Costs of Regulatory Compliance: Categories and Estimating Techniques

October 1978

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COSTS OF REGULATORY COMPLIANCE:
CATEGORIES AND ESTIMATING TECHNIQUES

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SUMMARY

Use of the categorization scheme and cost estimating approaches presented in this report can make cost estimates of regulation required compliance activities of value to policy makers. The report describes a uniform assessment framework that when used would assure that cost studies are generated on an equivalent basis. Such normalization would make comparisons of different compliance activity cost estimates more meaningful, thus enabling the relative merits of different regulatory options to be more effectively judged.

The framework establishes uniform cost reporting accounts and cost estimating approaches for use in assessing the costs of complying with regulatory actions. The framework was specifically developed for use in a current study at Pacific Northwest Laboratory. However, use of the procedures for other applications is also appropriate.

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INTRODUCTION

Accurate estimates of the costs of regulatory compliance activities are needed if quality is expected in regulatory policy. The estimated costs of complying with regulations are of primary concern when deciding if and when regulations should be adopted. If compliance activity cost estimates can be generated with reasonable accuracy, then policy decisions can be performed and regulations set forth with the assurance that the required action is good policy.

Past estimates of the costs of complying with regulatory actions have often been inaccurate. This inaccuracy has had two sources: 1) inconsistency in the designation of what costs to consider as regulatory compliance costs and 2) differences in cost estimating approaches and the treatment of secondary and indirect costs (i.e., cost escalation, interest during construction, taxes, etc.). This inaccuracy has resulted in cost estimates that are not comparable with one another, making them of limited value to policy makers.

PURPOSE AND SCOPE

The purpose of this report is to describe a set of guidelines currently being used at Pacific Northwest Laboratory^(a) to help in assessing and estimating the historical costs of complying with regulatory actions. Adherence to the guidelines will ensure that estimates are generated on a uniform basis. Standard cost estimating guidelines, applicability of the guidelines, and costs that should be considered as regulatory compliance activity costs are described in the report.

The procedures described in this document were developed from examination of past regulatory compliance activities, past regulatory compliance cost estimates, and general cost estimating literature. Study of the few regulatory compliance activity cost estimates available and discussions with regulatory agencies, utilities, architect/engineers, and constructors ensure that the report's content is accurate and current.

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The study was undertaken as part of an overall effort to determine the costs to the nuclear industry of complying with the changing radiation standards. The overall effort has as its objective:

- Determine capital and operating cost changes for nuclear fuel cycle facilities resulting from changes in radiation standards from 1965 to 1977.
- Explore the extent to which the forecasted costs of compliance made by regulatory agencies accurately predict actual costs of compliance.

Radiation standards refer to regulations, guides and standards promulgated since 1965 relating to the following:

- the routine control of release of radionuclides in the effluent stream, and
- routine occupational exposure.

The primary concern was with those standards promulgated by the Environmental Protection Agency (EPA) and the Nuclear Regulatory Commission (NRC). Standards from other bodies that are judged typical and important are considered.

The Department of Energy funded the effort initially through what is now the Division of Policy Analysis (DPA). The effort was completed under the direction of the Division of Technology Assessments (DTA). Participants in the effort were Pacific Northwest Laboratory (PNL) and Battelle Human Affairs Research Center (HARC).

ORGANIZATION

The report is organized as a step-by-step evaluation manual for use in 1) understanding regulation-required change and 2) understanding the effects of compliance (i.e., change) on costs. Initially, the report describes a conceptual approach to understanding compliance-related activities and the costs associated with such activities. In later sections, general cost estimating approaches and considerations in the application of these approaches are described. The final section of the report describes specific compliance activity categories (i.e., cost reporting centers), cost estimating guidelines, and the applicability of such guidelines. Such a "cookbook"-like approach should: 1) increase reader understanding of the procedures, 2) ensure consistency in the application of the procedures, and 3) provide the user with a source in which information can be quickly referenced.

DISCUSSION

Regulatory compliance activities are events or efforts needed to satisfy the requirements of regulatory actions. These events or efforts include installation of additional equipment, increased operating activities, and increased effluent monitoring and reporting activities. Regulatory actions consist of regulations, guides, and standards promulgated by the various regulatory agencies.

NEED FOR COST ESTIMATING STANDARDIZATION

The evaluation of proposed regulatory changes necessitates that expected costs of change (i.e. compliance) be known. The quality of regulatory decisions can be improved if these expected costs are accurately known for all alternative decision policies.

Past estimates of the costs of regulatory compliance have often been misleading or incorrect. A major problem has been that various cost estimates are noncomparable; there have been two basic causes for the estimates being noncomparable: incomplete estimates and inaccurate estimates.

Incomplete estimates have resulted from a lack of experience, standardization, and perception in estimating these costs. Regulatory actions have required a wide variety of compliance efforts, and there has been no group acceptance of a single estimating format. This lack of standardization has led to differences among estimators as to what types of costs constitute a cost of compliance, causing estimates to be incomplete and noncomparable.

Inaccuracy has resulted primarily from the use of aggregate cost accounts (categories) rather than smaller, more detailed cost accounts. In turn, the utilization of aggregate accounts has led to the use of aggregate category estimating techniques. This has resulted in a lack of ability to fine tune or tailor an estimate specifically to a particular compliance situation. By identifying and costing compliance using a greater number of cost accounts, the estimator is given the capability to fine tune the estimate.

To eliminate these causes of noncomparable and incomplete estimates, a standard set of detailed cost categories must be designated and accepted by the estimating community. Compliance related cost estimating approaches can then be established for each of the categories. These efforts will result in consistently accurate estimates of compliance related costs.

Regulatory compliance most often necessitates that change occur. To effect this change, compliance activities must be undertaken. In this report, these activities can be identified and defined depending upon their time of occurrence. These distinct chronological groupings of change activities, will be termed "phases of compliance change".

The regulatory compliance activity cost reporting categories identified in this report are shown in Table 1. The phases of compliance change corresponding to each of these cost reporting categories are also indicated.

Most regulatory requirements are in the form of engineering standards requiring similar actions for every situation. Thus, uniform cost estimating rules may seem to be appropriate. However, site and situation factors may cause wide variation in required actions resulting in considerable differences in compliance costs. Detailed categorization provides a means of identifying which costs depend on situational factors and the possible effects on total costs. Such an estimating format may aid in developing more flexible and hence less costly standards.

PHASES OF COMPLIANCE CHANGE

The six chronological phases of compliance change identified in this report are: 1) awareness of the need for change; 2) identifying appropriate change; 3) planning for change; 4) implementing and instituting change; 5) inspection, evaluation and modification of change; and 6) continued operation with change on-line.

The following sections briefly describe these phases of change and particular kinds of costs associated with each phase.

Awareness of a Need for Change

The first phase recognizes that there are time and activity costs associated with becoming aware of the need for change. These time-related costs

TABLE 1. Timing of Regulatory Compliance Costs

PHASES OF CHANGE		COST CATEGORIES																										
		DIRECT	DIRECT ALTERATION	DIRECT ACCESS	REPLACE PART ALLOWANCE	DECOMMISSIONING	INDIRECT	ENGINEERING	OWNER	AFDC	ESCALATION	CONTINGENCY	FEE	SECURITY	RADIATION CONDITION	GENERAL OPERATING & MAINTENANCE	ADMINISTRATIVE/LEGAL	SELECTION/PLACEMENT OF PERSONNEL	TRAINING OF PERSONNEL	FUEL	FACILITY SHUTDOWN/RESTART	SECONDARY	NON-QUANTIFIABLE	DELAY	QUALITY ASSURANCE/QUALITY CONTROL	FINAL TESTING	MONITORING/REPORTING	
I.	AWARENESS OF NEED FOR CHANGE																											
II.	IDENTIFICATION OF APPROPRIATE CHANGE																											
III.	PLANNING FOR CHANGE																											
IV.	IMPLEMENTING CHANGE																											
V.	INSPECTION, EVALUATION, MODIFICATION OF CHANGE																											
VI.	CONTINUED OPERATION WITH CHANGE ON-LINE																											

may be highly variable across change instances, particularly when change is externally imposed. Compliance events reflect the need to verify, communicate, understand, and possibly challenge the need for change. When a regulatory action is promulgated it may dictate a change and parties must respond to determine the implications of the new policy on their own operations. The parties must know that a change is needed, why it is needed, and what conditions will define the options available for making the change. The types of costs incurred during this phase are largely fixed expenses (i.e. operating, legal, and engineering) required in monitoring, interpreting, and evaluating outside events and communicating the effects of these events back to those external parties calling for the change.

Identification of Appropriate Change

The task of identifying appropriate change involves examining the options available for responding to the mandated change (i.e., compliance requirements). If the imposed change specifies a certain end-product or state, parties may develop or capitalize on the availability of many alternative compliance events to produce that end-state. The question in this phase is, what are the most appropriate compliance events to undertake? It is at this point that consideration of compliance event costs begins receiving detailed attention. This phase is likely to produce substantial generation and evaluation of alternative event strategies before selecting a particular compliance approach. Costs incurred during this phase are for staff operating time and occasionally consulting fees for evaluating alternatives. If the change must be implemented by some near term deadline, then the cost of staff operating time must include the cost of delay on the project that the staff was working on.

Planning for Change

Once a change strategy has been determined, compliance activities turn to planning for the change, or advance preparations for changing equipment, people, or work processes. Any compliance approach is likely to have several elements, and these elements must be specified and integrated. A major component of this phase is the communication of needs and plans among key people involved in the compliance activities. Contracting costs and planning costs as well as staff operating costs and delay costs of current projects comprise the principal expenses incurred during planning for change.

Implementation/Institution of Change

The implementation phase involves the installation and integrated putting into operation of the new procedures and resources needed to institute the change (i.e., comply). The costs incurred during this phase of change consist primarily of direct activity costs such as purchase, installation, supervision, and operating costs. Most compliance costs are incurred during this change phase.

Inspection, Evaluation, Modification, and Compliance Demonstration

Prior to long-term operation with change in place, there will be periods of review and modification. Time and resources must be spent inspecting the changed procedures and their outcomes, evaluating whether the change has resulted in satisfactory compliance, and modifying the change to achieve compliance if it has not. Costs incurred during this phase are primarily for large fixed expenses such as operating staff, legal, and engineering costs required in the routine inspection of compliance required actions.

Continued Operation with Change On-Line

Long-term operation with change on-line is the final phase. After compliance has been initially demonstrated, operations are continued with compliance effort levels maintained to assure continued compliance. Feedback from monitoring operations is used to insure that compliance levels are maintained. Staff operating costs are the principal costs incurred during this phase of change.

GENERIC ESTIMATING APPROACHES

To better decide the relative merits of contemplated regulatory actions, the policy maker must know the costs of such actions. A complete description and evaluation of cost-estimation techniques that could be employed is a complex task, and is beyond the scope of this paper. However, this section will identify the most common general approaches to cost estimation and comment on their strengths and limitations.

A cost estimate can vary from a gross overview to a detailed estimate prepared from complete specifications. The accuracy desired in the estimate and

ultimate use of the estimate influence the approach or combination of approaches employed. In general, the time and effort spent in preparation (the cost of the estimate) depend on the accuracy desired; this in turn is a function of the ultimate use or purpose of the estimate. Similarly the type, availability, and accuracy of inputs to the estimating techniques should be considered when choosing an appropriate approach. For example, it would be inappropriate to apply the engineering estimating approach in the assessment of costs resulting from changes in organizational structure. These types of costs are subjectively evaluated and do not lend themselves to quantification or a breakdown into elemental costs.

Approaches are often effectively used in combination with one another. One approach may be applied in a "first pass" to indicate those costs or cost categories dominating the total estimate and deserving the most attention. These costs if drastically misjudged can impact significantly on the magnitude of the total estimate. A second approach may then be applied to these dominant categories in an attempt to refine and improve the accuracy of the cost estimate for them.⁽¹⁾

As a first step in estimating costs, a categorization of costs should be made. Categorization provides 1) a useful conceptual framework for viewing the costs, 2) a checklist of the types of costs that should be considered, and 3) a guiding comment on the mechanics for the correct treatment of these costs.

These estimating approaches can be applied to the cost categories at virtually any level of categorical breakdown. For example, the quantified expert-opinion approach may be used to estimate the administrative and legal costs associated with the compliance activities while the more highly structured engineering approach is used for aggregating labor and equipment costs for such activities. As another example, the analogy approach could be used to estimate total project cost, total labor cost, labor cost for each phase, or labor cost for each labor category, each based on applicable data from a similar past experience.

As is evident from the description of these approaches, recommendation of an appropriate method for estimating the cost of a compliance change requires

consideration of a number of the characteristics of the change. The availability of historical cost data for similar compliance changes, the uniqueness or similarity of the change to past changes, the degree of accuracy sought, and the cost of estimation are all determinants of the "best" estimating procedure to employ. Because compliance change is such an expansive concept no single estimating procedure can be recommended as being definitively appropriate to all change situations.

The advantages and disadvantages of using each of the general estimating approaches are shown in Table 2. The four general estimating approaches; engineering, analogy, modeling, and quantified expert-opinion are described in the following sections.

Engineering Approach

The engineering or "grass roots" approach utilizes a work breakdown structure (WBS) -- a hierarchical tree of work elements which comprise the item to be estimated. The procedure is to estimate (from engineering specifications, rates, standards and appropriate cost handbooks) the hardware, labor and a portion of the overhead costs associated with each element and sum these to yield a total cost.

The engineering approach is predicated on a detailed categorical breakdown of costs. Hence, it is particularly suited for estimates of capital or labor intensive projects which are amenable to a systems analysis approach and for which elemental cost data are available. The cost categorization scheme identified in this paper provides a workable basis for estimation by this approach. Elemental cost data are available for the activities of the lowest WBS level.⁽²⁾

This approach is not appropriate if the design and configuration parameters of hardware, manpower requirements, time and location of activities, and documentation required are insufficiently defined. Thus the applicability of the engineering approach is largely a function of specific features of projected activities.⁽³⁾

An advantage of the engineering technique is that it provides a detailed itemization of costs by cost elements. This refinement is useful in sensitivity analysis of costs to determine which cost items have the most profound impact

TABLE 2. Advantages and Disadvantages of Generic Estimating Approaches

GENERIC ESTIMATING APPROACH	ADVANTAGES	DISADVANTAGES
ENGINEERING	<ol style="list-style-type: none"> 1. HIGH ACCURACY 2. SENSITIVITY ANALYSIS EASILY PERFORMED 3. ESTIMATE COMPARISONS EASILY PERFORMED 4. COSTS INCLUDED & EXCLUDED HIGHLY VISIBLE 	<ol style="list-style-type: none"> 1. HIGH COST 2. REQUIRES CONSIDERABLE TIME 3. NOT APPROPRIATE FOR SOME COST CATEGORIES, ADMINISTRATIVE & LEGAL
ANALOGY	<ol style="list-style-type: none"> 1. QUICKLY PERFORMED 2. LOW COST 3. DIFFICULT-TO-ESTIMATE COSTS ESTIMABLE 	<ol style="list-style-type: none"> 1. ACCURACY DEPENDS ON DEGREE OF SIMILARITY 2. DIFFICULT TO ASSESS ESTIMATING BOUNDARIES (i.e., COSTS INCLUDED IN THE ANALOGY)
MODELING	<ol style="list-style-type: none"> 1. QUICKLY PERFORMED, HIGH ACCURACY, LOW COST ONCE BASE MODEL ESTABLISHED 2. EASILY TRANSFERABLE FROM ONE SITUATION TO ANOTHER 3. WITHIN LIMITS, EXTRAPOLATION IS POSSIBLE 	<ol style="list-style-type: none"> 1. LARGE & ACCURATE DATA BASE REQUIRED 2. STATISTICAL PROBLEMS 3. ASSUMES CONTINUOUS, DIFFERENTIABLE FUNCTION 4. REQUIRES LARGE EFFORT TO ESTABLISH 5. TECHNICAL AND MARKET MAY QUICKLY RENDER MODELS INAPPLICABLE
EXPERT OPINION	<ol style="list-style-type: none"> 1. EASILY APPLIED TO NEW SITUATIONS 2. LOW COST 3. DIFFICULT-TO-ESTIMATE (INTANGIBLE) COSTS ESTIMABLE 	<ol style="list-style-type: none"> 1. REQUIRES PARTICIPANT COOPERATION 2. REQUIRES PARTICIPANT DETERMINATION 3. POSSIBLE INTRODUCTION OF BIAS BY PARTICIPANTS

on the total project cost and thus warrant the focus of any cost-reduction efforts. A detailed itemization of costs also facilitates an element-by-element analysis of the accuracy of the estimate after the actual cost is incurred. Such efforts can focus attention on specific cost areas where estimating procedures could be improved or modified.

Shortcomings of the engineering approach are:

- Its relatively high cost
- Considerable time is required in preparation of an estimate
- Many cost items are not amenable to an engineering estimate when the estimate is based on direct man-hours or catalog price quotations.

As with any method of estimation, a decision to use the engineering approach should be made only after a consideration of the features of projected change, activities, the cost of estimation, the accuracy desired, and the time element.⁽²⁾

Analogy Approach

The estimation by analogy approach compares the cost of a new activity to the cost of a similar activity that has already been accomplished and for which cost data are available. The previously developed activity becomes the baseline against which analogies are drawn and judgments regarding costs are extrapolated. The activity criteria used in analogous comparison include type, risk, impact, and scale.

One potential shortcoming of this method is the obvious requirement for the existence of a "similar" previously completed activity complete with cost data. Because regulatory requirements often comprise the threshold of the state of knowledge and experience in an area or technology, they often preclude the existence of a past change with a sufficient degree of similarity. As a result, the analogy approach may not be applicable to regulatory compliance changes. In any event, this method requires a subjective determination of the degree of similarity between the proposed and past activities. This determination translates to a judgment regarding the degree to which estimated costs should differ from those of the baseline activity costs. The potential accuracy of this method hinges largely on the degree of similarity.⁽⁴⁾

The primary advantages of this method are its relatively low cost and the speed with which a cost estimate can be derived. Although the analogy approach does not require a categorical breakdown of costs, some categorization scheme is helpful in conceptualizing and assessing the degree of similarity between projects.

Modeling Approach

Cost modeling or parametric estimation is a statistical procedure requiring a large compiled data base of activity costs. Cost is dependent on the technical characteristics (the independent explanatory variables) of the activity to be estimated. This relationship is expressed mathematically as a cost-estimating equation obtained through regression analysis of the compiled data base. However, the estimating relationships are only as good as the data base from which they are drawn.

The major shortcoming of cost modeling is its dependence on a large data base of similar activities. For regulatory compliance change, such a collection of data may not be available. In many situations, the uniqueness and dynamics of the kinds of compliance change rapidly render historical data obsolete and of little estimative value. This is particularly evident in areas with rapidly changing technologies.^(4,5) In addition the cost and time require to formulate a model and compile a data base are considerable and justified only if the model is projected to be frequently used or applicable well into the future. Lastly, these models are based on the assumption that costs are reasonably described by a continuous and differentiable function of the independent variables. This becomes a problem when the range for which the function is valid is not observed. For example, costs of reducing air emissions can be represented by a function within a range sufficient to include adding more filters. However, when the emission level requires the addition of an entirely different control method, the model will be invalid.

Quantified Expert-Opinion Approach

The quantified expert-opinion (QEO) approach is a combination of the analogy approach and the Delphi process of polling expert opinion. Although each of the previously described approaches has certain advantages, they are inadequate

for estimating costs of unique activities or activities for which old ways of operation or technology no longer apply. It is in these situations that the QEO approach may be most applicable.

The Delphi process is a subjective expert-oracle approach to estimation. A group of "authorities" knowledgeable and experienced in planning for and implementing the activity (or similar activities) to be estimated provide their "expert" opinions as to what an activity will cost. A typical Delphi process operates as follows: Each participant receives and completes a questionnaire. The identities of participants are kept confidential and not given other participants. The results of the questionnaires are then analyzed and forwarded to all participants so that answers can be compared. The participants at the extremes are asked to write short explanations of their positions, and these are relayed back to all participants unsigned. Each participant then has the opportunity to change their position. The process is repeated until opinion stabilizes. Finally, the responses are statistically analyzed and aggregated to yield a group response. For cost estimating, the expert opinions are made relative to an activity which has been chosen as a baseline.

The Delphi technique is a systematic attempt to best utilize group judgment and expertise in areas where knowledge is incomplete. The basic premise being that "many heads are better than one" and that a group will be more objective if there is no direct confrontation.^(4,6,7)

This method is particularly applicable to regulatory compliance changes for which a significant portion of the costs are not tangible "hard" costs. It also has the advantage of producing a relatively accurate estimate at a moderate cost in a short time period.

ESTIMATING CONSIDERATIONS

The development of any regulatory compliance cost estimate necessitates that many not so obvious estimating considerations be acknowledged and included in the costing approach. The following sections describe four such estimating considerations: 1) timing of costs, 2) inflation, 3) uncertainty, and 4) taxes.

Timing of Costs

Money values change with time, and a cost of "X" dollars incurred a year from now is not equivalent to a cost of "X" dollars incurred today. Thus the different activity cost estimates incurred at various points in the time continuum of the total compliance change are not strictly additive; they do not simply aggregate to a total cost figure for the change. To arrive at a meaningful single cost figure for the total compliance change, the correct procedure is to discount (at an appropriate discount rate) all the activity cost estimates. These "present values" can then be added to yield a single cost figure for the total compliance change. (5,8-10)

Inflation

Independent of the requirement to discount activity cost estimates to a present value, cost estimates must reflect costs when the actual cash outflow occurs. In other words, the relevant cost of a resource is not the current price of procurement but the prospective price when that resource is required. This consideration is particularly relevant when cost estimates are based on current market prices for material, labor, and equipment. Yet some of those costs will not be incurred until many years in the future. For cost estimating purposes, these dollar amounts must be revised to reflect the cost in the future when the cost outflow for these activities is expected to occur.

Uncertainty of Estimation

Any cost estimate presented as a discrete value, while it may convey the impression of a precise, official, and accurate quantity, is at best misleading. A better approach for stating estimates is to present probability distributions of the estimate, or "worst", "best" and "most likely" estimates with the associated probabilities of their occurrence. These estimated distributions can then be aggregated for all cost activities (using various statistical techniques, the most common of which is Monte Carlo simulation), to a composite total cost distribution. The composite provides the user of the estimate with a cost estimate indicating the "most likely" expected total cost and the variability of that expected cost, rather than a single seemingly authoritative cost figure.

Uncertainty enters the estimating procedure from two dimensions--magnitude and time. Uncertainties in the magnitude of cost estimates are inherent in the concept of estimation and include inflation, technological, economic, tax policy, and labor changes.

Estimates of when costs are expected to be incurred can also be in error. Uncertainty as to the timing of the costs may stem from delays due to unanticipated environmental impact studies and delays due to extended regulatory hearings. Such delays also affect the timing of cash outflows and thereby the process of discounting component costs to present value. Timing uncertainties also create the additional burden of unanticipated "carrying" costs, associated with maintaining the project in a "holding" status through the interim of the delay.

The relative uncertainty in the magnitude of estimates can be indicated using ranges of estimated costs instead of discrete estimates. Ideally, such estimates would be accompanied by subjective probabilities associated with each range. Time-related uncertainty is more difficult to handle. The "holding cost" component may be incorporated as a contingency cost (a percentage of total cost of the project or phase based on experience with past projects) or as an estimate of the duration of the delay times an estimate of the costs per period of delay. The effect on the discounting process is virtually impossible to determine as it would require an estimate of not only the duration of the delay but also when the delay would occur.

Tax Considerations

None of the cost estimate procedures described so far include tax considerations. However, the costs of compliance change are monetary expenses and do result in an incremental reduction in tax obligations. Pre-tax cost estimates are not indicative of the true economic costs of regulatory compliance change. The "true cost" rightfully associated with the change should be the after-tax costs.⁽⁹⁾ After-tax costs are a better representation of the change in "economic well being" of an organization attributable to the imposed change. Tax considerations usually reduce net compliance costs, since compliance activity expenses are tax deductible. Some compliance related capital equipment will also qualify for investment tax credits.

COST REPORTING CATEGORIES AND ESTIMATING GUIDELINES

Categories and guidelines used in estimating regulatory compliance costs must be very carefully chosen. Some are frequently used and commonly accepted by the estimating community; others are basically conceptual and require adequate caution in their application.

Compliance costs for a given regulation and facility will vary, depending on whether compliance occurs through 'backfitting' or before facility construction is complete. 'Backfitting' for compliance occurs after facility construction is complete. For most categories, the costs of compliance in this situation are easily estimated; the compliance efforts are the only activities occurring and all activity costs can be attributed to compliance efforts. Compliance can also begin concurrent with facility construction. The costs of compliance in this situation are not as easily estimated. Compliance required efforts occur simultaneously with facility construction efforts and often it is difficult to attribute a particular cost that is incurred to only one of the two efforts.

The detailed cost categories established in this paper are identified and described in the following sections. Estimating guidelines for each cost category are also discussed. These guidelines supplement the generic estimating approaches previously described. The techniques should be utilized to critique the cost figures generated from the use of the generic approaches. The five primary account categories are 1) direct costs, 2) indirect costs, 3) operating costs, 4) secondary costs, and 5) compliance assessment costs. Each one of these five primary categories are broken down into subcategories and described in the following sections. A complete listing of all categories and subcategories is presented in Table 3.

I. Direct Costs

Costs that are incurred as a direct result of compliance activities and involve equipment installation are categorized under this heading. These expenses are easily determined, resulting in high levels of accuracy in estimated costs. Direct costs are one-time expenses and should be capitalized.

TABLE 3. Cost Reporting Categories of Regulatory Compliance Activities

Account	Category Title
I	Direct
I.A	Direct
I.B	Direct alteration
I.C	Direct access
I.D	Replacement part allowance
I.E	Decommissioning
II	Indirect
II.A	Indirect
II.B	Engineering
II.C	Owner
II.D	AFDC
II.E	Escalation
II.F	Contingency
II.G	Fee
II.H	Security
II.I	Radiation condition
III	Operating
III.A	General operating and maintenance
III.B	Administrative and legal
III.C	Selection/placement of personnel
III.D	Training of personnel
III.E	Fuel
III.F	Facility shutdown/restart
IV	Secondary
IV.A	Secondary
IV.B	Non-quantifiable
IV.C	Delay
V	Compliance Assessment
V.A	Quality assurance/quality control
V.B	Final testing
V.C	Monitoring/reporting

Estimates of direct costs are quite specific to the regulation and facility, and require a detailed examination of projected compliance activities. Since the range of actions necessary to comply with different regulations is so great, no short-cut or simplified techniques are applicable to the estimating problem. For this reason, a rigorous look at compliance requirements is mandatory in estimating direct cost category expenses. The five direct cost categorizations are a) Direct, b) Direct Alteration, c) Direct Access, d) Replacement Parts Allowance, and e) Decommissioning.

I.A. Direct

This category includes expenses for basic equipment, materials, labor, and land resulting directly from compliance requirements. Costs incurred in this category are primarily expenses for the purchase and installation of major facility components required in compliance. Such components are determined directly from examination of engineering drawings and specifications. Costs include expenses for process equipment, structural parts, additional land, installation labor, and major construction equipment.

An example of direct category expenses can be seen in the compliance cost estimate for the Radwaste System Modification at Millstone Unit #2.⁽¹¹⁾ When the "as low as practicable" (ALAP) legislation was applied to radiation standard 10 CFR 20, compliance to the legislation necessitated changes in the initial Radwaste System Plan. Direct cost category expenses resulting from compliance activities include costs for additional waste holdup tanks, a boron evaporator, and a miscellaneous waste evaporator. Also estimated are costs for radwaste drumming facilities, steam jet air ejector modifications, electrical support equipment, and instrumentation/controllers. Estimated costs for engineering are not included in the category.

Direct costs of compliance requiring equipment installation will differ depending if compliance requires backfitting or not. In a backfit situation, the costs of removing facility components made obsolete by compliance less any salvage value of the removed components are considered a direct cost category expense.

Direct category expenses are usually determined from estimates of material and equipment requirements. Some requirements such as those for large equipment can be estimated exactly, while other requirements such as those for quantities of reinforced concrete or steel can only be approximated. Once all such requirements are known, the purchase costs and installation costs of such components can be determined. The total direct category expense is the summation of purchase costs, installation costs, and any transportation costs that may be incurred.

I.B. Direct Alteration

This category includes basic equipment, material, labor, and land costs that result from permanent alterations in the portion of the facility surrounding the area of direct compliance installation. In other words, expenses resulting from permanent changes required in the surrounding facility components.

Direct alteration category expenses are estimated concurrently with the estimation of direct expenses and also in the same manner. Material and equipment requirements for the permanent alteration of facilities in areas surrounding the direct compliance installation area are estimated. Using engineering drawings and specifications, such quantity requirements can be determined with significant accuracy. These requirements can then be translated into expected costs and used to determine installation costs. As in the direct category calculations, the sum of these expenses is the total direct alteration category cost.

I.C. Direct Access

Included in this category are basic equipment, material, labor, and land costs resulting from temporary alterations in the portion of the facility surrounding the area of direct compliance installation. These expenses result primarily from temporary openings in facility walls required to allow access to installation areas.

Direct access expenses are estimated similarly to other direct costs. Sufficient compliance effort planning will enable the estimator to visualize how compliance required components will be installed, and predict where access to working areas will be required. These access requirements can then be translated into material and labor costs to give total direct access category expenses. This expense will vary significantly depending upon whether or not compliance installation is in a backfit situation.

I.D. Replacement Part Allowance

Equipment, material, and labor costs of major replacement items for compliance required components are included in this category. An inventory of replacement items must be readily accessible in order to quickly make the

facility operational should breakdown occur. For replacement item expenses of greater than \$10,000, the costs should be capitalized and treated as a one-time expense. For replacement item expenses of less than \$10,000, the expense should not be capitalized but treated as a periodic operating cost.⁽¹²⁾

In the Millstone example, it is highly conceivable that the use of numerous waste gas holdup tanks would justify the purchase of a standby replacement tank. If the tank's total installed costs are greater than \$10,000, the cost should be treated as a capital expense and included in the replacement part allowance category.

Replacement part allowance expenses can be estimated with great accuracy. A preliminary investigation of the required components should determine where standby replacement components are needed. Purchase costs of the replacement components, in addition to the installation and transportation costs of the components can be easily estimated.

I.E. Decommissioning

Decommissioning category expenses provide an allowance for the cost of required dismantling and disposing of components at the end of their useful lives. For the most part, in nuclear facilities the costs of these activities are of sufficient magnitude to warrant distinction as an individual cost category. Such activities often involve decommissioning under conditions of potential radiation exposure, thereby increasing activity costs drastically.

Decommissioning costs of the components required in compliance are very difficult to estimate. There are two reasons for this. First, it is difficult to determine just what decommissioning activities will be required; whether a simple interim storage effort, or a far more complex dismantling and disposing effort will be needed. Second, it is difficult to estimate only the cost attributable to compliance-required components. This is difficult because decommissioning of the component will probably be carried out simultaneously with the decommissioning of the remainder of the facility. Under these conditions, it would be difficult to extract only the costs of the decommissioning activities on compliance-required components. Regardless of the complexity in generating accurate decommissioning cost estimates,

some allowance must be estimated to cover such expenses, which will surely be incurred. Such an allowance can only be estimated after a detailed examination of the facility design and expected decommissioning procedures.

II. Indirect Costs

Costs of direct cost category assistance activities (i.e. engineering, supervision, etc.) and time-related expenses (i.e. escalation and interest during construction) are included in the indirect cost category. These expenses are generally estimated as a percentage of the total direct cost. All indirect cost category expenses are one-time expenses and should be capitalized.

Indirect cost category expenses depend on the compliance activity. However, there are some standard estimating rules available which can simplify the estimator's job. Estimates of indirect costs for conventional construction are commonly determined by factoring (i.e., calculated as a percentage of direct category expenses). Yet in the case of installation required by compliance, factors may vary tenfold. Therefore, a rigorous examination of the procedures necessary for the installation is mandatory before indirect cost category percentages can be determined.

A survey of cost estimating groups was conducted to 1) determine the magnitudes of such percentages, and 2) determine the differences in the magnitudes of the percentages between estimating groups. Three estimating departments of major architect-engineers and architect-constructors were utilized in the survey. Requested from the estimators were the indirect cost percentages they would apply to the direct cost estimate for a specific regulation given them.

The specific regulation was a proposed NRC safety standard requiring increased capabilities of the overhead crane handling system.⁽¹³⁾ The hypothetical scenario assumed compliance performance was completed before facility construction was finished. The facility was of LWR design, labor was of average productivity, and the constructor was not the engineer. Results of the survey are shown in Table 4. All participants stressed that the percentages were applicable only to the given regulation and application elsewhere would be improper.

TABLE 4. Estimators Survey-Indirect Category Cost Estimating Percentages^(a)

	Category					
	Indirect	Engineering	Contingency	Fee	QA/QC	Final Testing
Estimator Participant #1	20-40%	--	--	--	--	--
Estimator Participant #2	5-10%	8-12%	10-20%	--	Included in indirect	2-5%
Estimator Participant #3 ^(b)	20-30%	9%	15%	3%	Included in engineering	Included in engineering

a. Percent of total direct costs.

b. Total direct cost = 4 x direct labor cost.

Participants also stressed that any variation in percentages would be dependent upon the particular indirect cost category. Some indirect category percentages vary little, such as fee and AFDC (i.e. interest during construction), while other category percentages, such as engineering and final testing may vary greatly. The nine indirect cost reporting categorizations are a) Indirect, b) Engineering, c) Owners, d) AFDC, e) Escalation, f) Contingency, g) Fee, h) Security, and i) Radiation Conditions.

II.A. Indirect

Minor installation expenses incurred by the constructor such as costs of payroll burdens, small tool allowances, and contractor mobilization on the installation site are included in this category.⁽¹²⁾ A breakdown of indirect cost items is shown in Table 5.

Indirect category expenses are usually easily estimated using standard cost percentages applicable to all compliance activities. These percentages when multiplied by the direct labor costs (i.e., total installation labor expenses) yield the appropriate indirect expense. Indirect category cost percentages obtained from the estimator survey are shown in Table 4.

II.B. Engineering

Engineering expenses result from the engineering, design, and impact assessments of new facility components required for compliance.^(12,14)

TABLE 5. Indirect Cost Reporting Category Components^(a)

1. Payroll and Field Labor: Fringe benefits Travel and subsistence for labor Workman's compensation insurance Federal and state payroll taxes, i.e., unemployment insurance, social security insurance	4. Miscellaneous Construction Services: General and final cleanup Watchman and guards Unallocated service labor: Janitors for temporary buildings Pickup truck drivers Tool room attendant Temporary elevator operator Snow removal and weather protection Welder's tests Material handling Maintenance of tools and equipment Move-on and move-off expense Surveying expense
2. Construction Equipment and Tools: Major equipment rental (including freight) Small tools expense Consumable supplies and purchased utilities: oxygen acetylene, welding rod, form material, office supplies, fuels, lubricants, first aid supplies, construction power, etc.	5. Field Administration Expenses: Contractor's fee Supervision Field engineering Administration Warehouse and purchasing First aid, medical and safety Computer rental Field office overheads Fringe benefits for non-manual labor Travel and subsistence, non-manual labor
3. Temporary Construction Facilities: Temporary buildings Temporary work areas and bays Temporary roads, walks, parking areas, fencing Temporary railroads and barge unloading docks Temporary power, light, and telephone Temporary air, steam, water, sewerage system Minor temporary construction and general purpose scaffolding, cribbing and dunnage	6. Other Distributable Expenses: Preliminary operations and testing Builder's all-risk insurance Owner's field-purchased materials State and local sales and use taxes Miscellaneous

a. Source: "Capital cost variation: Experience in power plant construction," Power Engineering, February 1976.

Expenses are incurred by the owner, architect-engineer, engineer-constructor, major equipment and system suppliers, and consultants. Included in this category are expenses for preliminary investigations, environmental studies, subsurface investigations, preparation of design documents, procurement of materials and equipment, selection of subcontractors, and scheduling.

Engineering expenses are specific to the regulation and facility and cannot be estimated accurately using standardized cost percentages. Detailed planning studies of expected compliance activities are required in determining expected engineering costs. Even though there is a wide variation in compliance engineering expense percentages, there was some conformity found among publications containing engineering cost percentages. These percentages are shown in Table 6 as a fraction of estimated total direct costs (i.e., equipment, material and installation costs). Engineering cost percentages obtained in the estimator survey are shown in Table 4. The participants again cautioned that these percentages are applicable only to the crane handling system regulation and should not be applied to other estimating efforts.

TABLE 6. Engineering Category Cost Estimating Percentages^(a)

<u>Estimate</u>	<u>Engineering Cost Percentage^(b)</u>
Boiling Water Reactor Capital Cost Study (United Engineers and Constructors)	11%
Radwaste System Regulation (Northeast Utilities)	7%
Protection of Pipe Ruptures Outside Containment Regulation (Northeast Utilities)	4%
Industrial Security Regulation (Northeast Utilities)	5%

a. Source: Guide for Economic Evaluation of Nuclear Reactor Plant Designs, NUS-531, 1969.

b. Percent of Total Direct Cost.

II.C. Owner

Owner costs are expenses incurred by the facility owner in administering the compliance effort.^(12,15) Included are expenses for additional licensing, attendance of personnel at hearings, preparation of testimony, and legal fees. Also included are any expenses incurred by the owner for the initial effort that determined that activity was needed in order to comply.

Owner category costs are also specific to the compliance activity. These expenses are usually minor and difficult to estimate because most compliance-required owner efforts are accomplished along with noncompliance required owner efforts. However, as a guideline to this estimating problem, Table 7 contains estimates of owner expenses resulting from the construction of entire facilities. This information may be helpful for approximating the owner's expenses of major compliance installation activities.

II.D. Allowance for Funds used During Construction (AFDC)

Allowances for funds used during construction costs are the net expenses of procuring the capital required to purchase and install the components required for compliance. Also known as "Interest During Construction," this expense includes the interest charges on the debt portion of the financing, the stockholder charges on the equity portion of the financing, and any

TABLE 7. Owner Category Cost Estimating Percentages^(a)

<u>Total Direct Cost (\$10⁶)</u>	<u>Owner Cost Percentage^(b)</u>
30	2%
50	1.3%
100	0.8%
200	0.5%

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- a. Source: Guide for Economic Evaluation of
Nuclear Reactor Plant Designs, NUS-531, 1969.
b. Percent of Total Direct Cost.

administrative charges on the financing. It is important that these financing charges be applied not only to the estimated costs, but also to escalation costs.

AFDC costs are treated as a capital expense because the charges are incurred before the facility is operational and cannot be passed on to customers until after the facility is operational.^(16,17,18)

AFDC expenses are easily and accurately estimated using standard percentages. These expenses are estimated as a function of 1) the cost of capital to the owner, and 2) the time between the purchase of the compliance-required component and when the entire facility becomes operational. AFDC expenses are calculated by multiplying the cost of capital by this time period.

The cost of capital is usually taken as the weighted average of the interest charged on debt and earnings required on equity. The long-term average mix of these two financing methods for facilities of private ownership has been 52% debt financing and 48% equity financing. For publicly-owned facilities, the financing is all debt. The interest charges or the interest rate are equivalent to the sum of the real cost of money and the general inflation rate. The real cost of money can be approximated as 4% per year while the general inflation rate will vary. The total earnings rate required on equity depends on the periodic dividends paid out and changes with the value of the stock itself. Earnings required on equity are traditionally 3% to 5% per year greater than debt interest rates.

The time between the date the compliance required component is purchased and the date the facility becomes operational can be obtained from construction schedules. The capital to finance component purchases is actually procured months before expenditure dates. Once procured, the capital is placed in short term notes, and earns a return up until expenditure dates. The interest differential between the long term debt that the owner has put out and the short term notes that the owner has invested in is usually negligible. This allows cost of capital charges to be applied only to the time period after a component is purchased and before the facility becomes operational.

A typical cumulative expenditure curve for construction of a nuclear power plant is shown in Figure 1.⁽¹⁹⁾ Expenditure patterns for each of the five major cost accounts (i.e. account 21 through account 25) are shown. The area under each curve multiplied by the cost of capital results in the total AFDC expenses required to finance that cost account's activities. Estimates of AFDC expenses for compliance-required component expenditures can be calculated in the same manner.

FIGURE 1. Cumulative Expenditure Pattern

II.E. Escalation

Escalation or escalation during construction category expenses are the expected increases in equipment, material, labor, and land costs above estimated levels.⁽²⁰⁾ In most instances, because general inflation is positive, component purchase prices will inflate until the components are purchased. These cost increases are estimated as escalation expenses.

Escalation expenses are easily and accurately estimated. Escalation costs are calculated as a function of 1) material, equipment, and labor escalation rates, and 2) the time between the price-level date of the cost estimate and the purchase date of the compliance-required components. This time period when multiplied by the expected escalation rate is the total estimated escalation expense.

Escalation expenses are calculated in the same manner as AFDC expenses in that both calculations utilize the cumulative expenditure curve (Figure 1). In instances where costs are estimated in 'beginning-of-installation' price levels, the area above the curve multiplied by the escalation rate is equivalent to the total escalation expense. The time period between the date the cost estimate was made and the date of the planned expenditure can be determined from construction planning schedules. Rates of expected component cost escalation can be obtained from extrapolation of past escalation rates into the future. Past escalation rates are available in the forms of cost indices. Escalation rates taken from one such index are shown in Table 8.

II.F. Contingency

Contingency category cost is the estimate allowance required to cover unestimated expenses resulting from compliance activities. This category reduces the risk to the constructor of underestimating installation expenses by providing a cushion or allowance to cover unanticipated expenses that occur. The estimator's perception of the accuracy of the estimate (i.e., the variance in the estimate) determines the amount of contingency allowance.

TABLE 8. Escalation Rates in the Construction Industry^(a)

Category	Year			
	1973	1974	1975	1976
General				
Structural steel erected	15%	53%	-7%	1%
Construction equipment	7%	30%	9%	8%
Labor				
Building trades labor	5%	7%	7%	5%
Common labor	7%	9%	6%	6%
Pipefitters	8%	6%	7%	5%
Material/Equipment				
Pumps	16%	28%	21%	5%
Steam pipe	0%	29%	5%	7%
Turbogenerators	5%	16%	19%	11%

a. Source: The Handy-Whitman Index of Water Utility Construction Costs, Bulletin No. 40, Whitman, Requardt, and Associates, Baltimore, MD, 1977.

Contingency costs cannot be as accurately estimated as many previous category expenses. The contingency percentage is usually subjectively determined based on the estimator's perception on the accuracy of the estimate. A total estimate contingency percentage is usually determined from the weighted averages of individual account contingencies. Total estimate contingencies given in the estimator's survey are shown in Table 4.

II.G. Fee

The profit or fee required by the parties involved in compliance-required installation activities (i.e., architects, engineers, and constructors) is included in this category. This fee is an allowance that serves as an incentive for the parties to obligate themselves to complete the work.

Fee expenses are usually easily approximated using standard percentages. These percentages may vary slightly depending upon the regional economy and

the amount of construction activity in the area. Fee percentages found in the estimator's survey are shown in Table 4.

II.H. Security

Security category costs are material, labor, and equipment expenses for additional security forces that may be required during installation of compliance-required components. Often such installation will require an extensive mobilization of construction forces on the facility site. Additional security may be required to reduce both the potential for dispersal of nuclear materials from within the facility and to minimize workers' exposure in facility radiation zones.

II.I. Radiation Conditions

Additional expenses resulting from compliance-required installation activities, carried out under conditions of potential radiation exposure rather than under conventional installation conditions, are included in this cost category. These additional expenses are generally associated with losses in worker productivity due to the increased caution required by workers. Expenses for continuous radiation monitoring, radiation protection clothing, and modifications in equipment and procedures required to avoid occupational radiation exposures are also included in this category.

III. Operating Costs

Operating expenses resulting from compliance activities are included under this heading. These expenses result primarily from increased staffing, maintenance, and internal power consumption required to operate facility equipment. Operating cost category expenses are periodic expenses that will be incurred regularly over the lifetime of the facility. The six operating cost categories are a) General Operating and Maintenance, b) Administrative and Legal, c) Selection/Placement of Personnel, d) Training of Personnel, e) Fuel, and f) Facility Shutdown/Restart.

III.A. General Operating and Maintenance

General operating and maintenance category costs include additional expenses for the daily operation of facility components. Such costs include

all additional expenses resulting from compliance activities with the exception of some personnel costs. Included are expenses for additional facility staffing, consumable supplies and equipment, power required to operate components, outside support services, replacement items whose installed costs are less than \$10,000 and maintenance.⁽¹²⁾

III.B. Administrative and Legal

Administrative and legal category costs are those operating expenses resulting from compliance activities that are incurred offsite.⁽¹²⁾ Such expenses are not incurred on a regular basis, but periodically over the lifetime of the facility. Home office management costs and occasional legal fees that result from incidents at the facility caused by compliance-related actions are included in this category.

III.C. Selection/Placement of Personnel

This category includes expenses incurred for the recruitment, selection, and placement of additional operating personnel needed to comply with regulatory actions.⁽²⁾ Such costs are both one time expenses and periodic expenses. Before the facility becomes operational, there must be an intensive recruitment program in order to staff all additional positions. Once the facility is operating, a smaller recruitment effort must continue in order to staff positions left empty by worker turnover.

III.D. Training of Personnel

Costs in this category include expenses for the training of additional personnel acquired to comply with regulatory actions.⁽¹²⁾ Included are expenses for the periodic requalification of operating staff personnel. This cost category is much like the preceding category in that costs may be incurred on a one-time basis and also on a periodic basis over the lifetime of the facility.

III.E. Fuel

Fuel cost increases due to compliance activities are included in this category. Replacement power costs are not included in this category (included in secondary cost category discussed below).

Estimates of operating cost category expenses are entirely regulation specific. No estimating rules of thumb are possible because the variation in possible compliance activities is so great. In many instances, operating expenses attributable to the additional equipment required by compliance are negligible. The equipment will simply become an integrated part of the facility and will function automatically. However, occasionally new equipment will incur significant additional operating expenses. Estimates of such expenses can only be made from detailed plans of both equipment and facility operating procedures and internal power requirements. Once additional manpower, selection, training, and internal power requirements have been projected, these costs can be estimated. It is unlikely that compliance activities would ever increase fuel costs radically.

III.F. Facility Shutdown/Restart

This cost category includes any additional expenses above normal operating expenses that result from the facility shutdown required to perform compliance activities. Also included are expenses for restart of the facility. Costs for these operations may be incurred periodically over the lifetime of the facility; once, for the initial installation of compliance-required equipment and possibly numerous times later, whenever the equipment requires replacement, inspection or maintenance. The value of the power lost during shutdown is included in the delay costs.

Facility shutdown/restart expenses will usually be negligible. Very little expense will be incurred in addition to normal operating expenses. In most instances, the facility operating staff alone can carry out any compliance procedures that may be necessary.

IV. Secondary Costs

Secondary costs are expenses that result from secondary or hidden effects of compliance activities. These expenses are primarily the "not so obvious" costs whose magnitude can only be approximated. Secondary costs may be one-time expenses or periodic expenses incurred on a regular basis.

Secondary cost category expenses are specific to the regulation and facility. Not only do the types of secondary costs that occur for compliance activities vary, but the magnitudes of the expenses vary. These expenses, though the secondary result of compliance activities, are nonetheless a real cost of compliance and must be included in the estimate. Estimates of such expenses can only be obtained using rather innovative estimating techniques for which there are no standard guidelines or procedures. The three secondary cost categories are a) Secondary, b) Nonquantifiable, and c) Delay.

IV.A. Secondary

Secondary category costs are expenses that occur as a secondary result of compliance and whose magnitudes can be approximated. Examples of secondary expenses are the resulting costs of compliance required reductions in operating speeds or capacities of facility components.⁽²¹⁾ Another example is increased installation labor costs resulting from poor workers (i.e., low productivity workers) who must be utilized because all good workers in the area are already employed on the site. The costs of delay in not getting the facility operational due to compliance activities are not included in this category.

Secondary expenses can be quantified. In doing this, the estimator will be forced to use conceptual techniques and the accuracy of the estimate will suffer. These conceptual techniques are necessary because the estimator must extract and estimate only the net effects of compliance. In instances where the compliance activities occur independently of other facility activities an estimator can easily estimate secondary expenses. However, where compliance activities do not occur independently of other facility activities, cost estimating becomes difficult. In these instances, the net monetary effects attributable only to the compliance efforts are not only difficult to estimate but even difficult to identify.

IV.B. Nonquantifiable

Costs included in this category are expenses that occur as a secondary result of compliance and whose magnitude cannot be approximated. Examples of such costs are the nonmonetary costs of the energy required to fabricate

components used in compliance efforts and the costs of adverse public sentiment that may surround compliance.⁽²¹⁾ An example of this adverse public sentiment cost is the expense of efforts required to fight adverse public reaction to the visual impacts of cooling towers. Also included in this nonquantifiable category may be costs of increased radiation exposure to installation workers while complying; the costs of labor productivity losses due to crowding of installation workers while complying; and the costs of disruption of the entire facility procurement activities to allow procurement of items required to comply.

Nonquantifiable secondary expenses must be identified in any estimate whether quantification of effects is possible or not. These costs are real and their effects must be considered in decision making. It is very likely in the future that techniques for estimating these secondary expenses will become available. As more information is collected on actual compliance expenses and estimating techniques are refined, secondary expenses may even be estimated with great accuracy. However, today the only method for either identifying or estimating secondary expenses is detailed planning of the projected compliance activities.

IV.C. Delay

Delay costs are those expenses that result from the facility not being operational because of compliance activities. Included in this category are expenses for the financing of capital over the period of delay, maintaining the constructor mobilized on site, and fuel used elsewhere to produce power that would have been produced at this facility had the facility been operational. In addition, there may be a cost resulting from revenue that is not generated but could have been if the facility were operational. In some instances, the power generated using new facilities is cheaper than that generated using older facilities.

Delay category expenses can be estimated more accurately than other secondary expenses.⁽²²⁾ Items that make up total cost of delay can be viewed with much more clarity and subsequently estimated more accurately.

Each item comprising the total delay cost can be estimated using standard cost estimating techniques. Some of these techniques are explained earlier in the discussion while others will require detailed examination of the regional energy pricing structure. An example of the calculation to determine the cost of one year's delay in completion of construction of an 800 MWe nuclear power plant is shown in Table 9.

V. Compliance Assessment Costs

Expenses that result from efforts to prove compliance are included under this heading. These costs may be incurred by owners, engineers, constructors, and examining agencies. Included are periodic expenses during installation, one time expenses upon completion of installation, and periodic expenses during facility operation. The three compliance cost categories are a) Quality Assurance/Quality Control, b) Final Testing, and c) Monitoring/Reporting.

V.A. Quality Assurance/Quality Control

Included in this category are those expenses that are incurred during installation of compliance required equipment for efforts in assuring adequacy in meeting compliance requirements. These expenses deal primarily

TABLE 9. Example of Delay Category Costs^(a)

The amount of a year's loss in schedule for an 800 MW nuclear plant nearing completion of construction is approximately as follows:

Million Dollars ^(b)	For
30	interest during construction
10	construction overheads
30	additional cost--fuel (burning about 8 million bbls of low sulfur oil at \$5/bbl (80¢/million Btu) rather than nuclear fuel at 20¢/million Btu)
<hr/> 70	

This total is approximately \$200,000/day in addition to the engineering and hardware cost increases.

a. Source: AEC Regulatory Effects on Cost and Schedule of Nuclear Power Stations. Northeast Utilities System, 1973.

b. Dollars as of December 1973.

with the structural adequacy of the installation and operational performance of equipment including expenses for such procedures as radiography, welder requalification, sampling, and documentation of testing results.

V.B. Final Testing

Final testing category costs are incurred after installation of compliance-required equipment and before the equipment becomes operational. Such expenses are usually the result of testing designed to overstress the equipment. These costs can be considered as one time expenses.

Quality assurance/quality control expenses and final testing expenses are specific to the regulation and facility. A detailed procedural plan for installation of the compliance-required equipment is required in order to estimate expenses. Also required are specific specifications relating to both the testing and operation of the equipment. Once these requirements are available, an estimate of compliance category estimates can be made. Compliance category cost percentages obtained in the estimator's survey are shown in Table 4.

V.C. Monitoring/Reporting

Included in the monitoring and reporting cost category are expenses incurred by the facility operator and regulatory agencies for providing continuous (on-going) proof of compliance. Such expenses include both the expense of monitoring effluents released from components required in compliance, and the expense of reporting (documenting) such monitoring. Such reporting is necessary in order to ensure that installation of components required in compliance is providing compliance.

Monitoring/reporting expenses are also a function of the particular compliance effort. Some compliance efforts may require no monitoring of compliance required operations while others may require significant monitoring. For this reason, to estimate expenses for these cost categories, a detailed procedural study of compliance-required operations is necessary.

The detailed cost estimate of the required compliance efforts on the radwaste system in the Millstone Unit #2 is shown in Table 10.⁽¹¹⁾ Such estimates apply only to the Millstone situation and must not be considered as applicable to estimating costs of Radwaste System modifications at other facilities.

TABLE 10. Radioactive Waste System Backfits
Millstone Unit No. 2

Change or Requirement	Direct Effects	Indirect Effects
Study alternatives to original radwaste system designs.	3,400 manhours of engineering.	Diverted mechanical engineering manpower from equipment specifications and purchase orders. Delayed project design.
Provide additional waste gas holdup tanks and space for future additions.	\$360,000 and 26,000 construction manhours.	Caused redesign and reordering of material at (-) 25 elevation in auxiliary building. Delayed construction ~2 wk in civil efforts. Additional tanks ordered 45 wk after original tanks and delivered 10 wk later. Construction blockouts for tanks remained open 30 wk longer than originally planned, affecting construction above elevation (-) 25.
Added boron evaporator and miscellaneous waste evaporator.	\$170,000 and 4,000 engineering and homeoffice manhours.	Caused late preparation of specifications and delay in placement of purchase order. Delivery slipped from original promise approximately 52 wk. Required delay in closing blockouts, delayed installation of other mechanical and electrical systems, added ~25 valves to plant designs.
Added solid radwaste drumming facilities.	\$200,000 and 11,000 construction manhours.	Caused late preparation of specifications and delays in placement of equipment purchase orders. Space originally designed as warehouse was used, resulting in requirement for new warehouse.
Miscellaneous treatment of secondary plant effluents; i.e., steam jet air ejector, steam generator blowdown, main steam traps, etc.	\$400,000.	Caused late design, procurement and construction activities. Blockouts required for piping and equipment. Equipment deliveries late. Increased piping and valve quantities.

All of the above changes caused redesign in building services areas such as fire protection, ventilation requirements, local electrical service supplies, equipment drain locations and routing, service air, instrument air, in addition to the changes dictated by the equipment such as shielding requirements and building layouts.

CONCLUSIONS

The previous discussion has provided a common framework from which to assess and estimate the costs of regulatory compliance activities. Whether used to actually estimate compliance costs, to provide guidance when estimating, or to critique and evaluate previously generated cost estimates, the framework is useful. The following conclusions can be made regarding the costs of regulatory compliance activities and this framework.

1. Before policy makers can establish quality regulatory policy, accurate estimates of the costs of regulatory compliance activities must be available.
2. In the past, regulatory compliance activity cost estimates have been of questionable value to policy makers because of their inaccuracy.
3. Inaccuracy in past compliance activity cost estimates has resulted from differences between estimators as to which costs should be considered "regulatory compliance activity costs", differences in estimating approaches, and differences in the treatment of secondary and indirect costs.
4. A conceptual look at the phases of change was helpful in establishing both the categorization scheme and estimating guidelines described in this report and would also be helpful when applying the framework to a specific regulatory compliance situation.
5. Costs and implications of specific regulations may be greater than has been previously indicated due to errors or omissions in cost analyses.
6. The magnitude of most regulatory compliance activity costs are situation and regulation specific and cannot be accurately estimated using generic cost estimating rules.
7. Regulatory compliance activity cost estimates can be standardized to the extent to make them comparable with one another and of use to policy makers, for the most part, simply by adhering to the guidelines described in this report.

Use of the framework described in this report will be a valuable addition to any regulatory compliance activity cost study. The framework will provide both cost estimators and policy makers with a tool that can assist in the establishment of quality regulatory policy.

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