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Cost Accounting to Adapt to the Needs of Nuclear Energy Plants

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Manufacturers making components with loose tolerances, and also specialized parts where extremely close tolerances are essential, (such as parts used in nuclear power plants) must realize that all costs rise sharply for the latter and adjust their . . .

COST ACCOUNTING TO ADAPT TO THE NEEDS OF NUCLEAR ENERGY PLANTS

by Thomas S. Dudick

Ernst & Ernst

WITH THE START of the nuclear age in the early 1940's, it was generally expected that interest in harnessing atomic energy for peaceful uses would eventually develop. Within two decades a number of industries were engaged in the production of components for nuclear applications.

The energy crisis has accelerated that relatively slow and easy development. There is now renewed emphasis on nuclear power as an eventual source of energy. Coal promises a quick, but temporary, solution to our energy needs—and an endless struggle with environmentalists. Geothermal and solar energy sources offer great possibilities but they are potentials only; their application on a large scale is a long way off. Nuclear power plants represent the only well developed technology that can be brought into production in a relatively short period of time.

It is a field that has come a lot farther than most people realize. The *New York Times* reported on its business page January 16 "Industry Report Asserts Nuclear Power 'Came Into Its Own in 1973'" and buttressed the report with a summary of its own showing that 42 plants with a generating power of 25½ million kilowatts are in operation now, that 56 plants are under construction, and that there are firm orders for 101 more.

But it is an industry that has encountered fierce citizen resistance, too, mainly because of the fear of nuclear disasters that might occur if anything went wrong.

Early components of nuclear power were built to existing specifications, used for commercial applications. Although some of these specifications were tightened for nuclear components, the Atomic Energy Commission (AEC) was not satisfied. Its concern was satisfying the developing fears on the part of the public about radioactivity from nuclear power plants. The AEC, as a result, pressed all manufacturers of nuclear components to come up with specifications that would guard against any remote possibility of accidents.

This pressure ultimately resulted in an expanded Section III of the ASME (American Society of Mechanical Engineers) Code. Before the expansion, only vessels had been covered. Certificates of authorization are now required of manufacturers of such nuclear components as valves, pumps, pressure vessels, reactor vessels, safety valves, and piping.

But manufacturers have found that the Code's requirements have not resulted in greater standardization, as some had expected; individual customers have established even stricter requirements than those called for in Section III. In effect, each nuclear component is a custom job. As an engineering executive of one producer put it: "The Code sets minimum quality levels but this does not result in standardized manufacturing procedures because each customer modifies to suit his own needs. As a result, each manufacturer has become a specialty house."

The advent of these stricter requirements has naturally had a great impact on the amount of inspection, quality assurance effort, engineering, contract administration, and rework. Additionally, the manufacturing cycle is greatly lengthened because of the many interruptions for inspection and the need for rework to meet Code and customer requirements.

Yet the manufacturers of these valves, pumps, piping, and safety vessels were mainly commercial concerns, the bulk of whose products required no such care in manufacture. Nuclear components posed all the problems of manufacturing to extremely close tolerances, in other words, whereas the manufacturers were accustomed to dealing with relatively loose tolerances; their business methods had been built on these practices.

This is a situation which does not apply to too many manufacturers yet, but it is spreading fast. As more and more emphasis is put on nuclear energy, we can expect to see more and more business problems arising among a growing number of manufacturers.

The importance of nuclear power production in the energy crisis has been heightened by the Administration's obvious dependence on it to help overcome the oil shortage. This was highlighted by energy chief Simon's recent paper, distributed to the international meeting of delegates from the petroleum-consuming countries, suggesting that floating nuclear plants anchored off coastal shorelines could be mass produced rapidly.—Editor

Impact of tighter specifications

The examples used to demonstrate the cost of impact of this new development and recommended treatment in the cost system have been taken from a study made for the valve manufacturing industry.

Inspection—The cost of inspection for nuclear valves is more than double that required for industrial type valves. There can be as many as 900 inspection, hold, witness, approval, and verification points by manufacturer, AEC, and customer. In addition to inspections during the manufacturing process, there would be inspections at vendors and review of procedures and drawings prior to manufacturing.

Manufacturing Interruption — The impact of increased inspection, not only by the manufacturer's personnel, but by customer representatives and third party inspectors, results in production delays and, consequently, a much longer manufacturing cycle during which costs keep accumulating and large amounts of investment are tied up.

Quality Assurance—In the manufacture of industrial type valves the quality function does not go much beyond the inspection stage. With the more demanding requirement for Code adherence in making nuclear valves, the quality assurance function must relate to the total controlled manufacturing system. To do this, quality assurance must take responsibility for:

- audit and control of suppliers to assure conformance to code and contract requirements
- internal training of inspection personnel
- audit and control of internal departments for conformance to code and contract requirements
- control of internal quality standards
- development and monitoring of programs for calibration of measuring equipment
- control of quality documentation.

The net effect is that the cost of assuring conformance can more than triple the cost of the quality function.

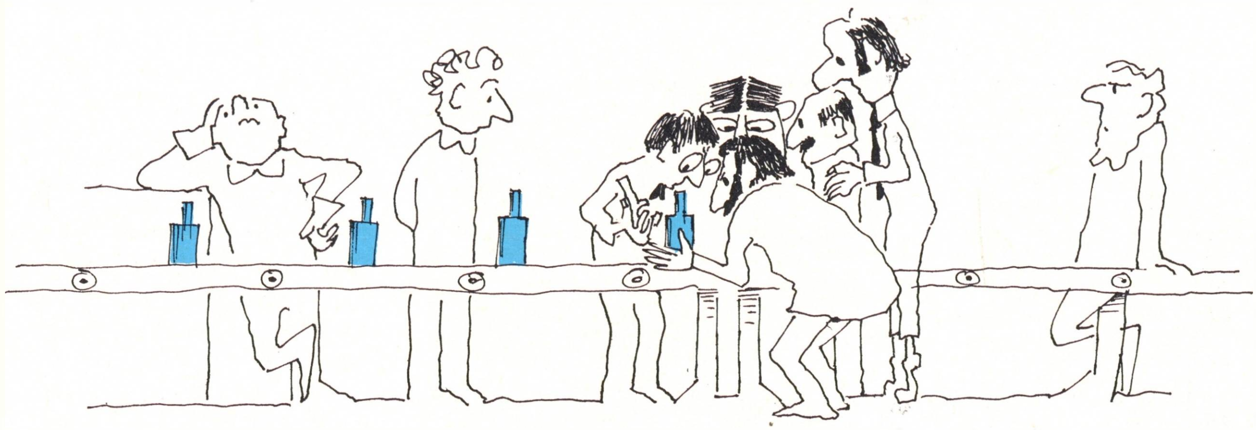
Engineering—Engineering must also expand its role. It must go far beyond its original mission of rendering assistance to the factory. Now, for each and every contract, engineering must:

- design the product
- certify that the design meets code and contract requirements
- spell out specifications for purchase of material
- make detail drawings for the shop and write instructions
- write test procedures
- coordinate customer requirements with manufacturing procedures.

As a result, engineering costs for a nuclear valve can be expected to be double or triple the cost of the industrial valve.

Contract Administration—In any product in which manufacturing procedures are spelled out in great detail and documentation for each step is required, a close liaison must be maintained between the manufacturer and the customer. This liaison goes much further than the conventional customer service function. It is called contract administration and has the following requirements:

- act as contact with the cus-



The great number of inspections required in nuclear valve manufacture can raise production costs tremendously . . .

tomer—providing the necessary liaison on all matters relating to the contract
- monitor status of the job and prepare progress reports
- review all correspondence relating to the contract
- furnish customer with any information required by him
- monitor witness inspection dates
- close out orders and finalize documentation.

Rework—In an industrial type valve, rework would normally be considered as overhead. In many cases, the parts would be scrapped rather than investing additional labor and overhead in salvage. In nuclear valves, rework is an unavoidable cost and should be considered as direct rather than overhead.

Mixed Production — Companies manufacturing the industrial type valve in the same facility that is used for making nuclear valves can expect to find costs of the industrial type increasing. This is due to the normal tendency to upgrade lower graded products when two disparate types are being manufactured.

The foregoing are some of the factors that will greatly impact the need for a more definitive interpretation of costs—particularly when industrial and nuclear type valves are being made in the same facility. Costs that have traditionally been classified as indirect must now be considered as direct. The "purist" definition of what is direct and what is indirect must be abandoned in favor of a definition that will recognize costs that are identifiable and supportable as direct charges to each contract. What these costs are and how they should be measured will be the subject of the sections that follow.

Identifying costs

It has been traditional in some valve manufacturing companies to consider as overhead such items as packing, gaskets, bolting, welding material, purchased services, incoming freight, shipping preparation, engineering/drafting, rework, and other costs. In light of the more demanding requirements in nuclear work, these costs have increased greatly in magnitude. They can also vary quite radically from one contract to another. Because of such variations, inclusion of these costs in the overhead rate could result in allocations to contracts that are quite different from reality.

A discussion of the various costs that should be identified more specifically follows:

Supply Type Items—In most accounting systems items of relatively small value are expensed at time of purchase and charged into an overhead account. The allowance in product cost is determined through an overhead rate usually applied to labor.

This is an acceptable expedient when items like a nut cost only five cents each, gasket material only a few cents per sheet, and welding material so little that it can practically be ignored. However, the aggregate cost of "supply type" expenses like the foregoing can amount to as much as $1,500 for a nuclear valve; it is thus highly desirable that such items be considered to be direct material and charged directly to the valve on which they are used.

Incoming Freight—In some companies, incoming freight is treated as an overhead expense. When valve manufacturers were, by and large, making castings in their own foundries, incoming freight was not as substantial an item as it is now, when many companies purchase their castings from outside foundries. If these higher costs are included in overhead as in the past, and allocated to the various valves on the basis of an overhead rate applied to direct labor, the amount charged to individual valves could

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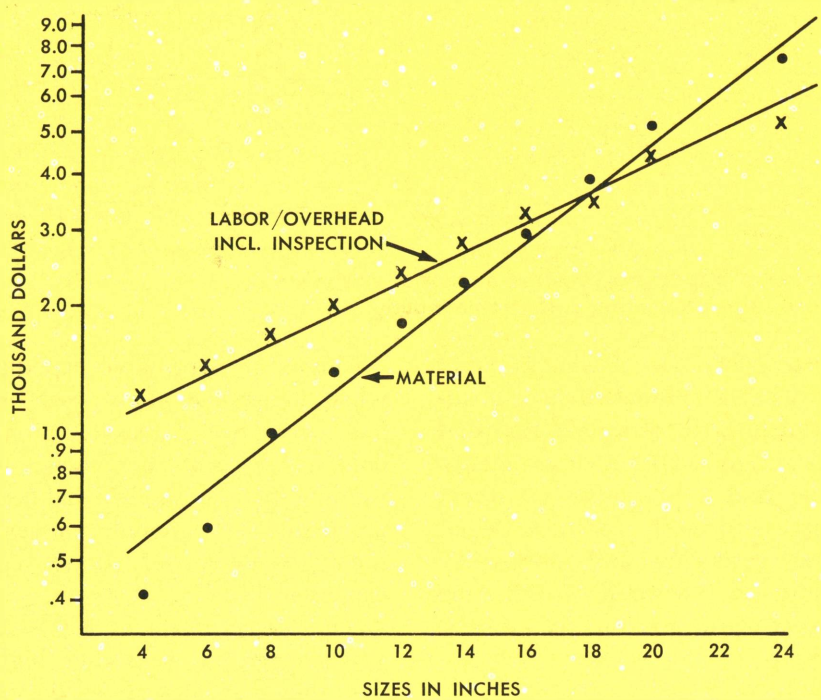
EXHIBIT I

COST COMPARISON

LABOR/OVERHEAD CONTENT VERSUS BASE MATERIAL FOR THE 600# CS PRESSURE SEAL VALVES

COST PER UNIT



be greatly distorted. This distortion occurs because the labor content in a valve does not correctly reflect the material content. Note in Exhibit 1, above, that the line representing material cost in the various sizes is quite different in slope than the line representing labor cost.[1]

A more accurate approach would be to identify the amount of incoming freight actually incurred for each casting and to add this amount to the cost of the casting as material.

Rework—The requirement for non-destructive examinations means that certain additional operations will need to be performed when defects are found. These are:

- gouging
- welding
- grinding
- hand dressing
- x-ray (if rejects still present, cycle starts again)
- heat treat
- remachining
- inspection.

Companies that include rework as part of overhead are allocating such costs to the various valves on the basis of the amount of direct labor required to make the valve. Obviously, when the rework operations can be specifically identified with the valve on which they are being performed, it would be more accurate to have the individuals doing the work charge their time to the specific valve and charge it as direct labor.

Special Tooling, Fixtures, and Patterns—Although the cost of these items could have a wide range, special tooling could cost $16,000-$18,000. Patterns and fixtures could cost $5,000.

Since these items are usually made for a specific valve, the cost should, like material, be charged directly to that valve rather than spreading such costs through an overhead rate. It is conceivable that fixtures, tooling, and patterns could be used for a subsequent order. The method of amortizing such costs against orders is a separate matter, the treatment of which depends upon the negotiations made with the customer.

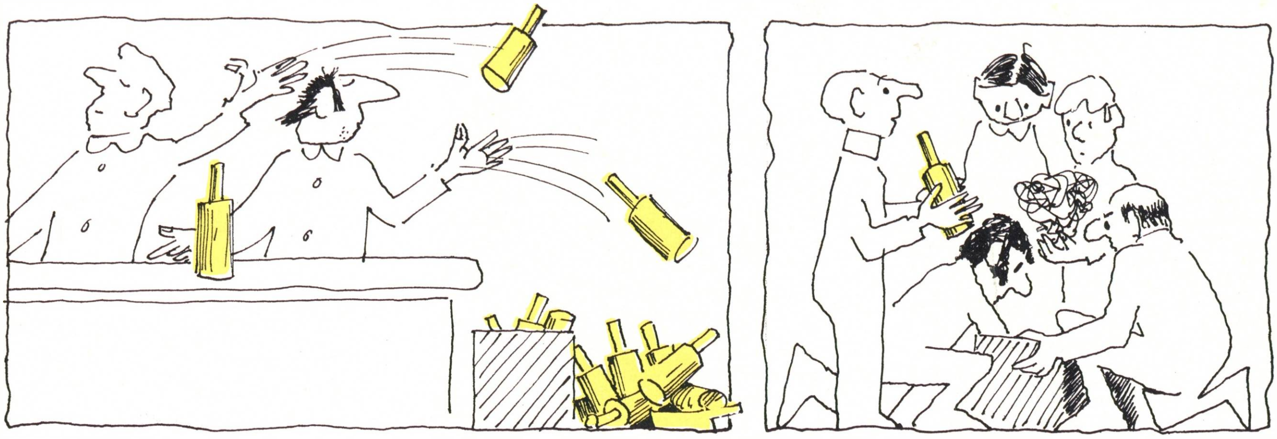
Shipping Costs – Traditionally, some companies consider shipping to be part of the selling group of expenses, rather than identifying them as part of the manufacturing cost. Before the advent of the nuclear valve, the industrial types could be loaded on trucks with little or no protective packing so that shipping cost was merely a handling expense.

This is no longer the case with nuclear valves, which must be crated to protect the weld end and the operating mechanisms. The crating of a large valve could amount to as much as $2,500. The operations required to prepare the valve for shipment should be identified as direct labor and charged to the specific valve.

Engineering/Drafting—The concept of product engineering has been expanded greatly with the introduction of nuclear valves. The function now includes design, writing instructions to the shop and the purchasing department, preparing detail drawings, writing test procedures, and coordinating with the customer. Engineering/drafting effort can start as much as a year before the shop begins to build the valve.

Because of the foregoing factors, and in the interest of matching costs with revenues, engineering—as well as other related items—must be charged as direct costs when incurred. Application of such costs through a manufacturing overhead rate (or a general and administrative, G&A, rate) rather than a direct charge, will not yield correct product costs. Take the case of one customer ordering two or more valves of the same type while another customer orders the same number of valves but each of a different type. Application of this cost through an overhead rate would overstate the cost

1—The plottings in Exhibit 1 are made to a semi-logarithmic scale. A line on such a scale reflects percentage, rather than absolute dollar changes.



Such a simple matter as crating a nuclear valve must be done so carefully that shipping preparation becomes a significant cost item.

of engineering/drafting to the first customer and understate it to the second.

The proper way of charging this function to the product is to identify the charges as direct costs to the specific product. Engineering/drafting, then, would become direct labor to which the engineering overhead rate would be applied. The same principal would apply to quality assurance.

If there are individuals in a company making both industrial and nuclear valves who find it impractical to charge their time to specific products, a nuclear material buyer, for example, it may be preferable to develop a nuclear overhead rate applied to nuclear direct labor.

Contracts Administration—Contract administration is a liaison function in which the administrator, or project manager, acts as a coordinator between the customer and the company. He must review all correspondence, must monitor the status of the job, advise the customer of witness inspection dates, and he must close out the orders and finalize the documentation.

The effort required for each contract is not likely to vary with the amount of shop labor required to make the product, so this expense should not be allocated through an overhead rate—it should be considered as a direct charge supported by time charges.

Those nuclear component manufacturing companies that do not have a "contracts administration" group must perform the function nonetheless. Undoubtedly the work is being performed by several individuals in such departments as production control, purchasing, accounting, or some other service department. If so, then the cost of the function is most likely being included in the product through application of the overhead or G&A rate—causing distortions.

The contracts administration function, whether a separate department or not, must recognize the amount of cost incurred against each contract and must be so charged to assure proper costing.

Which cost system is correct?

There is no pat answer to this question. The accounting system must adapt to the state of technology. When a product is new, unit volume small, and changes frequent, a job cost system is the most appropriate—it provides the means for identifying each cost as it relates to the specific job.

Standard Versus Custom Engineered Valves—As certain valves became standardized in past years, those companies that specialized in these types quite correctly adopted a standard cost system of accounting. Standard costs were predetermined—these became the costs of production and the inventory values from which variances were calculated.

Predetermined Standard Costs Versus Job Costing — However, when the complexity and proliferation of specifications expands, as it did for nuclear plant requirements —the valve can no longer be considered to be standard. Each one can be quite different in its specifications—each customer buying the same valve can have different requirements for the same valve. Also, purchases are low in terms of units purchased. Since the nuclear valve is not standard, then standard costs cannot be used for costing—a job costing system accumulating actual costs is mandatory. It is entirely possible that as nuclear plant production becomes standardized that nuclear components too will achieve a greater degree of standardization at some future time.[2]

Companies making standard type components which then add some nuclear components to their line are in the most vulnerable position when it comes to proper costing; they are not likely to change their cost system to accommodate the few nuclear items that have just been added to the line. Such costs as engineering, quality assurance, and contract administration, which are substantially larger for nuclear products, are likely to be included in the overhead rate

2—See *Engineering News Record,* July 26, 1973, page 11, "Utility Group Orders Six Identical Nuclear Units."

EXHIBIT 2

	BREAKDOWN OF HOURS			BREAKDOWN OF DOLLARS		
	Budgeted Hours	Actual Hours To Date	Estimated Hours to Complete	Budgeted Dollars	Actual Dollars To Date	Estimated Dollars to Complete
Labor and Overhead	1,655	—	1,655	$ 27,608	—	$ 27,608
Rework	279	—	279	4,655	—	4,655
Material	—	—	—	110,190	—	110,190
Engineering	264	214	50	1,588	$ 3,110	—
Drafting	250	293	—	1,504	2,819	—
Direct Charges	—	—	—	12,875	23,108	—
TOTAL	2,448	507	1,984	$158,420	$29,037	$142,453

and allocated on the basis of direct labor or in the G&A rate.

Thus, if nuclear items make up only 10 per cent of the business, the additional costs applicable to this 10 per cent will be spread over all products. The excess costs charged to the industrial types will probably not be noticed, but the cost of the nuclear will appear to be substantially lower than the true cost. Because the undercosted nuclear components will appear to be highly profitable, management will be encouraged to bring in more such business. As the proportion of nuclear business increases, the costing inadequacies of the standard cost system will become evident as the overcosted industrial types indicate lower and lower profitability. This situation bears out the observation made by one executive who states:

"We continued to use standard costs to value our castings after we sold out our standard line. When non-destructive examinations [NDE] became a larger and larger factor on nuclear castings, our variances from standard became correspondingly larger. The variances identified the excess cost all right, but they didn't tell us what product the variances should be charged to. We considered building the NDE costs into the standards since we recognized this was part of the material cost, but gave up the idea because of the infinite number of standards we would have had to keep in file.

"After this experience, we gave up on standard costing of nuclear valves and went to job costing."

Another company executive had this to say:

"A custom engineered product produced in a manufacturing system designed for standardized volume production creates costing problems which need far more attention than management generally gives."

Format for Accumulating Job Costs—The conventional job order cost system used by many companies accumulates three categories of cost. These are:

Material
Direct Labor
Overhead (usually applied on direct labor).

Under this conventional format, such costs as engineering/drafting, quality assurance, and rework would be included in overhead. Since overhead is usually applied to products through a departmental overhead rate based on direct labor, these costs are distributed in proportion to the amount of labor contained in the various products.

When custom engineered products such as nuclear components are made in the same facilities as standard products, use of this conventional format will result in the spreading of too much overhead to the standard products, which properly belongs with the custom engineered items.

More and more companies dealing in Government contract work have added an additional category called "Direct Charges" to identify such costs as special tooling or special equipment purchased for a specific job. This does not, however, provide for specific direct charging of such costs as engineering/drafting and quality assurance if these are left in the overhead category.

A more appropriate format would be one that recognizes as direct cost items the following:

Engineering/Drafting
Quality Assurance
Rework.

An example of such a format in use by a company making both nuclear and high specification special valves is shown in Exhibit 2, at left.

Estimate to Complete—The budgeted hours and budgeted dollars are synonymous with "estimated," the budget being based on the original estimate used to establish the selling price. The estimated hours and estimated dollars to complete are represented by the difference between the actual accumulated hours and dollars and the cumulative budgeted hours and dollars. If it appears that the budgeted hours and dollars remaining are not sufficient to complete the job, the estimate to complete is increased over and above the budget.

Reasons for deficient estimates

The importance of good product costing for custom engineered products cannot be overemphasized. Some of the reasons for deficient cost estimates are:

- arbitrary costing through use of predetermined standards
- failure to take into account cost escalation factors
- requests for changes
- hasty estimating.

Arbitrary Costing—Standardized products can be costed at predetermined standards with a reasonable degree of accuracy. Custom engineered items such as nuclear valves, cannot be costed through use of predetermined standards because of the many variations and differences in customer requirements that make it impractical to establish individual standards for all the possible combinations. Nor does the answer lie in "guesstimated token adders" that are used to adjust a predetermined standard to arrive at an actual cost. (If adders are used, there must be assurance that the costs they represent will be fully absorbed. Consequently, custom engineered products must be costed through a system that will identify the actual costs incurred for each job (see "Format for Accumulating Job Costs" in preceding section). Availability of the actual costs, correctly compiled, will provide a basis for monitoring performance as well as providing feedback on the correctness of the estimates.

Cost Escalation on Future Commitments—Cost estimates that may be correct at the time they are prepared could become very inaccurate if escalation factors are not taken into account to provide for cost increases with the passage of time. This is important when one considers how many commitments are made for delivery a year or more hence—during which inflationary cost factors continue with unrelenting pressure.

Requests for Changes—Requests for changes are frequently accepted from the customer with insufficient consideration of the impact of such a change in terms of additional out-of-pocket costs or the extended time during which inventory investment is tied up. Requests for changes should be handled in the same manner followed in making all cost estimates. The amount of additional cost required to comply with the change should be known to management as soon after receipt of the request as possible.

Hasty Estimating—There is no better way to assure faulty cost estimates than to make them in haste to meet an unreasonable deadline. One way to assure better utilization of a limited time allowance (though every effort should be made to obtain a reasonable amount of time) is for extra copies of the customer's order to be made available for purposes of obtaining, simultaneously, the various segments of information that are required in putting together an estimate. Availability of reliable history on past jobs can also be very helpful in cutting time requirements for making cost estimates.

Verification of cost estimates

A cost system provides the basis for regular accumulation of costs. In the accumulation process the system must correctly reflect actual product costs that can be used to verify the correctness of the cost estimates. And, even more important, the comparison of the actual with estimate is the basis for control—assuming that the estimates have been correctly determined.

Illustrative of this is the 12" 900# carbon steel valve for which the actual cost of the body was $3,123 while the original estimate called for $2,138. The difference of $985 in excess costs is explained in Exhibit 3, at right.

The estimate, which was incorrectly made, assumed that an elliptically shaped body would be used. Since a round shape was called for, more pounds of material were required. These were purchased at a higher cost per pound than was estimated. In addition, certain other costs listed above were not recognized or were understated.

Companies that fail to compare actual costs with the original estimate are missing an important step in the process of management control.

Summary

Costs such as engineering, quality, and rework, which are normally part of overhead and applied through an overhead rate based on direct labor, cannot be allocated in the conventional manner when nuclear components (or other close tolerance products) are being made. Costs of this type, that are substantially greater for nuclear components, must be excluded from the overhead rate and applied to the jobs on a "direct charge" basis in much the same manner as material is identified by job. Companies with sophisticated systems in which predetermined standards are used are particularly vulnerable to this type of cost distortion.

EXHIBIT 3

	Estimate	Actual
Body Weight (lbs.)	1450	1810
Cost of Body	$1,888	$2,444
Heat Charts	—	15
Sharpy Tests	—	45
Film	200	455
Rough Machine	50	164
Total	$2,138	$3,123

When inadequate accounting procedures are being followed there is every likelihood that these deficiencies will be carried over into the estimating process. For this reason, the following basic guidelines should be followed:

1. The cost system must provide for direct charging of major costs that are identifiable with a job.
2. When "adders" are used to adjust for differences among jobs because direct charging is impractical, these adders must be tested to assure that they will be recovered in the normal volume of business.
3. Estimates must provide for inflationary factors. The time phasing of such escalation must be explicitly stated and firmly enforced.
4. The cost impact of all engineering changes must be estimated in the same manner as if a new job were being estimated.
5. The cost system must go "full circle" to provide feedback through a comparison of actual costs with the original cost estimate used for quoting the job.

Must identify differences

The tighter specifications called for in nuclear components, the rigid documentation requirements, and the multiplicity of different specifications for the same product ordered by different companies add up to substantially higher costs for nuclear components than for their industrial counterparts. The adequacy of a cost system is not measured by its degree of sophistication but by its ability to identify these product cost differences and to relate them to the cost estimate.