially Optimal Level of a Public Good
Due to a Change in MC



MSB1-Perfectly elastic curve
MSB2-Relatively inelastic curve
MSB1-Relatively elastic curve

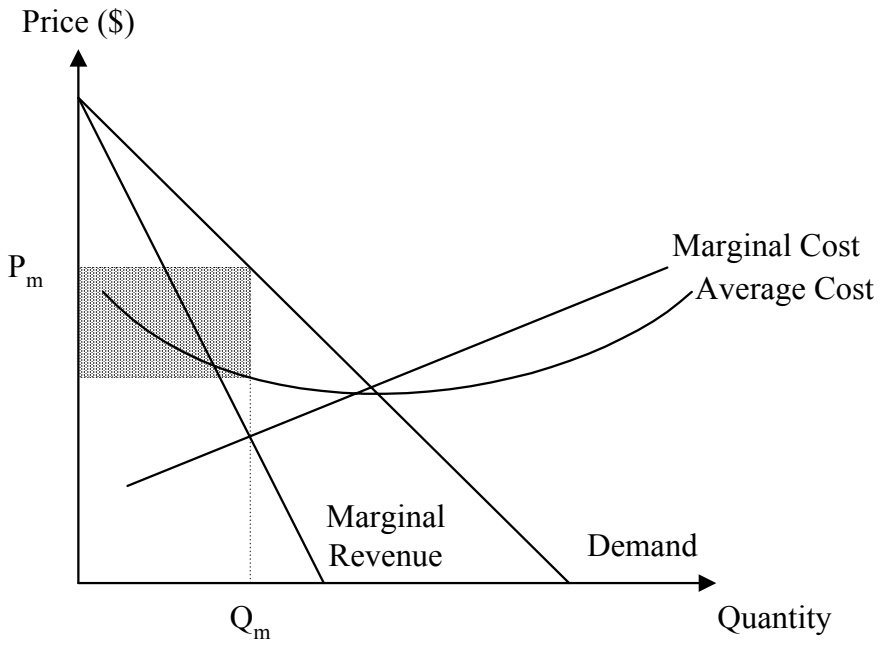
Information on the shape of the MSB curves for beryllium-containing goods is not available and therefore, DOE does not attempt to provide estimates of the reduction in the provision of beryllium-containing public goods. Nevertheless, DOE expects that the MSB curve for these goods is more likely to be inelastic than elastic. Goods that have inelastic demands are generally necessities such as food and gasoline. Increases in the prices of these goods produce little effect on the amount of the good that is demanded. On the other hand, elastic goods are generally characterized as luxury items. Increases in the prices of these goods may produce large decreases in demand. DOE believes that beryllium-containing goods produced in the DOE complex are necessities and thus, face relatively inelastic marginal social benefit curves. This implies that although the CBDPP rule may decrease the level of beryllium-containing goods that are produced, the reduction will not be substantial.

5.2 IMPACT ON THE MARKET FOR BERYLLIUM

As discussed in Section 5.1, the CBDPP rule will increase the cost of performing beryllium-related work, leading to an unknown but likely small decrease in the level of provision of beryllium-containing public goods. The decrease in production of beryllium-containing public goods will lead to a decrease in demand for beryllium within the DOE complex, This, in turn will effect the suppliers of beryllium metal. The primary supplier of beryllium metal to the DOE complex, and in the U.S., is the Brush Wellman Company of Cleveland, OH. Accordingly, DOE examines the impact of the rule on the market for beryllium assuming a sole supplier.

Standard economic theory suggests that a sole supplier of a good will maximize profits (i.e., the difference between revenues and costs) by producing at a point where its marginal revenue (MR) is equated to its marginal costs. Marginal revenues are defined as the additional revenues from producing an additional unit of the good, while marginal costs are similarly defined for costs. Figure 5-3 portrays the standard theoretical depiction of a market with one supplier. The supplier faces a downward sloping demand and marginal revenue curves, a *u*-shaped average cost curve, and an upward sloping marginal cost curve. The sole supplier of the good chooses to produce Q_m, where MR is equal to MC. Market price (P_m) is determined by evaluating Q_m on the demand curve. Profits for the supplier, given by the shaded area, are calculated as the difference between price (P_m) and average costs at Q_m (i.e., the per unit profit or markup) multiplied by Q_m (i.e., the number of units sold).

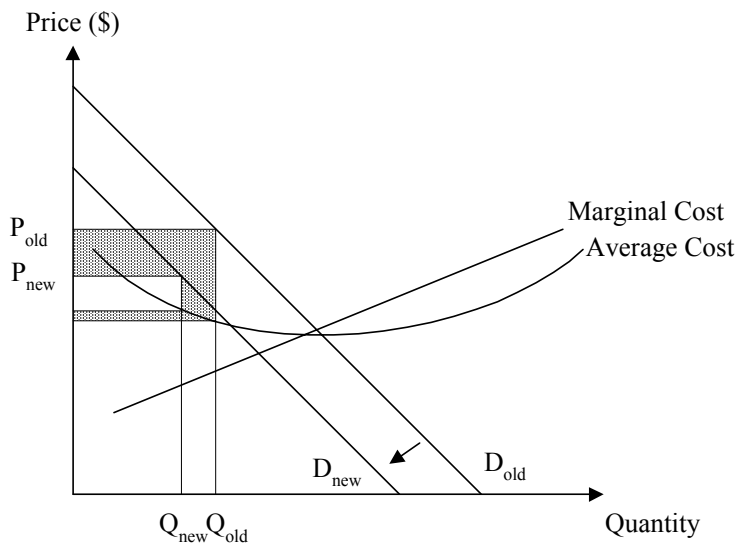
Figure 5-3
Determination of Output and Price for a Sole Supplier



A reduction in the DOE's use of beryllium metal will impact the market for beryllium metal by reducing the demand. This can be represented as a downward shift in the demand faced by the sole supplier. Figure 5-4 depicts a downward shift in demand (i.e., from D_{old} to D_{new}). The new level of production will once again be found by equating MR and MC. For clarity, marginal revenue curves have been omitted from Figure 5-4. A downward shift in demand will produce a corresponding downward shift in marginal revenue, and a consequent reduction in the level of production.[42] In Figure 5-4, the new level of production is given by Q_{new}. The reduction in production will be accompanied by a decrease in the profits of the firm. The new (reduced) level of profits is given by the white shaded area in Figure 5-4.

[42] From Figure 5-3, a decrease in the MR curve implies that the new MR curve will be below the old MR curve for all quantities. Thus, the new MR curve must intersect MC at a lower quantity compared to the old curve.

Figure 5-4
Effect of a Reduction in Demand on Quantity, Price, and Profits



DOE has not quantitatively estimated the impact of the rule on the market for beryllium (i.e., the reduction in quantity and profits) because not enough information exists to make such an estimate. Specifically, the impact that the CBDPP rule will have on the market for beryllium will depend on five factors:

- The increase in the marginal cost of performing beryllium-related work at DOE facilities (see Section 5.1);
- The elasticity coefficient for marginal social benefit curve (MSB) for beryllium-containing public goods (see Section 5.1);
- The share of DOE demand in the total market demand for beryllium metal;
- The shapes of the demand and marginal revenue curves in Figure 5-3; and
- The shapes of the average and marginal cost curves in Figure 5-3.

The first three of these factors will determine the decrease in demand faced by the sole supplier of the good (i.e., the extent of the shift from D_{old} to D_{new} in Figure 5-4). The final two factors would portray the market in Figure 5-3, allowing the impact of the CBDPP rule to be calculated. Since information on these factors is not forthcoming, DOE does not provide quantitative estimates of the impact.

Nevertheless, DOE does not expect the CBDPP rule to create a significant impact on quantity and profits. First, as noted in Section 5.1, assuming that the marginal social benefits of beryllium-containing goods are inelastic, the decrease in the production of beryllium-containing public goods is likely to be small. Thus, the increase in marginal costs of producing these goods (see Section 5.1) will not produce a large reduction in demand. Second, the contractual nature of work within the DOE complex implies that additional funding may be available for compliance with the CBDPP rule. This implies that any increase in marginal costs may be partially offset by an increase in funding, lessening the reduction in the amount of public goods provided.

5.3 SUMMARY

This chapter has examined the economic impacts of the CBDPP rule on markets associated with beryllium. Two impacts were examined:

- The impact on the provision of public goods that contain beryllium; and
- The impact on the supply of beryllium.

The CBDPP rule will increase the costs of performing beryllium-related work, potentially decreasing the government's provision of beryllium-containing public goods. DOE was unable to estimate the magnitude of the impact of the CBDPP rule on the provision of beryllium-containing public goods because information on the market for these goods was not available. DOE believes that the CBDPP rule will not impose a substantial impact on the provision of beryllium-containing public goods for two reasons. First, DOE expects that the marginal social benefits of beryllium-containing public goods are inelastic, implying that an increase in the marginal cost of producing these goods will result in a minimal decrease in the amount that is provided. Second, increases in funding from DOE may partially offset any increase in cost, reducing the impact of the CBDPP rule.

A decrease in the provision of beryllium-containing public goods will have an effect on the market for beryllium by reducing the demand for beryllium. A reduction in the demand for beryllium will have an effect on the price and profits of suppliers of beryllium. DOE does not expect the CBDPP rule to have a substantial effect on the market for beryllium for two reasons. First, Section 5.1 concluded that the reduction in the provision of beryllium-containing goods is likely to be small, and therefore, the reduction in demand for beryllium will also be small. Second, increases in funding may offset the reduction in demand for beryllium.

CHAPTER SIX
SMALL BUSINESS AND UNFUNDED MANDATES ANALYSIS

This chapter examines the potential small business and unfunded mandates impacts of the CBDPP rule. These analyses are conducted to fulfill regulatory requirements for federal agencies issuing rules. The small business analysis fulfills the requirements of the Regulatory Flexibility Act, as amended by the Small Business Regulatory Enforcement Fairness Act (SBREFA). The unfunded mandates analysis fulfills the requirements of the Unfunded Mandates Reform Act. U.S. Office of Management and Budget (OMB) guidance on performing economic analyses of federal regulations suggests that both the small business and unfunded mandates analysis should be incorporated in the economic analysis (OMB, 1996).

6.1 SMALL BUSINESS ANALYSIS

The purpose of the Regulatory Flexibility Act and its subsequent amendment in SBREFA is to ensure that federal regulations do not place an undue burden on small entities, including small businesses, small governments, and small non-profit organizations.[43] Federal departments or agencies issuing rules are required to assess the likely effect of the rule on small entities. If the rule is deemed to have a *significant* effect on a *substantial* number of small entities, then the department or agency must conduct further analyses that identify alternative, less-costly approaches to the requirements of the rule. The analysis performed here is to determine the potential for the rule to impose such a burden, thus determining if further analysis is required.

In terms of the CBDPP rule, small businesses that are involved in beryllium-related work will be required to comply with the requirements of the rule, and thus incur compliance costs. If the impact of the compliance costs on the small businesses is significant then further analysis may be required.[44]

DOE's first step in determining if the CBDPP rule will impose a significant impact on small businesses was to determine the number of small businesses that are engaged in beryllium-related work at the affected sites. To do this, DOE obtained information regarding the number of small contractors that are involved in beryllium-related work at the fifteen affected sites covered

[43] The CBDPP rule would only have an effect on small businesses and not small governments or small non-profit organizations.

[44] The impact of compliance costs on a small business can be estimated by the ratio of compliance costs to current revenues.

in this analysis.[45] Table 6-1 summarizes this information. As Table 6-1 indicates, none of the affected sites employ small contractors in beryllium-related work. Furthermore, DOE expects that the use of small contractors in beryllium-related work at affected DOE sites will not increase since the CBDPP rule requires minimizing the number of workers that perform beryllium-related work (Grasso, 1998; Ford, 1998).

Table 6-1
Estimated Number of Small Businesses Affected by the CBDPP Rule

Site	Estimated Number of Small Businesses Affected by the Rule	Workers that are Employed by Small Businesses	Source
Argonne East	0	0	Stamoudis, 1998
Argonne West	0	0	Stamoudis, 1998
ETTP (K-25)	0	0	Helms, 1998
Hanford	0	0	Morris, 1998
Kansas City (Allied)	0	0	Frede, 1998b
LANL	0	0	Abelin, 1998
LBL	0	0	Grasso, 1998
LLNL	0	0	Grasso, 1998
Mound	0	0	Uelen, 1998b
ORNL	0	0	DOE assumption [a]
Pantex	0	0	Meyers, 1998
Stanford	0	0	Grasso, 1998
Rocky Flats	0	0	Torma-Krajewski, 1998b
Y-12	0	0	Ford, 1998
Totals	**0**	**0**	**-**

[a] This assumption is based on DOE's knowledge of work that is being performed at ORNL.

Furthermore, DOE expects that any potential impacts on small businesses will be minimal for two reasons. First, in contrast to firms that compete in private markets, work performed by small businesses at DOE facilities is conducted under contract with either DOE or the prime contractor at the site. This contractual arrangement implies that increased funding may be available for compliance with the rule. If so, then any impact of the rule would be offset by the increase in funding that will be provided to comply with the requirements of the CBDPP rule.

[45] DOE collected this information though a combination of direct contact with the sites (7 sites) and contact with DOE operations offices that oversee the sites (7 sites).

Second, not all of the requirements of the CBDPP rule apply to all contractors on a site. A number of the requirements apply only to the prime contractor at a site and thus, small subcontractors may not be burdened with some of the requirements.[46] For example, each site is required to submit *one* CBDPP plans. This will most likely be prepared by the prime or integrating contractor at the site. Thus, not all of the compliance costs will be applicable to small businesses at DOE sites.

As a final consideration, DOE notes that some sites may employ small businesses in the future to perform decontamination and decommissioning (D&D) work. DOE has determined that the rule will not impose any *incremental* burden on small businesses that may be employed in the future. First, contracts for this type of work have not been written or offered at many of the sites that will perform D&D work in the future. This implies that these contracts would include additional funding to cover the compliance costs of the CBDPP rule. Second, small businesses have the choice not to accept the contract, or not to bid on the contract. Given that small businesses can choose not to perform the beryllium-related work, any costs incurred will not be incremental for the small contractors.

6.2 UNFUNDED MANDATES ANALYSIS

The purpose of the Unfunded Mandates Reform Act is to reduce the incidence of Federal agencies imposing unfunded requirements on state and local governments. DOE reviewed the CBDPP rule to determine if any of the requirements impose an unfunded mandate on state or local governments and has determined that no such mandates are imposed. The rule only imposes requirements on DOE contractors and does not require state or local governments to take any actions.

[46] Currently none of the prime contractors at the fourteen affected DOE sites in this analysis are small contractors.

CHAPTER SEVEN
SUMMARY

The CBDPP rule is designed to minimize the number of workers exposed to beryllium and reduce worker exposures in the DOE complex. This document constitutes the economic analysis of this rule, fulfilling three requirements:

- *Executive Order 12866*—EO12866 requires federal agencies issuing rules to evaluate the costs, benefits, and economic impacts of the rule.
- *The Regulatory Flexibility Act, as amended by the Small Business Regulatory Enforcement Act (SBREFA)*—Federal agencies are required to review rules for potentially significant impacts on small entities.
- *The Unfunded Mandates Reform Act*—Federal agencies are required to determine if rules will impose unfunded mandates on state and local governments.

The remainder of this chapter summarizes the results of each of these analyses.

Before conducting these analyses, DOE profiled the DOE sites and activities that will be affected by the CBDPP rule and estimated that the number of workers that will be affected by the rule (Chapter 2). DOE estimates that 1,634 workers may be exposed or potentially exposed in the DOE complex. Furthermore, DOE estimates that 1,236 of these workers (75.6 percent) are potentially exposed above the action level or short-term exposure limit proscribed in the CBDPP rule.

Chapter 3 provided estimates of the compliance costs of the CBDPP rule. The rule is estimated to impose a $8.54 million annual cost on DOE contractors between July 1997 and December 1999 and a $31.55 million cost on DOE contractors between December 1999 and December 2009. This includes an initial (i.e., startup) cost of $9.02 million incurred in July 1997 and another initial cost of $2.22 million incurred in December 1999.

The CBDPP rule will result in substantial benefits for DOE, DOE contractors, and workers. Chapter 4 assessed six benefits anticipated for the CBDPP rule:

- Reduced medical costs;
- Reduced mortality;

- Increased quality of life;
- Increased medical surveillance for workers at risk;
- Increased work-life for beryllium workers;
- Increased productivity;
- Reduced legal liability for DOE and DOE contractors; and
- A reduction in the externality associated with beryllium exposure through a transfer of the medical costs from workers to DOE contractors.

Because sufficient information on the dose-response relationship for beryllium is not available within the scientific community, DOE could not relate reduced levels of exposure to a specific reduction in CBD and beryllium sensitization. Nevertheless, DOE estimates that the monetary benefits from reduced lifetime medical costs could range from $10,100 to $16,093 for each avoided case of beryllium sensitization or CBD.[47] Although not quantified, DOE also expects that the other categories may also produce substantial benefits to DOE, DOE contractors, and affected workers.

Chapter 5 provided a discussion of the potential economic impacts of the CBDPP rule. Three potential impacts were discussed:

- The impact on the provision of public goods that contain beryllium;
- The impact on the market for beryllium; and
- The impact on D&D projects within the DOE complex.

DOE assessed each of these potential impacts and determined none of them will impose a significant economic impact. For the provision of public goods and the impact on the beryllium market, DOE determined that the potential reduction in the provision of beryllium-containing public goods will be minimal and consequently the reduction in demand for beryllium will also be small. For the impact on D&D work, DOE estimates that the D&D-related compliance costs

[47] These estimates assume that workers are diagnosed at age 40 and die at age 70. See Chapter 4, Section 4.2.3 for details of the estimates.

of the work represent less than 5 percent of the projected costs for this work. DOE does not consider this a significant impact.

Chapter 6 assessed the potential small business and unfunded mandates impacts of the CBDPP rule pursuant to the Regulatory Flexibility Act, as amended by the Small Business Regulatory Enforcement Fairness Act, and the Unfunded Mandates Reform Act. Information collected regarding all affected sites indicates that no small businesses are performing beryllium-related work at the affected sites. Thus, no small businesses would be impacted by the CBDPP rule. DOE also reviewed the CBDPP rule for unfunded mandates that may be imposed on state and local government (Chapter 6, Section 6.2). This review indicates that no unfunded mandates will be imposed on state or local governments.

CHAPTER EIGHT
REFERENCES

Abelin, Steve, 1998. Personal communication between Steve Abelin, Los Alamos National Laboratory, Los Alamos, NM and Lou Nadeau, Eastern Research Group, Lexington, MA, June 8.

Allied Signal, 1997. Chronic Beryllium Disease Prevention Program Plan submitted under DOE N 440.1.

Applied Medical Informatics, 1998. Personal communication between Applied Medical Informatics, Inc., and Aylin Sertkaya, Eastern Research Group, Lexington, MA, February 10.

Barnard, Anthony E., Janet Torma-Krajewski, and Susan M. Viet, 1996. "Retrospective Beryllium Exposure Assessment at the Rocky Flats Environmental Technology Site," *American Industrial Hygiene Association Journal*, vol. 57, pp. 804-808.

Brealey, Richard and Stewart Myers, 1984. *Principles of Corporate Finance*, Second edition, New York: McGraw-Hill Book Company.

Creek, Kathryn, 1998. Personal communication between Kathryn Creek, LANL and Lou Nadeau, Eastern Research Group, Lexington, MA, March 10.

Eisenbud, Merril, and Judith Lisson, 1983. "Epidemiological Aspects of Beryllium-Induced Nonmalignant Lung Disease: A 30-Year Update," *Journal of Occupational Medicine*, Vol. 25, No. 3, March.

Environment, Safety and Health (ES&H), Office of, 1995. "New Publication on Chronic Beryllium Disease Studies," *ES&H Synergy*, Fall.

Federal Express, 1998. Personal communication between Federal Express and Aylin Sertkaya, Eastern Research Group, Lexington, MA, February, 12.

Ford, Tom, 1998. Personal communication between Tom Ford, Lockheed Martin (Y-12 Plant), Oak Ridge, TN and Lou Nadeau, Eastern Research Group, Lexington, MA, June 8, 1998.

Frede, Bill, 1998a. Personal communication between Bill Frede, Allied Signal, Kansas City, MO and Brigette Brevard, Eastern Research Group, Arlington, VA, March 11.

Frede, Bill, 1998b. Personal communication between Bill Frede, Allied Signal, Kansas City, MO and Brigette Brevard, Eastern Research Group, Arlington, VA, April 9.

Grasso, Harvey, 1998. Personal communication between Harvey Grasso, DOE Oakland Operations Office, Oakland, CA and Lou Nadeau, Eastern Research Group, Lexington, MA, June 9.

Hargis, Barbara, 1998. Personal communication between Barbara Hargis, Los Alamos National Laboratory, Los Alamos, NM and Lou Nadeau, Eastern Research Group, Lexington, MA, March 10.

Helms, Ted, 1998. Personal communication between Ted Helms, K-25 Plant, Oak Ridge, TN and Brigette Brevard, Eastern Research Group, Arlington, VA, April 9.

Hiebert, Doug, 1999a. Personal communication between Doug Hiebert, Rocky Flats Site, Rocky Flats, CO. and Lou Nadeau, Eastern Research Group, Lexington, MA, August 25.

Hiebert, Doug, 1999b. Personal communication (via e-mail) between Doug Hiebert, Rocky Flats Site, Rocky Flats, CO. and Lou Nadeau, Eastern Research Group, Lexington, MA, August 30.

Internet Travel Network, 1998. Personal communication between Internet Travel Network and Aylin Sertkaya, Eastern Research Group, Lexington, MA, February 12.

Jameson, C.W., 1996. "Introduction to the Conference on Beryllium-Related Diseases," *Environmental Health Perspectives*, Vol. 104, Supplement 5, October.

Jenkins, Jim, 1998. Personal communication between Jim Jenkins, Y-12 Plant, Oak Ridge, TN and Brigette Brevard, Eastern Research Group, Arlington, VA, March 11.

Kreiss, Kathleen, Lee S. Newman, Margaret Mroz, and Priscilla A. Campbell, 1989. "Screening Blood Test Identifies Subclinical Beryllium Disease," *Journal of Occupational Medicine*, vol. 31, no. 7, July.

Kreiss, Kathleen, Margaret M. Mroz, Boguang Zhen, John W. Martyny, and Lee S. Newman, 1993a. "Epidemiology of Beryllium Sensitization and Disease in Nuclear Workers," *American Review of Respiratory Diseases*, Vol. 148, pp. 985-991.

Kreiss, Kathleen, Stephanie Wasserman, Margaret M. Mroz, and Lee S. Newman, 1993b. "Beryllium Disease Screening in the Ceramics Industry," *Journal of Occupational Medicine*, Vol. 35, No. 3, March.

Kreiss, Kathleen, Margaret M. Mroz, Lee S. Newman, John Martyny, and Boguang Zhen, 1996. "Machining Risk of Beryllium Disease and Sensitization With Median Exposures Below 2 $\mu g/m^3$," *American Journal of Industrial Medicine*, vol. 30, pp. 16-25.

Kreiss, Kathleen, Margaret M. Mroz, Boguang Zhen, Herbert Wiedemann, and Barbara Barnard, 1997. "Risks of Beryllium Disease Related to Work Processes at a Metal, Alloy, and Oxide Production Plant," *Occupational and Environmental Medicine*, Vol. 54, pp. 605-612.

Lab Safety Supply, 1998. *Safety Essentials Direct* catalog, Spring/Summer.

Los Alamos National Laboratory (LANL), 1996. "Los Alamos National Laboratory Site Characterization for TA-3-141, Volume 2—Detailed Analysis of Site Characterization Results," Prepared by Radian Corp. for Los Alamos National Laboratory, Industrial Hygiene Group, February 13.

Los Alamos National Laboratory (LANL), 1997. "Beryllium Technology Facility Auditable Safety Analysis, Los Alamos National Laboratory."

Meyers, Ken, 1998. Personal communication between Ken Myers, Pantex Plant, Amarillo, TX and Brigette Brevard, Eastern Research Group, Arlington, VA, March 6.

Morris, Holly, 1998. Personal communication between Holly Morris, Hanford and Lou Nadeau, Eastern Research Group, Lexington, MA, August 27.

National Jewish Medical and Research Center (NJMRC), 1993. "Med Facts: Beryllium Disease," http://www.njc.org/MFhtml/BER_MF.html (October 21, 1997).

Newman, Lee S., Kathleen Kreiss, Talmadge E. King, Jr., Sallie Seay, and Priscilla A. Campbell, 1989. "Pathologic and Immunologic Alterations in Early Stages of Beryllium Disease," *American Review of Respiratory Diseases*, vol. 139. 1989.

Newman, Lee S., Margaret Mroz, D.C. Lezotte, Priscilla A. Campbell, and Kathleen Kreiss, 1991. "Re--Examination of the Peripheral Blood Lymphocyte Transformation Test in the Diagnosis of Chronic Beryllium Disease," *American Review of Respiratory Diseases*, vol. 143, p. A103.

Newman, Lee S., Margaret Mroz, Beverly Schumacher, E. Daniloff, and Kathleen Kreiss, 1992. "Beryllium Sensitization Precedes Chronic Beryllium Disease," *American Review of Respiratory Disease*, v. 145, p. A324.

Newman, Lee S., 1996. "Significance of the Blood Beryllium Lymphocyte Proliferation Test," *Environmental Health Perspectives*, Vol. 104, Supplement 5, October.

Newman, Lee S., Jenifer Lloyd, and Elaine Daniloff, 1996. "The Natural History of Beryllium Sensitization and Chronic Beryllium Disease," *Environmental Health Perspectives*, Vol. 104, Supplement 5, October.

Occupational Safety and Health Administration (OSHA), 1986. "Final Regulatory Impact and Regulatory Flexibility Analysis of the Revised Asbestos Standard," Occupational Safety and Health Administration, Office of Regulatory Analysis, June.

Office of Environmental Health and Safety (EH), 1999. *The 1999 DOE N 440.1 and Proposed 10 CFR 850 Cost Impact Survey*. U.S. Department of Energy.

Office of Environment, Safety, and Health, 1998. "Health and Safety Plans Guidelines," U.S. Department of Energy, http://tis-hq.eh.gov/docs/hasp.

Office of Environmental Management, 1996. "The 1996 Baseline Environmental Management Report," U.S. Department of Energy, Office of Environmental Management, Office of Strategic Planning and Analysis, June.

Office of Management and Budget (OMB), 1992. "Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs," Memorandum for Heads of Executive Departments and Establishments, OMB Circular No. A-94 Revised (Transmittal Memo No. 64), October 29.

Office of Management and Budget (OMB), 1996. "Economic Analysis of Federal Regulations Under Executive Order 12866," January 11, Internet: http://www.whitehouse.gov/WH/EOP/html/miscdoc/riaguide.html.

Office of Naval Reactors, 1998a. Memorandum from J.J. Mangeno, DOE Office of Naval Reactors (NE-60) to DOE Office of Worker Health and Safety (EH-51), August 12.

Office of Naval Reactors, 1998b. Personal communication between DOE Office of Naval Reactors (NE-60) and Jackie Rogers, DOE Office of Worker Health and Safety (EH-51), August 12.

Office of Organization and Management, 1996. "Directives Cost Impact Estimating Guide," U.S. Department of Energy, Assistant Secretary for Human Resources and Administration, G 251.1-2, September.

Office of Scientific and Technical Information, 1997. *DOE R&D Project Summaries Database*, U.S. Department of Energy, Office of Scientific and Technical Information; Internet database search for the word 'beryllium', conducted by Lou Nadeau of Eastern Research Group, Lexington, MA, December 11, 1997.

Office of Worker Health and Safety, 1996. "DOE Beryllium Information Survey Report," Prepared by Eastern Research Group, Lexington, MA for DOE, Office of Worker Health and Safety, Draft version.

Rossman, Milton D., Jeffrey A. Kern, Jack A. Elias, Mark R. Cullen, Paul E. Epstein, Otto P. Preuss, Thomas N. Markham, and Ronald P. Daniele, 1988. "Proliferative Response of Bronchoalveolar Lymphocytes to Beryllium," *Annals of Internal Medicine*, v. 108, pp. 687-693.

Rossman, Milton D., 1996. "Chronic Beryllium Disease: Diagnosis and Management," *Environmental Health Perspectives*, Vol. 104, Supplement 5, October.

Smythe, Sean, 1998. Personal communication between Sean Smythe, National Jewish Medical and Research Center, Denver, CO and Aylin Sertkaya, Eastern Research Group, Lexington, MA, February 10.

Stamoudis, Lia, 1998. Personal communication between Lia Stamoudis, DOE Chicago Operations Office, Chicago, IL and Lou Nadeau, Eastern Research Group, Lexington, MA, June 10.

Stange, Arthur W., Duane E. Hilmas, and Francis J. Furman, 1996. "Possible Health Risks from Low Level Exposure to Beryllium," *Toxicology*, vol. 111, no. 1-3, pp. 213-224.

Steenland, K. and E. Ward, 1991. "Lung Cancer Incidence Among Patients with Beryllium Disease: A Cohort Mortality Study," *Journal of the National Cancer Institute*, vol. 83, pp. 1380-1384.

Torma-Krejewski, Janet, 1998a. Personal communication between Dr. Torma-Krejewski, Rocky Flats Site, Rocky Flats, CO and Lou Nadeau, Eastern Research Group, Lexington, MA, March 12.

Torma-Krejewski, Janet, 1998b. Personal communication between Dr. Torma-Krejewski, Rocky Flats Site, Rocky Flats, CO and Brigette Brevard, Eastern Research Group, Arlington, VA, April 9.

Uelen, M. 1998a. Personal communication between M.W. Uelen, Mound Plant, Miamisburg, OH and Lou Nadeau, Eastern Research Group, Lexington, MA, March 10.

Uelen, M. 1998b. Personal communication between M.W. Uelen, Mound Plant, Miamisburg, OH and Brigette Brevard, Eastern Research Group, Arlington, VA, April 9.

U.S. Department of Energy (DOE), 1997. *DOE Standard: Integration of Safety and Health Into Facility Disposition Activities, Volume 1: Technical Standard*, U.S. Department of Energy, Draft. September 26.

Wynveen, R.A., 1999. "Comments on Proposed Beryllium Regulation," Comment submitted on the proposed CDBPP rule to Jackie Rogers, DOE EH-51, July 2.

APPENDIX A
UNIT COSTS OF MEDICAL EVALUATIONS

This appendix estimates the compliance costs associated with the medical surveillance section of the Chronic Beryllium Disease Prevention Program (CBDPP) rule. The appendix begins with a discussion of the medical surveillance provisions (Section A.1) and then presents detailed estimates of the unit costs associated with the medical evaluations required by the CBDPP rule (Section A.2).

A.1 REQUIREMENTS OF THE CBDPP RULE

The CBDPP rule requires DOE contractors to establish and implement a medical surveillance program for all beryllium-exposed workers (i.e., all current workers that are or were exposed or potentially exposed to beryllium). The program includes the establishment and maintenance of an electronic beryllium registry of covered workers. In addition to these provisions, the CBDPP rule also imposes medical evaluation requirements that will impose further costs on DOE contractors. The medical evaluation requirements include:

- Providing medical evaluations for workers covered by the medical surveillance requirements;
- Performing data analysis to identify workers that are at risk and identify work practices that pose undue risk;
- Developing a plan for the removal of workers from beryllium-related work based on the findings of the medical evaluations;
- Protecting the benefits of workers that are removed from beryllium work for medical reasons, and providing alternative employment without occupational beryllium exposure for the workers who are permanently removed;
- Inform workers of the benefits and risk of medical tests and procedures used in the diagnosis and treatment of beryllium-related health effects; and
- Obtain signed consent forms from workers prior to medical evaluations.

DOE N 440.1 also required the establishment of a beryllium registry and a medical surveillance program plan. These two requirements impose only start-up costs and thus, the costs are assumed to be attributable to DOE N 440.1 and not attributable to the CBDPP rule.[48]

[48] This is based on the allocation criteria presented in Chapter 3, Section 3.1.2.

The following sections only discuss the incremental costs imposed by 850.34 (b) Medical Evaluations.

A.2 COST OF MEDICAL EVALUATIONS

This section presents cost estimates for paragraphs 850.34 (b) of the medical surveillance requirement of the CBDPP rule. Each section below begins with a review of the specific requirement and then presents detailed computations of the unit costs associated with each requirement.

A.2.1 Initial Medical Evaluation

Under the CBDPP rule, DOE contractors are required to offer each covered worker a baseline medical evaluation that includes:

- A medical and work history;
- A directed physical examination with special emphasis on the respiratory system;
- A chest radiograph (posterior-anterior 14 × 17 inches) interpreted by a NIOSH B-reader or board-certified radiologist;
- Spirometry; and
- A Be-LPT.

Although a similar requirement is contained in DOE N 440.1, these provisions of the CBDPP rule impose recurring burdens on affected facilities that are incremental (See Chapter 3, Section 3.1.2).

Table A-1 provides estimates of the costs associated with non-labor requirements for initial medical evaluations. This data was obtained from National Jewish Medical and Research Center, Applied Medical Informatics Incorporated, and Allied Signal's CBDPP plan submitted under DOE N 440.1. The cost of initial evaluations include $471 in medical procedure-related costs. Included among the procedures are a complete physical examination ($140), a spirometry ($28), chest radiograph ($65), and a Be-LPT ($231). Assuming sites use a blood Be-LPT, the

blood sample must be shipped to a laboratory within 24 hours for analysis. This is estimated to cost $7 per blood sample taken for initial medical evaluations.[49]

Also included in the cost of performing initial medical evaluations will be the labor cost for workers, clerical staff, and physicians. DOE assumes that the initial medical evaluation will require 2 hours for both workers and physicians and 5 minutes of clerical labor time. Thus, the labor cost for initial medical evaluations can be estimated as [2 hours*(physician hourly labor cost + worker hourly labor cost) + 0.083 hours*(clerical hourly labor cost)]. The physician hourly labor cost is $59.35 and the clerical hourly labor cost is $11.50. The hourly labor cost for workers varies by site and is presented in Table 3-1 of Chapter 3 for each site. Table A-2 summarizes the labor costs for initial medical evaluations.

Table A-2 also summarizes the cost of conducting an initial evaluation for each site (i.e., the site-specific unit cost for initial medical evaluations). The unit cost ranged from $683 to $874 with a weighted average of $724.[50]

[49] This assumes that blood samples for each individual are shipped separately for initial medical evaluations.

[50] The weighted average was calculated using the number of workers eligible for medical surveillance under the rule as weights (see Table 3-13 of Chapter 3).

Table A-1
Unit Costs Associated with a Baseline Medical Evaluation

Cost Element	Unit Cost	Comment
Complete physical examination	$140.00	Performed on-site
Spirometry	$28.00	Performed on-site
Chest radiograph	$65.00 [a]	Performed off-site
Be-LPT	$231.00	Blood is drawn during physical examination
Sample shipment	$7.00 [b]	Requires shipment to a laboratory knowledgeable in Be-LPT
Total	**$471**	**-**

Source: Applied Medical Informatics Inc. (1998), Allied Signal (1997), National Jewish Medical and Research Center (Smythe, 1998), Federal Express (1998).
[a] The figure is based on the median value of the price range, $50 to $80, for chest radiographs supplied by Applied Medical Informatics Inc. (1998).
[b] The cost of sample shipment is based on the U.S. Government rate of shipping a 1 to 4 pound package from the East Coast to Denver, CO, where National Jewish Medical and Research Center is located, using Federal Express Priority Overnight Delivery to ensure delivery within 24 hours of sample collection.

Table A-2
Estimated Unit Costs for Initial Medical Evaluations

Site	Medical Test and Procedures Cost [a]	Labor Cost [b]	Total Cost Per Initial Evaluation [c]
Argonne-East	$471	$221	$693
Argonne-West	$471	$402	$874
ETTP (K-25)	$471	$211	$683
Hanford	$471	$250	$722
Kansas City	$471	$212	$684
LANL	$471	$261	$733
LBL	$471	$344	$816
LLNL	$471	$250	$722
Mound	$471	$281	$753
ORNL	$471	$224	$696
Pantex	$471	$250	$722
Stanford	$471	$250	$722
Rocky Flats	$471	$257	$729
Y-12	$471	$219	$691

Note: Estimates may contain some rounding error.
[a] Table A-1.
[b] Calculated as [2 hours*($59.35 + worker hourly labor cost) + 0.083 hours*($11.50)] for each site. The hourly labor cost for workers is taken from Table 3-1 in Chapter 3.
[c] Sum of medical test and procedures cost and labor cost.

A.2.2 Periodic Medical Evaluations

The CBDPP rule stipulates that DOE contractors shall provide all workers who are currently exposed or potentially exposed with an annual medical evaluation. As a minimum, periodic evaluations are required to include:

- A respiratory symptoms questionnaire;
- A physical examination; and
- A Be-LPT.

Table A-3 provides estimates of the costs associated with non-labor requirements for annual medical evaluations. This data was obtained from National Jewish Medical and Research Center, Applied Medical Informatics Incorporated, and Allied Signal's CBDPP plan submitted under DOE N 440.1. The cost of annual evaluations include $373 in medical procedure-related costs. Included among the procedures are a complete physical examination ($140) and a Be-LPT ($231). Assuming sites use a blood Be-LPT, the blood sample must be shipped to a laboratory within 24 hours for analysis. DOE assumes that for annual medical evaluations, four samples can be shipped at once. Thus, the $7 shipment cost can be divided by four to get a sample shipment cost of $1.75.

Also included in the cost of performing annual medical evaluations will be the labor cost for workers, clerical staff, and physicians. DOE assumes that the annual medical evaluation will require 1.5 hours for both workers and physicians and 5 minutes of clerical labor time. Thus, the labor cost for annual medical evaluations can be estimated as [1.5 hours*(physician hourly labor cost + worker hourly labor cost) + 0.083 hours*(clerical hourly labor cost)]. The physician hourly labor cost is $59.35 and the clerical hourly labor cost is $11.50. The hourly labor cost for workers varies by site and is presented in Table 3-1 of Chapter 3 for each site. Table A-4 summarizes the labor costs for annual medical evaluations.

Table A-4 also summarizes the cost of conducting an annual evaluation for each site (i.e., the site-specific unit cost for annual medical evaluations). The unit cost ranged from $532 to $675 with a weighted average of $563.[51]

[51] The weighted average was calculated using the number of workers eligible for medical surveillance under the rule as weights (see Table 3-13 of Chapter 3).

Table A-3
Non-Labor Unit Costs Associated with a Periodic Medical Evaluation

Cost Element	Unit Cost	Comment
Complete physical examination	$140.00	Performed on-site
Be-LPT	$231.00	Blood is drawn during the physical examination
Sample shipment	$1.75	One quarter of the $7 sample shipment cost
Total [a]	**$372.75**	**-**

Source: Allied Signal (1997), National Jewish Medical and research Center (Smythe, 1998), Federal Express (1998).

Table A-4
Estimated Unit Costs for Annual Medical Evaluations

Site	Medical Test and Procedures Cost [a]	Labor Cost [b]	Total Cost Per Annual Evaluation [c]
Argonne-East	$373	$166	$540
Argonne-West	$373	$301	$675
ETTP (K-25)	$373	$158	$532
Hanford	$373	$188	$562
Kansas City	$373	$159	$533
LANL	$373	$196	$570
LBL	$373	$258	$631
LLNL	$373	$188	$562
Mound	$373	$211	$584
ORNL	$373	$168	$542
Pantex	$373	$188	$562
Stanford	$373	$188	$562
Rocky Flats	$373	$193	$566
Y-12	$373	$165	$538

Note: Estimates may contain some rounding error.
[a] Table A-3.
[b] Calculated as [1.5 hours*($59.35 + worker hourly labor cost) + 0.083 hours*($11.50)] for each site. The hourly labor cost for workers is taken from Table 3-1 in Chapter 3.
[c] Sum of medical test and procedures cost and labor cost.

A.2.3 Referral Evaluations

Workers that exhibit sign and symptoms of CBD or beryllium sensitization may be referred for further medical procedures and tests. These procedures and tests will most likely be conducted by specialists in the field of beryllium-related health effects. DOE contacted NJMRC to determine the procedures that would be involved in a referral evaluation.

Table A-5 provides estimates of the costs associated with non-labor requirements for referral evaluations. This data was obtained from National Jewish Medical and Research Center, Applied Medical Informatics Incorporated, and Allied Signal's CBDPP plan submitted under DOE N 440.1. The cost of medical tests and procedures associated with referral evaluations total $6,427. Included among the procedures and tests are a second Be-LPT ($231), bronschoscopy with lung biopsy ($3,441), tolerance testing ($1,500), comprehensive pulmonary testing ($750), serial chest radiographs ($225), and a complete physical examination ($280). No shipment cost will be required for the blood sample since DOE assumes that the referred worker will travel to NJMRC (or another qualified institution) for the referral.

In addition to the tests and procedures, travel costs will also be incurred. The rule requires that referral evaluations be conducted by physicians knowledgeable and experienced in the diagnosis and treatment of CBD. DOE assumes that this will require travel to the National Jewish Medical and Research Center in Denver, CO (or another qualified institution). Travel costs include round-trip airfare ($810), 2-night hotel stay at $66 per night ($132), and three days of expenses at $50 per day ($150) for a total of $1,092.

Also included in the cost of performing referral evaluations will be the labor cost for workers to go to the referral. DOE assumes that each referral will require three days of travel for each referred worker. Thus, each worker will be compensated for 24 hours worth of labor time away from work (8 hours per day time 3 days). The cost of this labor time is calculated in Table A-6 by multiplying 24 hours by the hourly labor cost for workers from Table 3-1 in Chapter 3.

Table A-4 also summarizes the cost of conducting an referral evaluation at each site (i.e., the site-specific unit cost for referral medical evaluations). The unit cost ranged from $8,622 to $10,917 with a weighted average of $9,120.[52]

[52] The weighted average was calculated using the number of workers eligible for medical surveillance under the rule as weights (see Table 3-13 of Chapter 3).

Table A-5
Unit Costs of Test and Procedures for Medically Indicated Referrals

Cost Element	Unit Cost	Comment
Second Be-LPT	$231[a]	Always performed to ensure accuracy
Bronchoscopy with biopsy	$3,441	May vary depending on patient's needs and consent
Tolerance testing	$1,500	-
Comprehensive pulmonary testing	$750	-
Serial chest radiographs	$225	-
Visit with a qualified physician	$280[b]	-
Total [d]	**$6,427**	**-**

Source: Allied Signal (1997), National Jewish Medical and Research Center (Smythe, 1998), Internet Travel Network (ITN) (1998).
[a] Since the Be-LPT is conducted at the National Jewish Medical and Research Center, no additional costs are incurred for blood sample shipment.
[b] The cost of a visit with a qualified physician was unavailable at this time. Thus, the figure is obtained by assigning a 100 percent markup over the $140 cost of a complete physical examination supplied by Allied Signal (1997).
[c] The airfare is computed based on the average of nonrefundable coach class fares between Albuquerque, NM and Denver, CO, Knoxville, TN and Denver, CO, and San Jose, CA and Denver, CO. The choice of Denver, CO as a destination is based on the fact that National Jewish Medical and Research Center is located there. The cost of lodging is based on an average of rates obtained from 11 different hotels that are all located within a 25-mile radius of Denver, CO. Finally, $50 per day is allocated as business allowance for meals and other miscellaneous expenses. It should be noted that the actual amount might vary from one DOE contractor to another depending upon the individual contractor's policies.

Table A-6
Estimated Unit Costs for Referral Medical Evaluations

Site	Medical Test and Procedures Cost [a]	Travel-Related Costs [b]	Labor Cost [c]	Total Cost Per Referral Evaluation [d]
Argonne-East	$6,427	$1,092	$1,233	$8,752
Argonne-West	$6,427	$1,092	$3,398	$10,917
ETTP (K-25)	$6,427	$1,092	$1,103	$8,622
Hanford	$6,427	$1,092	$1,581	$9,100
Kansas City	$6,427	$1,092	$1,122	$8,641
LANL	$6,427	$1,092	$1,713	$9,232
LBL	$6,427	$1,092	$2,700	$10,219
LLNL	$6,427	$1,092	$1,581	$9,100
Mound	$6,427	$1,092	$1,945	$9,464
ORNL	$6,427	$1,092	$1,265	$8,784
Pantex	$6,427	$1,092	$1,581	$9,100
Stanford	$6,427	$1,092	$1,581	$9,100
Rocky Flats	$6,427	$1,092	$1,658	$9,177
Y-12	$6,427	$1,092	$1,210	$8,729

Note: Estimates may contain some rounding error.
[a] Table A-5.
[b] See discussion in text.
[c] Calculated as [24 hours*(worker hourly labor cost)] for each site. The hourly labor cost for workers is taken from Table 3-1 in Chapter 3.
[d] Sum of medical test and procedures cost, the travel-related cost, and the labor cost.

A.2.4 Information Provided to the Physician

Under the CBDPP rule, DOE contractors are required to provide the examining physician with a copy of the rule, a description of the covered worker's duties, records of the covered worker's beryllium exposure, a description of personal and respiratory protective equipment in current or anticipated use, and relevant information from previous medical examinations of the covered worker. DOE assumes that much of this information can be provided in the development phase of the medical surveillance program. DOE N 440.1 contains a similar requirement, thus the start-up costs are assumed to be attributable to the Notice. Although some information may need to be supplied on a recurring basis, affected facilities are required to generate much of this information under the performance feedback (850.40) section of the CBDPP rule. Therefore, DOE assumes that the cost of communicating these records to the Site Occupational Medical Director will be minimal.

A.2.5 Physician's Written Report (850.33 (j))

The CBDPP rule stipulates that all DOE contractors shall furnish each covered worker with a physician's written report containing the results of all performed tests and procedures as well as an explanation of any abnormal findings and any recommendations for additional testing. DOE assumes that the examining physician will be able to note his or her findings pertaining to the examined worker during the course of the medical evaluation. The report can then be compiled by a clerical worker to be presented to the worker. The labor costs associated with this provision for both the physician and the clerical worker are already incorporated into the costs of medical evaluations estimated in Sections B.2.1 to B.2.3.