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# PLANNING REPORT

## Performance vs. Design Standards

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## FOREWORD

Standardization activities in the United States have recently received considerable attention from Congress, the Office of Management and Budget, the Federal Trade Commission and others in the Federal Government and the private sector. There is increased awareness of the potential impact of standards on the health, safety and welfare of the public. There is also a growing concern over the impact of standards on international trade.

Harvard economist David Hemenway, a specialist in industrial organization theory and author of the book Industrywide Voluntary Product Standards (Ballinger Press, 1975) and the National Bureau of Standards publication Standards Systems in Canada, the U. K., West Germany, and Denmark: An Overview (NBS/CCR 79-172, April 1979) has done extensive research into the nature and problems associated with the current standardization practices both in the United States and in foreign countries. His work has been well-received by those interested in gaining greater insights into the workings of the standardization process here and abroad. His research and findings also stimulated others in pursuing additional research in this area.

One of the National Bureau of Standards' (NBS) responsibilities is to enhance the technological and scientific base of the Nation's productive sectors by developing basic technologies and information that underlie product and process development and innovation. In recent years, there has been a substantial decline in the rate of growth of U. S. industrial productivity. NBS continues to conduct and sponsor research which may lead to increased innovation and productivity. One area likely to encourage innovation is the increased application of the performance concept to the development of product standards. NBS has played a leading role in promoting the development of performance standards, particularly in the building field. However, opposition to the replacement of traditional design or prescriptive standards with performance standards still exists.

In this report, Dr. Hemenway looks at the pros and cons of both performance and design standards and brings parts of the current thinking on the design vs. performance issue into perspective. He also describes areas where further research may be needed. The study has already been useful to NBS and I am confident that it will be equally interesting to the standards community in general and to other Federal agencies involved in the development and use of standards. It should be noted that the opinions expressed in this report are Dr. Hemenway's own and not necessarily those of the National Bureau of Standards.

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## ABSTRACT

This report compares and contrasts performance and design standards from an economic perspective. The research consisted of a careful examination of the literature and interviews with interested NBS personnel. The paper describes the characteristics of performance standards, explains why they are not used more often, and discusses particular areas where they may be appropriate. The report examines the design versus performance issue in automobile regulation and health care. There are suggestions for further NBS action to promote performance standards, and a listing of areas for further research. Nine brief cases at the end of the paper illustrate points made in the main text.

# EXECUTIVE SUMMARY

This report compares and contrasts performance and design standards from an economic perspective. The research consisted of a careful examination of the literature and interviews with interested and informed NBS personnel.

## Characteristics of Performance Standards:

Performance and design standards are not substitutes, but should be used as complements. Performance standards can include design specifications as examples of current state-of-the-art methods of meeting the performance criteria.

Performance standards are more than equivalency statements. They are useful as a way of organizing thoughts. Their economic advantage is that they should encourage competition and innovation. But they are not panaceas:

1. It is possible to write poor performance standards.
2. All standards, even performance standards, are restrictive. It can be useful to consider any performance standard as a part of a hierarchy, from the more general to the more specific and restrictive.
3. Performance standards do not eliminate the problems of determining proper quality levels.
4. Decisions still have to be made concerning whether or not to permit trade-offs among quality components.

## Why Performance Standards Are Not Used More Often:

It is difficult and costly to write performance standards and to create reliable test methods. There are also incentive problems--e.g., some groups benefit from design standards and may prefer them. From the regulator's viewpoint, performance standards may increase enforcement costs, and there may not be adequate institutional mechanisms for new product evaluation.

## Where Performance Standards May Be Inappropriate:

There are some areas where design standards may be preferable to performance standards. These include (1) testing standards, where the need to ensure comparability usually outweighs the possible benefits from encouraging innovation, and (2) safety standards, if risks are large and laboratory tests are not completely reliable predictors of actual product performance.

## Design/Performance Issues in Automobile Regulation and Health Care:

In automobile regulation, performance standards are sometimes used to push technological advance. The use of design versus performance standards affects the information flow and the areas of controversy between regulators and producers.

The terminology in the health field is "process" versus "outcome." Outcome measures are not ideal because good procedures do not always lead to good results. There are many factors other than medical care affecting health, and it is not currently possible to statistically control for all of them. Also, outcomes cannot normally be determined before-the-fact in the laboratory, but only after medical treatment has been delivered.

Role of NBS:

NBS currently promotes performance standards, but there are additional actions it might consider, including increased marketing of its standards writing services. There are also many specific areas for fruitful research related to the design/performance issue which are good candidates for additional funding.

Cases:

Nine brief cases illustrate many of the points made in the body of the paper.

# I. CHARACTERISTICS OF PERFORMANCE STANDARDS

"The performance approach is an organized procedure within which it is possible to state the desired attributes of a material, component or system...without regard to the specific means employed."[1]

Performance standards are written in terms of functional requirements rather than design or construction specifications. Performance standards for buildings, for example, describe how the structure should perform rather than precisely how it must be built.

Performance standards should have three essential parts: (1) the requirement, (2) the criterion, and (3) the test. The requirement is a qualitative statement about the important aspects of product quality. The criterion is a quantitative statement providing specific minimum levels for attaining compliance with the intent of the requirement. The test portion of the performance statement indicates the specific method of assessment.[2]

The creation of performance requirements and criteria are useful as a way of organizing thoughts, of making explicit otherwise implicit goals. In this respect the performance approach is similar to formal cost/benefit analysis. Both are systematic methods of attacking problems. The performance approach makes it easier to spot questionable requirements in a standard (see CASE 1).

The economic advantages of good performance standards are that they should encourage competition and innovation. Design or construction standards are more likely to promote price-fixing conspiracies and exclude new and existing products. Even well written design standards may, over time, retard beneficial innovation (see CASE 2). Of course, both design and performance standards need to be updated. They should be revised when there are important changes in user requirements or when test methods improve. But to permit beneficial innovation, design standards would also need to be immediately updated for every technological change.

This paper contrasts design standards with the performance standards approach. It is recognized that these are more complements than substitutes. Good performance standards often include design specifications as examples of current state-of-the-art methods of meeting the performance criteria. They tell the draftsman, builder, inspector and regulator specific solutions--but not the only solutions--to the stated requirements. Manuals of accepted practice are thereby incorporated into the standard. This "second half" of the performance based system transmits a large amount of practical information, reducing the costs and uncertainty for business, particularly small business, in meeting the standard.

Conversely, performance criteria are implicit in any design standard. Often a first step in writing a performance standard is to state these criteria explicitly. Then it should be decided if these are set at the correct levels (e.g., "testing to failure"). A case can be made for government legitimately using its regulatory powers only to prescribe (explicit or implicit) performance standards rather than specific construction criteria.[3]

Building codes generally include "equivalency" statements. Products which pass the implicit performance criteria embedded in the design specifications should theoretically be acceptable. But this is a far cry from the performance approach. An incredible burden of proof is placed on the innovator. He must (a) determine and get agreement from various regulators on exactly what the implicit criteria are, and (b) he must prove that his product meets these criteria. He must find acceptable test procedures, as well as show his product passes them. Explicit, generally accepted performance requirements, criteria and tests dramatically lighten his burden.

The performance approach has definite advantages. But certain points need to be recognized:

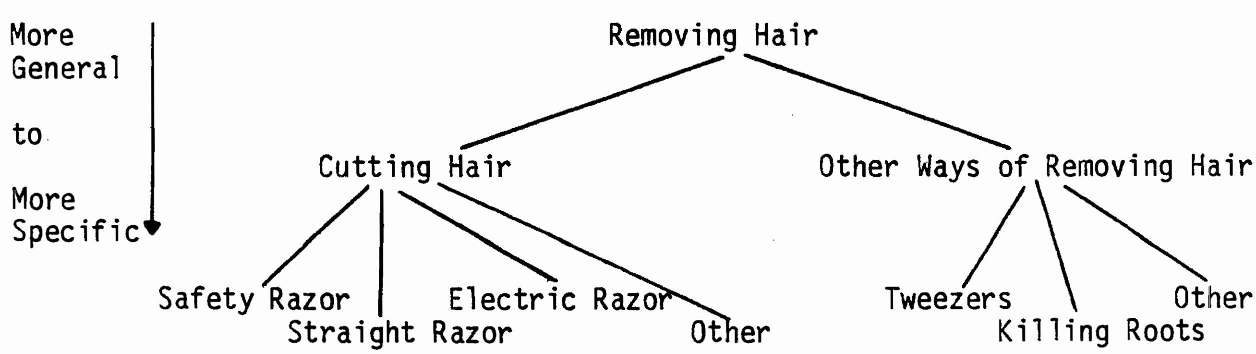
1. Poor performance standards are possible

Performance standards can be poorly written. They may emphasize relatively unimportant criteria and neglect important functional characteristics. Tests may be such that they virtually force products into certain patterns. Performance standards could thus exclude or place excellent products at a competitive disadvantage.

2. Performance standards will be restrictive

In practice there is always the necessity for a hierarchy of performance standards based on the degree of restrictiveness. This is quite separate from the requirement/criteria/test division. At the pinnacle of the performance hierarchy is the broadest functional requirement. Each successive step narrows the focus, thereby reducing the range of options. CASES 3 and 4 are examples.

CASE 3 describes a possible standards hierarchy for a facial hair control system. A schematic version of it appears below.



A design/construction standard could be written for one particular product, such as electric razors. Alternatively, a performance standard for electric razors could be created, which of course might cite specific designs as ways to meet the criteria. This would be a performance standard, but a narrow or incomplete one in the sense that safety razors and tweezers would be excluded. A design specification for electric razors is more restrictive than a performance standard for electric razors, and a performance standard for electric razors is more restrictive than a performance standard for the removal of facial hairs.

Theoretically, any hierarchy can generally be extended further in both directions. In this instance there could be more restrictive performance specifications, such as for steel electric razors or 110 volt steel electric razors, and so forth. And there are certainly more fundamental and encompassing objectives in life than the removal of facial hair. One higher goal is the desire to be attractive or presentable facially. This could be aided by hair grooming, hair bleaching, skin tanning, lip coloring, eyebrow reshaping and pimple elimination as well as by hair removal.

The performance approach tries to create criteria and test methods for requirements as high as possible on the hierarchy. In practice, however, criteria and tests may be simpler, cheaper and make more sense if the focus is narrower and more restrictive.

3. Cost/Quality Decisions Are Still Required

The performance approach should put primary emphasis on the fulfillment of human wants. Unfortunately, it may not be even theoretically possible to define "the attributes necessary to satisfy human requirements."[4] Users vary in their tastes and incomes, so there will rarely be unanimity about optimal quality levels. On a practical level, even a single individual's preferences may be difficult to ascertain. Thus the performance approach does not eliminate the need for making tough cost/quality trade-offs. Nor does it obviate the related problem of deciding upon what trade-offs will be permitted among various quality aspects.

4. Quality Trade-off Decisions Are Still Necessary

When there is more than one product attribute, a decision must be made about the appropriateness of allowing trade-offs among them. CASE 5 lists a variety of desirable performance characteristics for sanitary plumbing features. Should a standard require fixed minimum requirements in all areas, or should high performance in one area offset low performance in another? If the surface were more "slip resistant," would this permit it to be less "cleanable"? If so, some scoring or weighting system is essential.

CASE 6 discusses fire standards. In terms of even the single goal of increasing fire safety, what trade-offs should be permitted? If a sprinkler system is installed, can there be fewer exits? If fire departments are improved, can houses be made less safe?

Trade-offs may be difficult to write, monitor and enforce. But they may also be quite useful and efficient. Permitting all beneficial trade-offs requires beginning at the very highest level of the performance hierarchy.

## II. WHY PERFORMANCE STANDARDS ARE NOT USED MORE OFTEN

There is general consensus among federal agencies that performance standards are preferable to prescriptive standards. Government directives, advisories and proposed laws all praise the performance approach.[5] The National Institute of Building Sciences (NIBS) was created with a principal function of

> "...development, promulgation and maintenance of nationally recognized performance criteria, standards and other technical provisions...suitable for adoption by building regulatory jurisdictions."[6]

The performance approach is generally accepted as being superior to the prescriptive approach to standards writing. While most standards contain a mixture of design and performance type requirements (see CASE 7), prescriptive standards still predominate. Why isn't the performance approach used more often? There are a variety of interrelated reasons:

### 1. Difficulties in Writing Standards and Creating Test Methods

> "In many areas good performance standards are impossible (or to use economists' jargon, too costly) to write."[7]

It is generally easier to write design/construction standards than performance standards. A good design specification represents the current state-of-the-art and describes actual products and production methods. A good performance standard must be written to include potential products. It takes more time, thought and energy to create performance criteria. A Brookings Institution study concluded: "Physical specifications are used because performance is difficult to observe directly and such specifications are cheaper to develop."[8]

The problems are especially acute in terms of devising acceptable test methods. Certain important product characteristics may be impossible to measure objectively (e.g., odor) and thus require subjective judgment. This, of course, reduces the reliability, validity and acceptability of the evaluation.

A second problem is devising laboratory tests which simulate actual use. Performance characteristics measured in the laboratory should continually be checked with those determined in the field. A characteristic that is often difficult and costly to test for is product durability.

The problems in creating valid and acceptable test methods are not easily surmounted. A recent, careful analysis of building regulations concluded: "The simple fact is that many of the test procedures upon which standards are based are clearly inadequate representations of actual conditions."[9]

CASE 8 describes the current situation for drain waste and vent piping materials. The pipe can be made of different materials, and while there are adequate test methods for each, it is not a simple task to devise unbiased procedures for making comparisons among the different materials.

Not only is it often costly to produce performance standards, but sometimes inexpensive, yet beneficial, standards may not be created. In other words, there may be inadequate or perverse incentives.

Good standards create external benefits. This is especially true of performance standards. While many people and institutions benefit from standards, the cost of their creation is usually born by those who do the work. Individual decision-makers may not have adequate incentive to become involved in the time-consuming standards creation process.

Since decentralized decision-making may not lead to the optimal level or type of standards development activities, it may be advantageous for government--and particularly organizations within government with technical expertise--to help in the process. The argument for government subsidizing or helping in the creation of performance standards is virtually identical to the justification for government support of basic research.

Important beneficiaries of performance standards are new (and future!) innovative firms who may be small and unorganized. They may not have the financial resources to participate in the standards creation process. Additionally, while performance standards generally provide a net benefit to society, they may hurt some institutions. These institutions often include established firms who are not especially innovative and do not wish to lose part of their market share. They may not only refuse to promote performance standards, but may actually be able to impede their creation. They may spend their time and resources trying to ensure that the resulting standard is biased in favor of their particular design. One possible reason prescriptive standards may be so prevalent is that the specific firms that benefit from these standards may push hard for their creation and maintenance.

## 2. Evaluation Problems

To be of any worth, a standard must be used. The standard must not be so general as to be inappropriate for most specific uses. The tests must not be overly costly, and purchasers and regulators must not misinterpret or misuse the standard.[10]

It is sometimes argued that a "systems approach" to performance standards development is essential. Merely writing the standard is not sufficient. One "system" that is needed is the availability of reliable institutions for the evaluation of new products and processes. Since a primary purpose of the performance approach is to enhance innovation, it is crucial that new technology be rapidly, inexpensively and fairly judged.[11]

It has been suggested that testing laboratories, the institutions which currently do most of the evaluations, sometimes act as barriers to the introduction of beneficial innovation. One problem is that, even if performance standards are used, the referenced test methods may be inappropriate for judging a new product. As a result, it may be impossible to test the product without going through the time and expense to get the standard revised. In some cases, the state-of-the-art may not even permit the development of appropriate test methods

Devising a suitable test method for an innovative product can be a costly procedure. There may be great expense merely in the production of new testing equipment. Paperwork burdens are usually higher for the innovative firm since detailed information on the product and its functions is needed to develop proper testing criteria. The resulting tests can still not be ideal for the model product initially provided, and costly modification may be required, not only in the model, but in the production process itself.

If, as some groups allege, monopoly power exists in the testing industry in certain product areas (as a result of scale economies in testing, or reputational advantages, or most detrimentally, government regulation[12]), then the barriers to innovation could be even greater, due to the artificially high prices and slow service often associated with monopoly. Current efforts to accredit testing laboratories[13] and thereby promote competition between major testing groups and smaller ones, could eliminate some of the problems, but may not be sufficient to substantially reduce the burdens on the small innovative company.

It is sometimes claimed that the institutional mechanisms for new product evaluation must be improved.[14] It is also argued that further government involvement would make the system work better. Government action might take the form of direct evaluation of products, like the French Agrément System; or it might take the form of promoting independent, reliable product evaluation systems for new and innovative products.

### 3. Problems of Administration and Enforcement

> "Physical specifications are cheaper to administer. Visual inspection often suffices and, where it does not, only simple laboratory tests are necessary. To establish whether a product meets the performance specifications may cost thousands of dollars."[15]

Enforcement officials normally prefer design over performance criteria. Design specifications usually make life easier for inspectors--it limits their discretion and judgment. Inspectors can be less skilled and less well trained. A recent study by the National Bureau of Standards found that the performance approach concerned many regulatory officials "since they felt they did not have the ability or experience to make the required decisions."[16]

There is a potential for increased liability problems for regulators using performance standards, especially if objective test methods for all performance criteria are not available. Several court decisions have assessed damages against individual code officials where "judgment" was used to approve innovative systems whose failure resulted in injury or loss of life.[17]

Design standards are generally preferred by regulators, but not always. In workplace safety, for example, detailed specifications are often more difficult to enforce than general performance standards citing "hazardous conditions."

> "According to many compliance officers, the detailed specification standards are not frequently used because the technical definitions are often extremely difficult to interpret by employers as well as OSHA officials, and detailed descriptive standards require sophisticated, expensive measuring equipment, often not available to the compliance officer. A more substantial case that a violation exists can sometimes be established by citing the performance standard and demonstrating through factual documentation that an unguarded hazard exists."[18]

## III. AREAS WHERE PERFORMANCE STANDARDS MAY BE INAPPROPRIATE

There are areas where performance standards may not be preferable to design standards. These include:

1) Testing Standards

Few people advocate the use of performance criteria in the testing process. Testing standards are almost always written in prescriptive terms. The need to assure comparability seems to outweigh the possible benefits from encouraging innovation through the use of performance standards for test methods.

2) Safety Standards

It is normally impossible to ensure that innovative items meeting performance criteria are as reliable as well known and often-used products which pass the same tests. In other words, performance tests are not 100 percent reliable predictors of actual performance, especially over time. Where risks are large (e.g., nuclear reactor safety), it may be appropriate to use specific construction criteria. The gains from promoting innovation are overshadowed by the potential hazards of failure.

The Presidential Task Force on OSHA regulation explains:

> "Because certain situations and machines are extraordinarily dangerous, the proposed regulation contains a section which imposes mandatory design standards. In these few instances, the employer is not free to design his machine guard, but rather must adhere to the requirements set forth in the regulation."[19]

3) Interconnection Standards

> "Design will be specified only to the extent that controls are necessary to achieve commonality and interchangeability."[20]

It is often asserted that when there are interconnections, design standards are preferable to performance criteria. This does not need to be the case. Performance standards can specify interconnection as a key requirement without prescribing how interconnection is going to be achieved, thereby allowing innovation. Design specifications can be included to describe known ways of ensuring interconnection.

A major reason for preferring prescriptive standards over performance criteria is that prescriptive standards are known to work. Performance criteria and performance tests may not be perfect and may "pass" products which should not be accepted. But this argument seems more convincing for safety than for interconnection standards, especially since interchangeability can often be reliably and inexpensively determined. It is true, however, that in areas where performance tests are suspect, it is often better to use design specifications.

## IV. DESIGN/PERFORMANCE ISSUES IN AUTOMOBILE REGULATION

The design/performance issue also occurs in many areas outside the building construction field. The issue can be important in any area of purchasing or regulation. It is primarily a question of how to determine quality--via input or output measures. This section briefly describes the issues in the area of automobile regulation. The next section discusses the health field.

Current regulation of motor vehicles is largely by performance standards.[21] Problems caused by design standards in the building field may have been instrumental in producing support for the performance approach to automobile regulatory standards. While there is little direct explanation for initial Congressional preference for automotive performance standards, the legislative history of the 1966 National and Motor Vehicle Safety Act contains this comment:

> "The Secretary (of Commerce) would thus be concerned with the measurable performance of a braking system, but not its design details. Such standards will be analogous to a building code which specifies minimum load-carrying characteristics of the structural members of a building wall, but leaves the builder free to choose his own materials and design. Such safe performance standards are thus not intended or likely to stifle innovation in automotive design."[22] (emphasis added)

Interestingly, many standards in the automotive field are used in a manner not normally employed in the building area--they are intended to push technological advance. The strategy of using standards to force the pace of innovation has been followed with respect to fuel economy and certain polluting emissions. An example was the requirement that the hydrocarbon and carbon monoxide emissions from new 1980 model year cars be 90 percent below 1970 levels.

This is not the place to discuss the appropriateness of using standards to induce technological change,[23] but some observations may be presented concerning the design/performance issue in the automotive field. It should first be noted, however, that it is virtually impossible to use design standards in the regulations if the current state-of-the-art is not yet sufficiently advanced to meet the regulatory goals.

An academic has suggested a number of generalizations about the design/performance issue in automobile regulation.[24] These include:

(1) Performance standards tend to favor innovation.

(2) Performance standards tend to impose more risk on manufacturers. (This, of course, would be especially true if performance standards exceed available technology.)

(3) Performance standards are subject to a greater degree of ambiguity and imprecision.

(4) Performance standards tend to emphasize short-term characteristics of materials. (In large part this is due to the difficulty of determining durability in the laboratory.)

Probably the most interesting insights have to do with the differing effect of design versus performance standards on the relationship between regulators and producers.

(5) Controversy regarding design standards most often takes the form of disputes about the content of the design regulation itself. Controversy regarding performance regulations most often takes the form of disputes over the testing standards.

Laboratory tests are not identical to field situations. As the Environmental Protection Agency has gained more knowledge and information, it has modified test methods to better reflect the regulatory goals. EPA feels this ability to change test procedures gives them needed flexibility. Manufacturers, however, often complain that the use of an "elastic yardstick" can be unfair, and can burden them with unnecessary risk and cost.

(6) The incentive for producers to provide the government with information can be affected by the use of performance or design standards. For example, if design standards are expected, individual manufacturers may supply a great deal of information about the worth of their particular design configuration. However, if performance standards are used to force innovation, oligopolistic producers may have an incentive to withhold information on new advances, and form a united front in assuring government regulators of the impossibility of meeting the requirements.[25]

## V. DESIGN/PERFORMANCE ISSUES IN HEALTH CARE

How can regulators determine whether a hospital or a doctor is doing a good job? One possible approach is to use input measures. Another is to look at results. The jargon in the health field is "process" criteria versus "outcome" criteria. Outcome measures are usually preferred, in part because they permit innovation. A health care economics text sums up the conventional wisdom:

> "Ideally, the states should monitor the outcome of all delivery systems' medical care. Although outcome measures are difficult to determine, emphasizing them in the monitoring process would speed their development and allow greater flexibility in the use of medical inputs to achieve those outcomes. Measuring quality in terms of the inputs used or the medical treatment process itself would raise the costs of providing care...and might inhibit innovation in the provision of medical care."[26]

While outcome measures are preferred, process measures are generally used.

How could the quality of a doctor's services be determined? Quality might be judged on whether he asked the correct questions, made the appropriate tests, followed the proper procedures. It could also be judged on whether the patient's health improved. That, after all, is what really matters. The problem is that procedures and outcomes are not sufficiently correlated. Good procedures do not necessarily lead to good outcomes, nor poor procedures to bad outcomes. Many diseases are self-limiting, and with poor or even no medical care, the patient will recover. For other health problems, even the best of care may frequently prove of little value. In other words, many factors other than medical inputs affect health. And there is not sufficient medical knowledge to allow for the statistical control of these other influences.

Using performance criteria may be less of a problem in the building area where there is more certainty and more control. While the doctor must take the patient as given, the builder can effectively start from scratch. It is more appropriate to run laboratory experiments on building materials and structures than on human beings.

A distinction can be made between performance measures that can be determined before-the-fact (ex ante) and those which only can be established after-the-fact (ex post). In the building fire area, for example, a primary desirable outcome is that the structure not burn down. We do not want to have to wait two hundred years, however, to determine if the building is sufficiently non-flammable. We do not even want to wait until after the building has been constructed. We need performance tests which measure the flammability of building components and systems in the laboratory, before construction begins.

In the health care field, many laboratory experiments on humans are not permitted, so ex ante output measures are difficult to establish. The performance approach thus usually relies on ex post determinations. In such a situation, input or process measures of quality may be more appropriate.*

*The Quality Assurance literature in the health field is rapidly developing its own detailed terminology. "Implicit process criteria," for example, imply overall judgment by experts about the medical care provided. "Explicit process criteria," by contrast, specifically delineate required steps. "Validated process measures" are procedures considered sufficiently correlated with good outcomes to allow confidence in their use. And "proxy outcomes" are intermediate performance standards. If the goal is to prevent stroke, and high blood pressure is known to be a contributing cause, the reduction of blood pressure could be considered an intermediate or proxy outcome.[27]

## VI. ROLE OF THE NATIONAL BUREAU OF STANDARDS (NBS)

The National Bureau of Standards has an important role to play in the creation of performance standards. Because of the positive externalities involved, the government should play a part. And NBS is an important research branch of the federal government.

NBS already promotes performance standards. It advocates the performance approach in its standards development activities.[28] Basic science research at NBS provides much knowledge needed for the creation of good performance tests. NBS managed the evaluation program for "Operation Breakthrough"[29] and has produced publications such as "Performance Specifications for Office Buildings" and "Performance Criteria Resource Document for Innovative Construction." (CASE 9 cites examples of Performance Criteria and Tests from that document.) Currently, NBS is developing methods for determining equivalency that are expected to be incorporated in the 1980 edition of NFPA's "Life Safety Code."[30] Additionally, the NBS accreditation program provides information on the quality of testing laboratories in certain limited areas.[31]

Suggestions for further NBS action include:

(1) NBS could increase its role in the evaluation of new technology. The accreditation program, which is already indirectly involved in product assessment could be vastly expanded. NBS might also evaluate innovations directly, or support institutional mechanisms for performance evaluation.[32]

(2) NBS could more aggressively seek customers for its performance-writing activities. In some circumstances it might be useful for NBS to charge less and produce a slightly lower quality product. Currently NBS does not always offer a low price option. (A similar situation exists in the health area where it is claimed that only "Cadillac medicine" is permitted. Lower cost/lower quality options are often unavailable, so millions of poor uncovered by Medicaid receive no medical treatment at all.)

(3) NBS could simply devote more of its own resources to performance standards-writing and standards promotion activities. CASE 8 presents an example where a more performance oriented approach might be especially helpful, and where new test methods applicable to a variety of materials are required.

There are many areas for further research about the design/performance issue. These include:

(1) NBS could further document the economic benefits of performance standards. Concrete evidence on the dollar value of performance standards might convince others of the value of this approach.

(2) NBS could provide better information on the cost of converting design standards into performance criteria.

(3) NBS could support research on the cost of verifying compliance with performance standards. In particular it seems useful to have greater understanding about the types of products, technical areas and conditions that lend themselves to performance testing.

(4) NBS could support research on a related issue, the enforcement of performance standards.

(5) Further study would be useful about the effect of design versus performance standards on the relationship between the regulated firms and the regulatory agency. For example, how do these different approaches affect the areas of controversy and the flow of technical information?

(6) One interesting area for research is the role of design versus performance standards throughout the product life cycle. Is one type of standard preferable at one stage? a different type at another?

(7) In depth case studies are always a useful way of increasing understanding about standards and standards issues.

(8) As with all issues concerning standards, a cross-national approach is often illuminating.

Additional research on economic and social effects of standards is essential. It is less clear whether top priority should go to the design/performance issue.* But any further research in this area might be pinpointed to a particular subtopic such as those suggested above.

*There are many other worthwhile topics, from the certification issue to standards for services. Carol Chapman Rawie's "The Economics of Standards: Research Topics and a Review of the Literature," National Bureau of Standards, unpublished, contains an excellent discussion of many of these.

FOOTNOTES

1. Wright, James R., "The Performance Approach: History and Status," in Performance Concept in Buildings, NBS Special Publication 361, Volume 2, 1972, p.848.

2. Ibid, p.850.

3. Discussion with Professor James Brown, George Washington University Law School, September 1979.

4. "Building Research at the National Bureau of Standards 1968-1974," NBS Building Science Series 75, p.17.

5. This is true for the use of standards in both purchasing and regulations. E.g., Federal Property Management Regulations, Federal Register Vol.44, #44 March 5, 1979, p.12032 states "The policies include maximizing the use of functional or performance type requirements."

   The proposed Office of Management and Budget circular #A-119, Jan.,1980, §6(C)11 states: "Preference is given to the use of performance criteria in standards development when such criteria may reasonably be used in lieu of design, materials or construction criteria."

   Proposed law S825 §102(b)(2)(C) 95th Congress, 1st Session, 1977 stated: "Performance standards (are) preferred over design or construction standards."

   The 1971 Federal Trade Commission Advisory letter to the American National Standards Institute stated "Construction or specification standards should not be used except in exceptional circumstances and never when performance standards can be developed."

   In the defense procurement field, directives call for a performance approach beginning with a determination of mission needs, followed by evaluation and reconciliation of needs in the context of agency mission, resources and priorities, and the exploration of alternative systems. Office of Management and Budget "Major Systems Acquisitions," Office of Federal Procurement Policy Pamphlet #1, August 1976.

   The performance approach is also consistent with the new emphasis on government off-the-shelf purchasing. Office of Management and Budget "Implementation of Policy on Acquisition and Distribution of Commercial Products," Dec. 1977.

6. Title VIII of the Housing and Community Development Act of 1974, Public Law 93-383; 42 U.S.C.5301.

7. Hemenway, David, Industrywide Voluntary Product Standards. Cambridge, Mass.: Ballinger Publishing Co., 1975, p.77.

8. Nelson, Richard, Peck, Merton and Kalachek, Edward, Technology, Economic Growth and Public Policy. Washington, DC: The Brookings Institution, 1967, p.201. They give some rough estimates of the relative costs of creating design versus performance standards.

> "The average cost of developing Federal Supply Service specifications is about $1,000. This is estimated from appropriations data in the hearings on the fiscal year 1966 budget (Independent Offices), and data in the Administrator's Report. In contrast, the National Bureau of Standards' tire testing program to develop performance standards cost roughly $300,000 (Reck, Dickson, Government Purchasing and Competition. Berkeley, California: University of California Press, 1954)."

9. Seidel, Stephen, Housing Costs and Government Regulations: Confronting The Regulatory Maze. Washington, DC: Center for Urban Policy Research, 1978, p.80.

10. The problems of misuse are emphasized in Fox, Lester and Allan, Jeffrey, "Tailoring Specifications and Standards to Today's Needs," Defense Management Journal, Oct. 1977, pp.10-16.

11. e.g., Wright James R., "Integration of the Performance Concept into Building Regulations," National Building Regulations Symposium, S83A, 1974.

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13. U.S. Department of Commerce National Voluntary Laboratory Accreditation Program (NVLAP).

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15. Nelson, Peck and Kalachek, p.201. The quote reflects the conventional wisdom, but need only be valid for innovative products. Design criteria should be incorporated into the performance standard to reflect current acceptable technology.

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CASES

## CASE 1

This example illustrates the systematic approach that should be used in writing performance standards.

### Waste Disposal:[1]

The performance approach should begin with a qualitative statement that describes the problem. This will normally include identification of the nature of the problem, including who has it, and also why, where and when it exists.

Questions that need to be answered include:

1. What must we do? In this case, provision must be made for the disposal of waste products--from human digestion, cleansing, food preparation, as well as discarded paper and other trash.

2. Why is this important? It is crucial for safety and health. It is also important for aesthetic reasons.

3. Where do the requirements exist? Arrangements for the disposal of waste must be made for all dwelling units, and particularly for multifamily buildings.

4. When must these requirements be met? Often 24 hours a day, every day.

Performance criteria for the disposal of waste in dwelling units include: availability at all times, visual privacy, maintenance, odor control, physiological requirements, durability of materials, no additional problems created, acoustical privacy, attractiveness.

## CASE 2

This case illustrates that even good design standards may have to be continually revised if they are not to retard the introduction of beneficial innovation.

Antitrust:

Standards can lessen competition in two principal ways:

1. Standards may limit competition among established firms by facilitating price fixing or withholding arrangements;

2. Standards may handicap particular rivals or potential entrants, helping to exclude or boycott their products from the market.

In both cases, design standards are more likely to limit competition than are performance standards. Successful price-fixing agreements usually require a uniformity of products more readily achievable with the help of prescriptive standards. It is well known that design or construction critiera can exclude innovative products from the market.[2]

A famous antitrust case involving design standards is Structural Laminates, Inc. v. Douglas Fir Plywood Association.[3] The case involved a complaint that the defendant trade association had conspired to limit the plaintiff's access to the plywood market by means of a design standard.

For years the industry trade association had a standard requiring that 1/2-inch plywood be made of five plies. This was a reasonable standard at the time it was adopted since the technology had not advanced to the point where less than five plies could satisfactorily be bonded together.

Structural Laminates developed a new processing technique that permitted plywood to be constructed of three instead of five plies. Although this product exhibited performance equal to that of approved plywoods, the trade association did not revise its standards to take account of this technological change. Because contractors generally used the Association standards as guides, and because many mandatory building codes incorporated the five-ply standard, Structural Laminates was unable to effectively compete in the market, and was forced out of business.

The court found that plaintiff's product should have been approved, and that the Association's members had economic reason to exclude it. But since there was no proof of bad motives, the judge held for the defendant:

"The mere failure of one who is responsible for the adoption of a commercial standard to appreciate changes which make that standard obsolete and to take immediate and effective action to alter it, does not amount to a conspiracy to restrain trade."[4]

## CASE 3

This case provides an example of a performance hierarchy in terms of restrictiveness.

Facial Hair Control System:[5]

Given a goal of providing a system for controlling facial hair, a fundamental performance specification might be written which covers all means for freeing the face of unwanted hair.

A more narrow performance specificaton might cover all means for cutting hair from the face. This specification would encompass safety razors, straight razors, and electric shavers, but would exclude tweezers for pulling out hair and methods of killing their roots.

An even more restrictive performance specification could be written for all electric shavers.

A design/construction or hard specification might list materials, and give engineering drawings, assembly, and instructions for an electric shaver. The solution for controlling facial hair would be described in terms of physical characteristics.

## CASE 4

This case provides another example of a possible performance hierarchy.

Waste Management:[6]

At the top might be a fundamental performance specification defining the maximum level of waste to be tolerated in the house with no mention of methods of achieving this goal.

At a lower level might be a derived performance specification which would address the problem from the point of view of establishing plumbing requirements.

Below that might be a more restrictive specification that prescribed a hydrostatic head for the power source.

Beneath that might be a hard specification listing the materials to be used, hardware locations in the structure and the methods for joining pipes.

## CASE 5

This example illustrates the large number of desirable performance characteristics for a particular product.

Sanitary Plumbing Fixtures:[7]

There are many important characteristics of sanitary plumbing fixtures. They can be divided into:

A) Structural components, including such aspects as uniform loading, concentrated loading, impact loading, local deflections, drain fitting load, watertight joint potential, and localized heat source;

B) Thermal aspects, including cracking and crazing, maintenance of bond, and localized heat source;

C) Mechanical aspects, such as surface inspection, water absorption, abrasion, impact resistance, dimensional stability, maintenance of bond, cleanability, slip resistance, scratch resistance, and drainability;

D) Chemical aspects, including household chemical resistance, stain resistance, color stability, surface texture aging, and odorlessness;

E) Biological aspects, including micro-organism nutrients, vermin resistance, and dermal toxicity; and

F) Noise control features, such as noise dampening, and sound attenuation.

CASE 6

This case discusses the issue of trade-offs with respect to fire standards.

Fire Standards:

Sufficient technological information is not yet available to write excellent fire standards. The physics of combustion are complex and are still poorly understood. More needs to be known about the ease of ignition, the rate of spread of fire, the production of smoke and toxic gas, and other characteristics of single materials and combinations of materials. Currently "we are still far from being able to predict the behavior of real fires."[8]

The basic technical problems are suggested by the great discrepancy among countries in judging flammability. In the early 1960's, six European nations, in cooperation with the International Organization for Standardization, ranked twenty-four wall covering materials by their flammability according to each country's standard test. The results were widely divergent. Phenolic-foam wallboard, for example, was the safest of all twenty-four materials according to the standard test in Germany; it was the most hazardous according to Denmark's test.[9]

The test results were markedly dissimilar because the tests were based on different beliefs and judgments rather than on scientifically established fact. No one really knows what characteristics a material should have to be safe in a fire. Moreover, the present approach of assigning a single value to indicate the flammability of a material is basically unsound.

> "As every boy scout knows, one cannot make a campfire with a single log; it takes at least two and preferably more. A single log does not have an inherent fire-safety measure. Only the entire system involved in a potential fire can be rated."[10]

Current building standards and codes overly restrict the range of alternatives for achieving the desired level of fire safety. Individual standards often require a particular design or construction, and the overall codes generally prescribe specific fire safety approaches.

It is not the individual log that should be given a fire safety rating, but the entire campfire. Similarly, it is not each material and aspect that needs to reach a certain level of safety, but the system itself.

Specific trade-offs are sometimes permitted in the codes. The general concept of equivalency--"where the total impact of the risk factors and the compensating safety features produce a level of safety equal or greater to that achieved by rigid conformance to the explicit requirements of the code" is recognized.[11] The equivalency concept, however, has rarely been successfully implemented, and the problem of combustion is typically attacked piecemeal.

All standards, not only for buildings, but also for furnishings, for clothing, for matches, for cigarettes, etc., should be coordinated, something that is not currently done. For example, it might be more efficient to require self-extinguishing cigarettes rather than fire-safe but costly building materials. Ideally, the use of standards and codes for fire prevention should be part of a broader integrated effort--a systems approach--that would include research, education, arson investigation, fire services, etc.

## CASE 7

This case provides an example of a standard containing both prescriptive and performance criteria.

### Portland Cement:[12]

Portland cement is the most important cementitious binder used in buildings throughout the world. Standards for Portland cement contain two sets of requirements, physical and chemical. The physical test requirements include fineness, expansion and strength properties and are primarily functional in nature. The chemical requirements, however, include the maximum percentage of magnesium oxide, sulphuric anhydride and insoluble residue as well as limits of ratios of lime to silicia and alumina to ferric acid. These are prescriptive standards.

Since there is not complete overlap between the physical and chemical requirements, both must be met to pass the standard. The two complement each other. While the physical tests could theoretically cover all the functional requirements, scientists have not yet been able to create performance tests that cover all the important characteristics. The chemical or prescriptive requirements are still essential, particularly with respect to the longer-term properties of the product. Moreover, the chemical tests are helpful to manufacturers in their quality control efforts.

CASE 8

This case illustrates the need to write standards high enough on the performance hierarchy, and to create test procedures that allow comparisons among various materials.

Drain Waste and Vent Piping Materials:[13]

The pipe can be composed of any one of nine different basic materials including copper, brass, and plastic. Standards have been written for each material by separate standards writing committees. Although all the groups are within the American Society for Testing and Materials, there seems to be insufficient coordination among them.

While the standards for each individual material seem fairly reasonable, collectively they do not fill the needs. The standards and tests simply are not comparable. They don't always describe the same properties for the materials, or use comparable methods of measurement. The user is not given sufficient information to make an intelligent judgment concerning which of the various materials is most appropriate for his requirements.

A performance approach could be useful. The most important characteristics for the buyer (e.g., crushing strength; expansion; flammability) should be determined and attempts made to devise unbiased testing methods that would permit comparability. It is not only for drain waste and vent piping that standard test for different materials are not comparable. Similar problems exist for such simple products as doors and windows.

## CASE 9

This case provides examples from NBS' proposed performance specifications for particular aspects of office buildings.

Office Buildings:[14]

A. Control of Noise Levels in Interior Spaces

Criterion:

Noise in interior space shall not exceed an A-weighted level of 45 decibels resulting from interior sources such as heating, plumbing and air conditioning.

Noise levels in interior spaces shall be kept below levels which will cause discomfort or annoyance to the occupants. Each subsystem shall perform its intended function without excessive noise generation or degradation of the acoustical performance of other subsystems. Required exterior-shell attenuation will be dependent upon ambient noise characteristics of specific cases.

Method of Evaluation:

Measurements shall be in accordance with ANSI S1 13-1971, "Standard Methods for the Measurement of Sound Pressure Levels."

B. Protective and Decorative Exterior Coating: Impact Resistance

Criterion:

No chipping, cracking or flaking shall occur when subjected to impact by a 0.9070 kg cylindrical weight.

Method of Evaluation:

American Society for Testing and Materials D2794, Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact). The test shall be performed with coated side up.

C. Protective and Decorative Exterior Coating: Washability

Criterion:

(1) Gloss retention shall be at least ±20% of initial gloss and

(2) 45° reflection shall be not less than 90% of initial reflectance.

Method of Evaluation:

(1) Federal Test Method Standards No.141a, Method 6101, $60^{o}$ Specular Gloss of Method 6121, $45^{o}$, $0^{o}$ Directional Reflectance; followed by:

(2) Method 6141, Washability of Paints, and

(3) Specular Gloss and Directional Reflectance as in (1) above.

## FOOTNOTES TO CASES

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This report compares and contrasts performance and design standards from an economic perspective. The research consisted of a careful examination of the literature and interviews with interested NBS personnel. The paper describes the characteristics of performance standards, explains why they are not used more often, and discusses particular areas where they may be appropriate. The report examines the design versus performance issue in automobile regulation and health care. There are suggestions for further NBS action to promote performance standards, and a listing of areas for further research. Nine brief cases at the end of the paper illustrate points made in the main text.

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