CHAPTER 20

ESTIMATING SPECIALTY COSTS

1. INTRODUCTION

Specialty costs are those nonstandard, unusual costs that are not typically estimated. Costs for research and development (R&D) projects involving new technologies, costs associated with future regulations, and specialty equipment costs are examples of specialty costs. This chapter discusses those factors that are significant contributors to project specialty costs and methods of estimating costs for specialty projects.

2. RESEARCH AND DEVELOPMENT COSTS

Traditionally, cost estimating has involved the compilation of historical data for use in correlating and validating existing estimating methodologies. These methodologies and the corresponding cost data are then used to prepare cost estimates. Historical data lends a cost estimate some accuracy and credibility. In today's environment, a problem arises when the cost estimate is required for new, innovative, "state-of-the-art," first-of-a-kind projects. According to one author,[1]

> "For many new ventures economic feasibility is dependent on process innovations as yet untried and unproven, and the technical alternatives are numerous and complex. In these cases, technical feasibility must be established and, depending on the size of the project, detailed systems design and planning may be needed to ensure accurate cost estimates."

Knowledge of the processes involved will help the cost estimator in preparing an accurate cost estimate. In the absence of accurate cost information, process knowledge can focus the estimator towards those parts of the project that are significant contributors to overall project cost.

A. Personnel Costs

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[1] Clifton, D.S. and Fyffey, D.E. 1977: "Project Feasibility Analysis—A Guide to Profitable New Ventures."

Personnel costs are usually the largest R&D expenses. R&D personnel are well educated and a have a higher pay scale than employees for conventional projects.

B. Equipment Costs

Equipment costs for R&D projects can be divided into hardware and software costs. Hardware includes machinery, computers, and other technical equipment. Equipment costs increase with increasing project complexity. For example, if the research involves extensive modeling or computer calculations, a supercomputer may be required. Specialized software may have to be developed for the project, so software costs can also be significant contributors to the overall project cost.

C. Prototypes and Pilot Plants

In some instances it will be cost effective to develop a prototype or a pilot plant for an R&D project. A cost estimate for a prototype or a pilot plant will have to account for the following:

- construction of the equipment or plant;
- operation of the equipment;
- development of test criteria for plant studies;
- analysis of test results; and
- computer simulation of plant processes.

The estimate will also have to provide for project management and personnel during the pilot plant study or prototype testing.

D. Scaled Models

Plastic, scaled models of industrial facilities are used to improve visualization of the facility in three dimensions. Building the model can identify problems that may occur during actual construction of the facility. Models can also be used as a management tool if the model is constructed as the facility is constructed. The model then shows the status of the project.

Models have many advantages, but the main disadvantage is cost. The models are expensive to construct; however, in most cases the benefits obtained from the model exceed the model's cost.

E. Computerized Models

Computerized modeling may need to be performed for some projects. For example, if the project goal is to construct a new incinerator for mixed hazardous and radioactive waste, site-specific air dispersion modeling may be required to demonstrate that emissions from the incinerator will not have an adverse impact on public health or the environment. Groundwater modeling may be required for some remediation sites. Assume the groundwater contamination had been found at a site, and several technologies are being proposed for the site. Modeling can be used to select the best technology or to determine the optimum locations for pumping or injections wells. Computer models have also been used to develop risk assessments for contaminated sites. Finally, for conventional projects, finite element analysis may be used to determine potential weaknesses in a design.

Some models can be quite complex and require specialized technical expertise on the part of the modeler to avoid the "garbage in = garbage out" phenomena. The labor hours required for gathering input data, modeling time, labor and computer, and report preparation must be accounted for in the cost estimate.

F. Cost Estimating Methods for Research and Development Projects

Estimate detail will be a function of the project size, technical complexity and innovation of the project, number of alternatives to be evaluated, and the required accuracy of the estimate.

Several levels of cost estimating methods may be available to the cost estimator.

1. Scoping Estimate

This method is also known as "back-of-the-envelope," and it is a preliminary estimate that is developed during the preliminary design phase. Total project cost is estimated by multiplying the cost of a major piece of equipment by a factor. This technique was originally proposed by J. J. Lang. "Lang factors" range from about 4 to 5 and vary based on the type of process plant to be estimated.

2. Scaling Factors

Order-of-magnitude estimates require that major project units be known and sized. The estimate is prepared from major equipment purchase prices plus scaling factors. Estimate accuracy will be plus or minus 40 percent because data required for the estimate may not be available due to the "state-of-the-art" nature of the project.

Good results can be obtained from a scaling factor by using the logarithmic relationship known as the "six-tenths-factor rule," if the new piece of equipment is similar to one of another capacity for which cost data are available. According to this rule, if the cost of a given unit at one capacity is known, the cost of a similar unit with X times the capacity of the first is approximately $(X)^{0.6}$ times the cost of the initial unit.

$$\text{Cost of equip. } a = \text{cost of equip. } b \left(\frac{\text{capac. equip. } a}{\text{capac. equip. } b} \right)^{0.6}$$

The preceding equation indicates that a log-log plot of capacity versus equipment cost for a given type of equipment should be a straight line with a slope equal to 0.6. Figure 20-1 presents a plot of this sort for shell-and-tube heat exchangers. The application of the 0.6 rule of thumb for most purchased equipment is an oversimplification of a valuable cost concept since the actual values of the cost capacity factor typically vary from less than 0.2 to greater than 1.0. Because of this, the 0.6 factor should only be used in the absence of other information. In general, the cost-capacity concept should not be used beyond a tenfold range of capacity, and care must be taken to make certain the two pieces of equipment are similar with regard to type of construction, materials of construction, temperature and pressure operating range, and other pertinent variables.

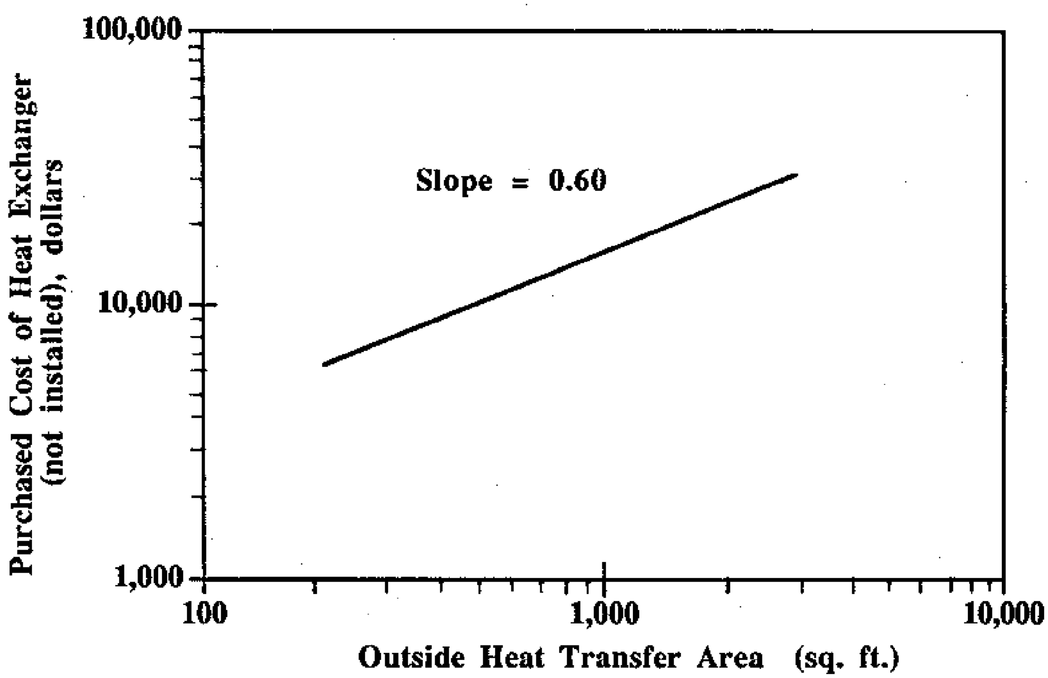


Figure 20-1. Application of "six-tenth-factor" rule to costs for shell-and-tube heat exchangers.

3. Detailed Estimate

Detailed estimates will be similar to an estimate prepared for engineering or construction bid purposes. This level of estimate will be costly to prepare but may have an accuracy of plus or minus 20 percent. It should be noted that detailed estimates may not be cost effective when determining economic feasibility between several technical alternatives.

4. Level of Effort

A level of effort estimate is made by determining how much of a resource is required for a given time. For example, the design of a large remediation project may take 150 engineers for a period of 5 years. Historical data can be referenced to determine resource loading.

3. REGULATORY COSTS

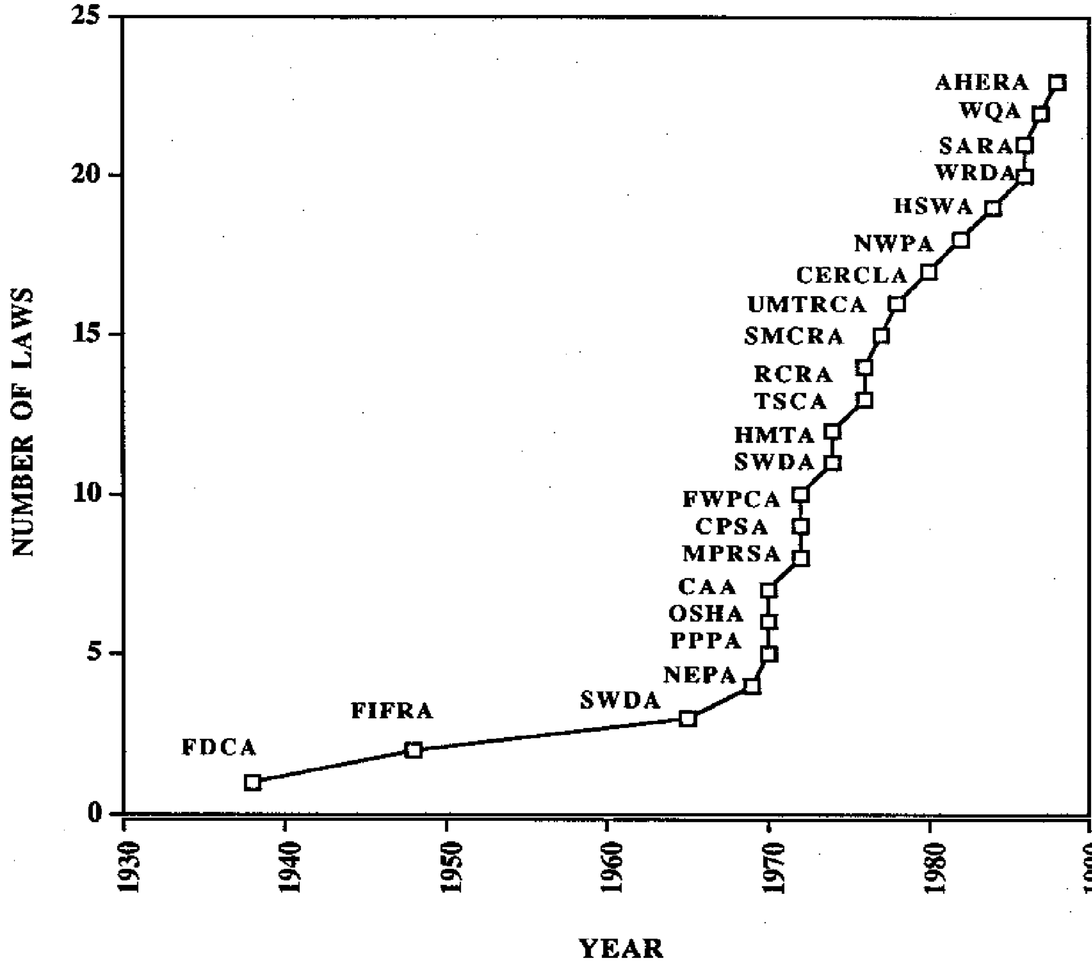
There are certain environmental and health and safety regulatory compliance costs associated with all facilities and projects. For conventional government projects, the facility must satisfy all federal, state, and local waste disposal, wastewater effluent disposal, and air emission limitations imposed by the applicable agencies. Regulations are even stricter for facilities that process or store radioactive materials. Construction sites must follow Occupational Safety and Health Administration rules. Environmental projects must protect human health and the environment during all phases of the project. Cost estimates must contain sufficient provisions for environmental and health and safety compliance. A familiarity with applicable regulations is required so a plan may be developed so the project may comply with those regulations.

A. Environmental Compliance Costs

The number and requirements of environmental regulations have increased dramatically in the past 20 years, as shown by Figure 20-2.

Several items should be considered when preparing environmental compliance cost estimates:

- type of project,
- project location, and
- waste generation, effluent characteristics, and air emissions from the project.



FDCA = Food, Drug, and Cosmetics Act (1938); FIFRA = Federal Insecticide, Fungicide, and Rodenticide Act (1948, 1972, 1975, 1983); SWDA = Solid Waste Disposal Act (1965); NEPA = National Environmental Policy Act (1969); PPPA = Poisonous Packaging Prevention Act (1970); OSHA = Occupational Safety and Health Act (1970); CAA = Clean Air Act (1970, 1977); FWPCA = Federal Water Pollution Control Act [Clean Water Act] (1972, 1977); MPRSA = Marine Protection, Research, and Sanctuaries Act (1972); CPSA = Consumer Product Safety Act (1972); SDWA = Safe Water Drinking Act (1974, 1986); HMTA = Hazardous Materials Transportation Act (1974, 1984); RCRA = Resource Conservation and Recovery Act (1976); TSCA = Toxic Substances Control Act (1976); SMCRA = Surface Mine Control and Reclamation Act (1977); UMTRCA = Uranium Mill Tailings Radiation Control Act (1978); CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act (1980); NWPA = Nuclear Waste Policy Act (1982); HSWA = Hazardous and Solid Waste Amendments (Amendments to RCRA) (1984); WRDA = Water Resources Development Act (1986); SARA = Superfund Amendments and Reauthorization Act (Amendments to CERCLA) (1986); WQA = Water Quality Act (1987); AHERA = Asbestos Hazard Emergency Response Act (1988).

Figure 20-2. Growth of Health and Environmental Protection Laws

Project location is significant to the project cost. If the project will disturb a wetlands area or if the project is located in an extremely environmentally conscious state, such as California, the estimator should account for increased environmental compliance costs in the project estimate. The project will be more expensive to complete and operate under these special conditions. Estimators are strongly advised to discuss the project with knowledgeable design staff and contact personnel familiar with environmental regulations that will affect the project.

A knowledge of wastes generated or air emissions during the project will facilitate the identification of environmental compliance design requirements and subsequent costs. For example, wastewater treatment may be required prior to effluent discharge into a stream or publicly owned treatment works. Air pollution control devices may be required for process equipment.

To estimate regulatory costs, an understanding of the types of costs that can be expected is needed. For example, permitting costs could include:

- labor to gather data,
- equipment for testing,
- analytical tests,
- time for interface with project personnel and outside consultant, if applicable,
- permit fee,
- annual permitting costs,
- upgrades to existing equipment, and/or
- new pollution control equipment.

Once a plan for regulatory compliance has been established, the regulatory costs can be estimated for that plan. This will establish a baseline for the costs, and regulatory changes that affect this baseline can be tracked and estimated throughout the project’s life.

B. Health and Safety Compliance Costs

Employee health and safety regulations have followed the same general trends as environmental regulations towards increased regulation. As allowable worker exposure limits decrease, design cost estimates will have to account for specific engineering controls to minimize employee exposures to toxic or hazardous substances in the workplace, especially for facilities involved with radioactive materials. Past experience with “increased regulatory rigor” within DOE has shown that the costs associated with employee workspace controls, including industrial hygiene monitoring, is the most significant cost factor in a more rigorous health and safety program. This trend will continue. Planning is essential since retrofit costs can exceed original installment costs.

State-of-the-art, high-tech facilities may require additional initial employee exposure monitoring if unknown situations are encountered. Protective equipment must also be supplied and maintained for the employee. Environmental projects may have strict health and safety requirements, including routine medical surveillance, preparation of health and safety plans, and employee training. Employees may not be able to work 8 hours a day if daily decontamination of personnel and equipment is mandatory.

C. Compliance Costs and Scheduling

For some projects, a permit is required before the project can commence. For example, construction projects that will disturb more than 5 acres are now required to obtain a stormwater permit prior to commencing construction.

Project scheduling can be affected if operating permits are not received in a timely manner. Facilities may be shut down for violations of operating permits or failure to comply with existing regulations. The time required for regulatory review of the permit application must also be factored into the cost estimate.

4. SPECIALTY EQUIPMENT

Specialty equipment includes non-typical hardware or equipment such as glove boxes for radioactive handling or architectural specifications such as computer room floors or flag poles. None of these examples are common to conventional projects; however, in most cases, a good cost estimate can be developed with the help of vendor quotes.

Computerized modeling may be required as part of the permit process, and any cost estimate for the project should include consideration for an outside consultant's modeling and report preparation costs.