

ACKNOWLEDGEMENTS

The author is deeply indebted to Professor W.F. Dawson,
Professor of Civil Engineering and Building Science, for his guidance
and advice throughout the course of this work.

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CHAPTER I

1.0 INTRODUCTION

In today's world our needs vary from those of the past, and continuously increasing user's requirements are to be satisfied concerning both quality and quantity. In building, the increase in demand is unfortunately accompanied by a depletion of the world natural resources and resulting scarcity of materials. In order to satisfy the balance between demand and supply, the idea of allowing, and in effect, encouraging the introduction of new "Fabrics" (materials, components, systems, products,...) which were not traditionally used in construction, imposes itself on the market.

In a market that is progressively being overwhelmed by new products, which have not been previously tested, the question arises of "How to evaluate these products". Naturally, the first attempt was to try to compare these products with the traditional ones. In other words, the acceptance criteria for a new product was its similarity to and duplication of, all the properties of the traditional product it replaced. This implies that the properties of the traditional fabrics are well determined, which is not the case. Even more importantly, it should first be determined whether all these properties are necessary and sufficient for a fabric to satisfy the required function. It should also be noted that what used to be done in the past is not necessarily the best way of doing things; a method that has proved to be successful, does not mean that it is necessarily optimal. Furthermore, the development of modern technology allows for innovative materials and superior control of their properties as compared to past methods.

1.1 Development of the Performance Concept

Due to the above reasons, it has been realized that another way of thinking is to be adopted in evaluating building fabrics to cope with the new demands of man's modern life. Thus, it seems more advantageous

to define objects in terms of their required functions, rather than their similarity with traditional ones in terms of their materials, their design, their dimensions, etc. In this approach, the main guide for determining the required functions of each object should be the user's needs, since the object is produced for the use and satisfaction of the intended user. There may also be other needs to be satisfied, which may originate from owners, financiers, neighbours, or the community, as well as future users.

Consequently the new approach needs new evaluation criteria against which the performance of each object is to be measured. In other words, a product will be evaluated according to its potential to perform certain functions. In this way the performance concept has developed and hence performance criteria have become the new evaluation criteria.

1.2 Nature and Advantages of Performance Concept

The performance concept can be looked at as merely an organized procedure to express the user's needs in a precise technical form, in terms of the desired characteristics of a product (Fabric) without regard to the specific means to be employed in achieving the results. At its present stage, the performance concept may still be considered a fairly new concept. Therefore, some of its aspects, definitions, and terminology may need some clarification. For this purpose the definitions and terminology that have been adopted by CIB (Commission W-60) since (1975), are quoted as follows:

"In all buildings (structures, projects), the Fabric (building material, building components, products, units, items, elements of construction, assemblies) of which they are composed, is subject to a wide variety of stresses (agents, agentia, forces, states of simultaneous stress, external stresses) in the widest sense of the term, stemming from natural, and artificial or man-made phenomena in their surroundings (environment, physical environment, context) such as fires, wind loads, dampness, impacts, stresses originating from other parts of the fabric, which may

collectively be called environmental factors or given conditions.

The fabric, depending on its nature, will possess certain properties (attributes, features, characteristics, internal forces, qualities) which may or may not influence how the fabric reacts in particular ways to particular stresses (characteristic stresses) occurring in use, or related to use, and the outcome of this dynamic balance, systematic in character, is called the actual performance (performance characteristics) of the fabric. There will be a concomitant performance of the spaces within the fabric, though the attributes and description will differ."

The collection of the performance criteria, such as fire resistance, noise elimination... etc, and the desired performance attributes (properties) of a fabric, e.g. compressive strength, thermal conductivity, that satisfy the requirements of the intended users, constitute the performance specifications. In order to be of practical use, the performance specification should not only include a list of performance attributes and descriptions but should also include practical testing methods to evaluate objectively these attributes.

This will be a necessity since the performance concept no longer specifies materials, designs, or specific solutions, and fabrics are accepted as equal candidates to be tested for the evaluation of their potential to perform the function in question. Therefore, the need for practical standard tests is obvious.

In brief, a summary of the necessary and sufficient constituents of the performance specification can be formulated as follows:

Requirements + Criteria + Tests = Performance Specification.

Some of the advantages that can be cited by using a performance specification are:

- (1) Its use allows the expression of the users needs in more technical terms, thereby allowing greater possibility of more satisfaction,
- (2) It provides an objective basis for selection between available products,

- (3) It provides a stimulus for innovation and development of new alternatives.
- (4) It allows more flexibility in the design process, as compared to the traditional method that imposes a specific solution for each aspect of design.

1.3 Objectives

Users are not normally concerned with the performance of isolated materials, such as for example, mortar in a brick wall. They are rather concerned with the performance of a wall as an integral unit. The focus, therefore, tends to move up a hierarchy of size and complexity - from material to component to building element to spatial envelope to building. Windows thus may be considered an integral part of the weather envelope while doors will be considered an integral part of the interior partitions.

This study will only be concerned with developing technical performance specifications (performance check-list) for the interior construction in residential buildings; namely, the following:

- (1) Floor finishes
- (2) Interior partitions
- (3) Ceiling finishes.

1.4 Scope of Work

Since the system of using the performance concept enfranchising the user within the building industry, the first step in developing the performance specifications was an extensive study of the users' requirements. It should be noted that only the physiological requirements of the users were considered in this study. Other requirements such as psychological, sociological, etc. are beyond the scope of this work. The reason for these limits is that the intended measurements in this study refer to physical qualities (i.e. length, time, mass, temperature, electric current, luminous intensity, etc) while the other requirements (e.g. security, comfort, prestige...) are measured in a more subjective manner that belongs to the soft sciences.

Secondly, a study of all possible user's requirements and a translation of these requirements (needs) in the form of functional requirements allowed the establishment of technical performance criteria that were spelled out in terms of a check list of performance attributes which is the final objective of the study.

However, in order to provide a complete performance specification list, the testing method to measure each attribute should be defined and accompanied - whenever possible - by a recommended minimum value for that attribute, stated in the proper units. For this objective to be accomplished the available test methods (if any) for each performance attribute were surveyed first. The cases for which no tests are available are indicated, as a reference for future research work.

The study was guided by the form of performance requirements developed by the U.S. Corps of Engineers (CERL) in 1972.

CHAPTER II

2.0 TECHNICAL PERFORMANCE SPECIFICATIONS FOR INTERIOR CONSTRUCTION

This chapter constitutes the main body of the report. It presents the technical performance specifications for the floor finishes, the interior partitions, and the ceiling finishes. As mentioned in Section 1.2, the performance specifications are written in the form of:

Requirements (R) + Criteria (C) + Testing (T) = Technical Performance Specification

(A) FLOOR FINISHES (i.e. carpets, tiles, terrazo, etc.)

1.0 SAFETY

1.1 Life

1.11 Fire

1) Flame Spread

R: Control Flame Combustion along the exposed surface

C: Flame spread of the exposed surfaces of this subsystem in use shall not exceed 25.

T: ASTM, E-84 (Vol. 18)

2) Fire Resistance

R: Confine a fire so that it can be controlled

C: The exposed surfaces other than carpets (unless fire retardants) shall have 1 hour rating at least.

T: ATMS, D2859 (Vol. 32), E119 (Vol. 18)

3) Combustibility/Fuel Contributed

R: Withstand high temperature without ignition

C: Surfaces of this subsystem shall not flame after an exposure of thirty (30) seconds and shall not exhibit a temperature rise in excess of (12.22°C) above the furnace air temperature when exposed to a furnace temperature of (750°C)

T: ATSM, E84 (Vol. 18) and E136 (Vol. 18)

4) Smoke Production and Toxic Substance

- R: Non-Production of smoke or toxic fumes
- C: This subsystem shall have a maximum smoke development of 50 and shall not produce any toxic vapor or particles under temperatures of up to (315°C).
- T: ASTM, E84 (Vol. 18), Toxic Materials listed by the American Conference of governmental industrial hygienist at the recommended maximum allowable concentrations.

1.12 Toxicity Characteristics

- R: Non-toxic
- C: Materials used in this subsystem shall not be toxic or give off toxic vapor or particles under the normal conditions of use or at temperatures up to (315°C)
- T: ASTM, E84 (Vol. 18), Materials listed by the American Conference of governmental industrial hygienists at the maximum allowable concentrations.

1.13 Radiation Characteristics

- R: No radiation hazard
- C: Materials used, does not include any radio active materials or does not emit radiation under the normal use or when exposed to high temperatures.
- T: ASTM, D2954 & E261 (Vol. 45)

1.14 Azotic Characteristics

- R: This subsystem in use shall not be subject to vermin or organic deterioration, or provide life support for any organisms.
- C: This subsystem shall provide resistance to:
 - a) termites attack of rating not less than 9
 - b) fungal and algal growth so that the rating of degree of surface disfigurement is not less than 8.

c) carpet black beetle attack so that the loss in weight of tested samples is not more than 5 mg on average provided that no single specimen shows more than 6 mg.

d) mold growth of rating not less than 8

T: (a) ATMS, D3345 (Vol. 22) (b) MSTM, D3274 & D3456 (Vol. 27)
(c) MSTM, D1116 (Vol. 32) (d) MSTM, D3272 (Vol. 27)

1.15 Electrical Characteristics

R: Provide safety against electricity and electrostatic shocks.

C: Shall conform to the requirements of the National code, and develop no static electricity potential, greater than three kilovolts.

T: National Electrical Safety Code, ASTM, F150 (Vol. 46)/
AATCC Test method 134-1969, AATC Technical manual,
Vol. 46, 1970, Electrostatic propensity of carpets,
American Association of textile chemists and colorists,
Research Triangle Park, North Carolina.

1.16 Hazardousness

R: No development of life endangering situations or by-products under normal use.

C: This subsystem shall comply with "American Standard Specifications for making buildings and facilities."

T: ASA A117.1-1961 "American standard specifications for making buildings and facilities".

1.2 Property

1.21 Fire

1) Fire Endurance

No requirements.

1.22 Theft Security

Not applicable.

1.23 Vandalism Security

It is the contribution of:

toughness, touch, stain resistance, washability,
cleanability, scratch resistance, effect of chemicals.

The evaluation of vandalism security shall be, therefore, the summation of the effects of the above factors. The tests and the norms for it will be the tests and norms specified for each factor separately.

1.24 Resistance to Misuse

It is the contribution of strength attributes (e.g. compression, tension, ...etc) plus the durability attributes (e.g. scratch resistance, brittleness, corrosion, ...etc)

The sum of the evaluation of these factors will constitute the evaluation rating for the "Resistance of Misuse".

1.3 Specific Restrictions

- R: The production and installation of this subsystem should cause no jurisdictional disputes.
- C: The subsystem should comply with all applicable enforceable Union requirements.
- T: Observation/specifications.

2.0 FUNCTIONAL

2.1 General Functional Performance Characteristics:

This subsystem shall comprise all wall to wall interior floorings. Floorings shall be designed to provide a durable, comfortable, easy, and safe circulation in the building. It may act to reduce impact sound transmission, sound reverberation and may also serve as a vapor barrier or waterproofing.

All fittings in interfaces shall be included in this subsystem.

Subsystem shall be completely finished in accordance with the other provisions of this specification.

2.2 Size, Weight, Dimensional

1) Dimensions

R: Fit within available space.

C: Dimensions of the subsystem shall be designed to be compatible with the proposed floor plan module.

Subsystem's thickness will fit into floor recesses (if applicable) within tolerances of (specified in Section 3.1) and will not stop doors from working easily and properly.

Joints of the subsystem shall not protrude beyond the plane of the finished floor.

T: Measurements.

2) Flatness

R: The bare eye should not recognize any changes in the flatness of the finished floor.

C: The surface of the finished floor shall not deviate from a flat plane by more than $(1/360)$ of the small dimension of the area covered.

T: Measurement, ASTM, C314 (Vol. 17)

3) Weight

R: The weight of this subsystem should not harm the load carrying capacity or the strength of the supporting elements.

The weight of a component of this subsystem shall be able to be lifted manually by labourers.

G: The weight of this subsystem shall not exceed the specified design value.

Each person carrying, lifting, positioning or manipulating a component shall not be responsible for more than 34 kg of the component's weight.

T: Calculations/Measurements/Specifications.

2.3 Strength

No requirements.

2.4 Durability

2.41 Surface Stability

1) Cleanability

R: Floors should be cleanable and the cleaning process should not damage the original surface.

C: Difference in color between a reference sample and a washed sample should not be more than 3 NBS units.

- cleanability index of 1 or less.

T: Federal Test Method, standard No. 141a, Method 429.1/
ASTM, D1729 (Vol. 46)/ASTM, D2244 (Vol. 46)/ASTM, D2814
(Vol. 32)

- ASTM, C756 (Vol. 17)

2) Washability

R: Provide easy removing of soil and dirt from the surfaces of the floor.

C: Stains should be removed in less than 100 cycles using ASTM test D3450 without erosion of the surface.

T: ASTM, D3450 (Vol. 27)

3) Scratching

R: Surfaces should resist scratching and gouging for its expected life.

C: 4H pencil shall not cut through the film to the substrate for a distance of at least (3.0 mm).

T: ASTM, D3363 (Vol. 27)

4) Abrasion

R: Surfaces shall resist abrasive forces induced by normal use and maintenance.

C: Surface will not wear through to the substrate in fewer than 1500 cycles with a bristal brush wetted with a soap solution.

T: FTMS 1412 Method 6142

-ASTM, D968, D658, D1395 (Vol. 27)/ASTM, C241 (Vol. 19)

5) Staining

R: Surfaces shall provide stain resistance.

C: Surfaces shall resist the stains of staining reagents e.g. foods, cosmetics, beverages, pharmaceuticals, cleaning agents, solvents, etc. with difference in color after removing the staining agent not more than 3 NBS units.

T: ASTM, D2299 (Vol. 35)/FTMS No. 141A, method 4249.1

6) Spalling

R: Surface of the finished floor shall resist chipping

C: Surface should have the rating of "A" (no more than 50 chips of diameter of 1 mm in the 10 x 20 cm)

T: ASTM, D3170 (Vol. 27).

7) Blistering

R: Surfaces shall not show blistering appearance

C: Surfaces should not show blistering any more than the rating of Blister size No. 8 (Few)

T: ASTM, D714 (Vol. 27)

8) Chalking

R: The surface of the finished floor should display no chalking or efflorescence under normal use.

C: The degree of efflorescence of the surface should not be rated more than "flattening and glossing" after 8 cycles of exposure.

T: ASTM, D1736 (Vol. 27), and ASTM, D2831 (Vol. 27).

9) Fading

R: Color of the surface should not change due to the normal use conditions.

C: No change in color due to flat abrasion test more than 3 NBS units.

T: ASTM, D2814 (Vol. 32)/FTMS No. 141a, method 4249-1.

10) Indentation

R: Floor surface should resist indentation under the normal use.

C: The permanent indentation caused by impact energy of (1094 N/M) at any location will not be more than 10% of the elastic deflection.

T: ASTM, F142 (Vol. 46).

11) Change in Appearance

R: Minimum change of the appearance under service during the life of the subsystem.

C: The surface has a change of appearance rating of not more than 1.

T: ASTM, D2401 (Vol. 32).

12) Cracking, Grazing, Splitting and Delaminations

R: The floor under the normal use should not exhibit cracking, grazing, splitting or delamination.

C: Surfaces shall not crack, graze, split or delaminate when exposed to 40 standard fading hours.

T: FTMS, 191, method Federal Specification DDD-C-95/FTMS, 501a, method 5421.

2.42 Material Stability

1) Chemicals

R: Surface of floors should not be damaged by household chemicals and cleaning agents.

C: The surfaces should not be affected by household chemicals and reagents that might be used or come in contact with the floor surface during its lifetime depending on the location of the floor; e.g. distilled water, cold; distilled water, hot; ethyl alcohol (50% volume); vinegar (3% acetic acid); alkali solution, acid solution; soap solution, detergent solution, lighter fluid and volatile reagents; fruit-piece of cut fruit, with cut portion placed face down on surface of floor; oils and fats (butter, margarine, lard, shortening, vegetable oils, etc); condiments (mustard, catsup);

beverages (coffee, tea, cocoa). Effects will be measured in terms of discoloration, change in gloss, blistering, softening, swelling, loss of adhesion, or special phenomena.

T: ASTM, D1308 (Vol. 27)/measurements.

2) Dimensional Stability

R: The floor surface will be stable under fluctuating temperature and humidity.

C: All surfaces other than carpeting shall show linear dimensional change of not more than 0.20 cm/m. Carpeting shall not shrink or buckle more than 1% under service loads and maintenance.

T: Specifications/FTMS 501a, method 6211, ASTM 2494, Federal specification DD-C-95.

3) Cohesiveness-Adhesiveness

R: Floor coverings, surfaces, and coatings shall remain attached to the substrate.

C: All coatings on exposed surfaces of this subsystem under 0.125 mm thick shall not delaminate and shall be rated no less than 3 on scratch test.

T: Federal specification M-MM-A-1/5a, paragraph 4.4.4

4) Brittleness

R: Brittleness of the surface of floor shall not be a problem under normal use.

C: Surface of floor shall not show any fracture or break from an 8 oz. 37.5mm outside diameter steel ball dropped from a height of 600 mm.

T: In accordance with MIL-T-1717 A (ships)

2.43 Life of Subsystem and Component Parts

R: Maximum economic life of the subsystem.

C: Building surface covering and coatings will have a life cycle commensurate with acceptable trade norms.

T: Specifications/drawings/market review (Comparison etc.)

2.5 Transmission

1) Sound

R: Control impact generated sound transmission

C: This subsystem shall not impair the masking of footstep sounds on finished flooring of contiguous rooms vertically by an NC environment of 35.

T: Impact sound transmission test by footfall method/ IBI-1-I, 1965/modification. ASTM, E492 (Vol. 18).

2) Heat

R: Heat gain or loss through conductance should be minimized, commensurate with other criteria demanded.

C: Average values of thermal transmittance, U , thermal conductance, C , inside surface coefficient, h_i , and outside surface coefficient, h_o , shall not exceed the standard values. (Not developed yet).

T: ASTM, C236 and E119 (Vol. 18)

3) Moisture and Liquid

R: Subsystem in use shall not transmit liquids or vapors through its thickness when subjected to washing or spills, or fluctuation of humidity due to common use.

C: Permeability and rate of WVT shall not exceed the standard values (not developed yet).

T: ASTM, C355 (Vol. 18)/ASTM, E96 (Vol. 18)

2.6 Dynamic and Operating Characteristics

No requirements.

2.7 Environmental Quality

2.71 Acoustic

1) Sound generation

Not applicable.

2) Reverberation

R: Floors should absorb or reflect sound in accordance with Acoustic Requirements.

C: When the specimen is in the form of an extended plane surface, the sound absorption coefficients,

and the noise reduction coefficient, NRC, will be not less than the minimum standard values (not developed yet).

T: ASTM, C423 (Vol. 18) and C384 (Vol. 18)

2.72 Illumination

1) Reflectance

R: Provide comfortable reflectance.

C: The subsystem shall have reflectance within the range of (21-39).

T: ASTM, C523 (Vol. 18)/ASTM, LM-22 (Vol. 44).

2.73 Air

R: This subsystem shall not cause any air related discomforts or health hazards.

C: This subsystem shall not release odors deemed to be objectionable in any concentration reasonably predicted.

- It will not release dust or fines that cause air contamination.

- It will not absorb the air humidity leaving the space dry.

T: ASTM, D1354 and D1391 (Vol. 26)/D2553 (Vol. 30).

2.74 Tactile

1) Friction, Slipperiness, Traction

R: The surface of the subsystem shall provide enough skid resistance to prevent inconvenience and accidents.

C: The subsystem should have surface friction not less than 30 BPN through its service life.

- The surface of floor shall not have a coefficient of static friction less than 0.5 (which meets the requirements for compliance with Rule 5 on "The use of terms slip retardant, slip resistance or terms of similar import", of the proposed Trade Practice Rules for floor wax and floor polish Industry as issued by the Federal Trade Commission on March 17, 1953).

T: ASTM, E303 (Vol. 15)/ASTM, D2047 (Vol. 30).

2) Resilience (if applicable)

R: Floors should provide enough resilience to allow for walking comfort and to prevent accidents.

C: Resilient textured floorings shall have embossed depth of not less than (not developed yet).

- wear layer thickness of resilient floor coverings shall not be less than (not developed yet)

- the thickness of resilient nontextile floor coverings shall not be less than (not developed yet)

T: ASTM, F373 & F410 & F386 (Vol. 46).

2.75 Pollutants

R: The use of the subsystem shall not cause pollution hazards.

C: The subsystem under the normal use shall not release any gases, vapors, particles or any other materials that are considered contaminants or hazardous by the ASHRAE or listed by the American Conference of Governmental industrial hygienists, at the recommended maximum allowable concentrations.

T: ASHRAE Handbook/List of toxic materials by American Conference of Governmental Industrial Hygienists.

2.8 Planning and Visual

1) Modularity

R: Easy and fast erection and installation

- Possibility of using other modular systems.

- Easy replaceability.

C: All components are modularly co-ordinated and joints fall on regular module.

T: Measurements/review of plans and drawings.

2) Uniformity.

R: The available exposed surfaces should be matching and coordinated with each other.

C: All exposed surfaces of this subsystem shall have a uniform and coordinated surface texture.

T: Observation.

3) Variety of Colors

R: The colors of exposed surfaces shall satisfy the different users tastes.

C: The exposed surfaces shall be available in at least 5 visually compatible colors.

T: Observations.

3.0 PRACTICAL

3.1 Interface

1) Fit

R: Control fit at interfaces

C: Accomodate partitions, stairs, corridors, etc.

- accomodate joints between individual components.

- trim pieces shall accomodate tolerances.

T: Measurements/Observations.

2) Attachment

R: Provide enough attachments for the subsystem.

C: Floor coverings shall be attached to the structural elements of floors.

T: Details/observation.

3) Tolerances

R: The subsystem shall have acceptable tolerances that will not make erection a problem nor make the production cost very high (because of the high precision).

C: Tolerances shall comply with the following standards:

In 10 ft. 1/4"

Bay 20 ft max. 3/8"

In 40 ft. or more 3/4"

T: Measurements.

4) Relocatability

No requirements.

3.2 Service

1) Repairability and Replacibility

R: Maximum use of the subsystem.

C: Every part of the subsystem shall be able to be repaired or replaced within no more than the original time of installation plus + 25%.

T: Demonstration/observation.

2) Interchangeability

R: Flexibility of using the components of the subsystem.

C: Components, if modular, shall be interchangeable one with another.

T: Demonstration.

3) Disturbance to other systems and occupants

R: Convenience of use of the subsystem all through its life span.

C: Changes and relocations will not require work in any space or room other than that affected by the changes.

T: Observation.

4) Required Maintenance

R: Subsystem shall be maintained inexpensively.

C: Normal service maintenance shall be simple so that local (semi-skilled labour) and commonly available tools can be used.

T: Drawings/specifications.

5) Personnel

R: Avoid need for special (skilled) personnel.

C: All erection, replacements, maintenance, repair and relocation for the subsystem must be done by local (semi-skilled labour) and commonly available tools.

T: Specifications/Calculations/Drawings.

(B) INTERIOR PARTITIONS

1.0 SAFETY

1.1 Life

1.11 Fire

1) Flame Spread

R: Control flame combustion along the exposed surface

C: Flame spread of the exposed surfaces of this subsystem in use shall not exceed 25.

T: ASTM, E-84 (Vol. 18)

2) Fire Resistance

R: Confine a fire so that it can be controlled

C: The exposed surfaces shall have 1 hour rating at least. Doors rating shall comply with the values specified by ASTM, E152.

T: ASTM, D2859 (Vol. 32), E119 and E152 (Vol. 18)

3) Combustibility/Fuel Contributed

R: The finished partition withstands high temperature without ignition.

C: Surfaces of this subsystem shall not flame after an exposure of thirty (30) seconds and shall not exhibit a temperature rise in excess of (12.22°C) above the furnace air temperature when exposed to a furnace temperature of (750°C).

T: ASTM, C84 (Vol. 18) and E136 (Vol. 18)

4) Smoke Production and Toxic Substance

R: None-Production of smoke or toxic fumes.

C: This subsystem shall have a maximum smoke development of 50 and shall not produce any toxic vapor or particles under temperatures of up to (315°C)

T: ASTM, E84 (Vol. 18), Toxic Materials listed by the American Conference of governmental industrial hygienist at the recommended maximum allowable concentrations.

1.12 Toxicity Characteristics

R: Non-toxic.

C: Materials used in this subsystem shall not be toxic or give off toxic vapor or particles under the normal conditions of use or at temperatures up to (315°C).

T: ASTM, E84 (Vol. 18), Materials listed by the American Conference of governmental industrial hygienists at the maximum allowable concentrations.

1.13 Radiation Characteristics

R: No radiation hazard

C: Materials used does not include any radio active materials or does not emit radiation under the normal use or when exposed to high temperatures.

T: ASTM, D2954 and E261 (Vol. 45).

1.14 Azotic Characteristics

R: This subsystem in use shall not be subject to vermin or organic deterioration, or provide life support for any organisms.

C: This subsystem shall provide resistance to:

a) termites attack or rating not less than 9

b) fungal and algal growth so that the rating of degree of surface disfigurement is not less than 8 that no single specimen shows more than 6 mg.

c) mold growth of rating not less than 8

T: (a) ASTM, D3345 (Vol. 22) (b) MSTM, D3274 & D3456 (Vol. 27)

(c) MSTM, D3273 (Vol. 27)

1.15 Electrical Characteristics

R: Provide safety against electricity and electrostatic shocks

C: Shall conform to the requirements of the National electrical code, and develop no static electricity potential, greater than three kilovolts.

- T: National Electrical Safety Code, ASTM, F150 (Vol. 46)
AATCC Test method 134-1969, AATC Technical manual,
Vol. 46, 1970, Electrostatic propensity of carpets,
American Association of textile chemists and colorists,
Research Triangle Park, North Carolina.

1.16 Hazardousness

- R: No development of life endangering by-products or
situations under normal use.
C: This subsystem shall comply with "American Standard
Specifications for making buildings and facilities:
T: ASA A117.1-1961 "American standard specifications for
making buildings and facilities.

1.2 Property

1.21 Fire

1) Fire Endurance

- R: Enough elapsed time during which the subsystem continues
to resist fire in order to allow for fire control.
C: This subsystem shall have at least 1 hour rating.
Doors rating shall comply with the values specified
by ASTM, E152.
T: ASTM, E119 and E152 (Vol. 18).

1.22 Theft Security

Not applicable.

1.23 Vandalism Security

- It is the contribution of:

toughness, touch, stain resistance, washability,
cleanability, scratch resistance, effect of chemicals,...

The evaluation of vandalism security shall be, therefore, the
summation of the effects of the above factors. The tests and
the norms for it will be the tests and norms specified for
each factor separately.

1.24 Resistance to Misuse

It is the contribution of strength attributes (e.g. compression, tension,...etc) plus the durability attributes (e.g. scratch resistance, brittleness, corrosion, ... etc).

The sum of the evaluation of these factors will constitute the evaluation rating for the "Resistance to Misuse".

1.3 Specific Restrictions

R: The production and installation of this subsystem should comply with the applicable codes.

C: The subsystem should comply with all applicable National Codes and building regulations.

T: National codes (only applicable ones) e.g. including and not limited to the following:

a) DOD 4270.1-M "Construction criteria manual"

b) Uniform building code

c) National Fire protection Association Standard(s)

d) American National Standards Institute Safety Standard(s)

e) Federal specification DDD-C-95

f) Federal specification TT-C-0055A

R: The production and installation of this subsystem should minimize the risk of the labour dispute.

C: The production and installation of this subsystem shall comply with all applicable union requirements.

T: Observations/specifications.

2.0 FUNCTIONAL

2.1 General Functional Performance Characteristics

R: Privacy and security in variety of spaces.

C: This subsystem shall comprise all floor to ceiling interior non-load bearing partitions. Partitions shall be fixed, operable, and relocatable types, and may attach to floor and/or ceiling. Partitions shall be designed to provide visual and acoustical barriers between spaces and must have provisions to allow them to provide fire-resistance smoke barriers.

- Interior space dividing elements shall be of the color, texture, finish, and appearance appropriate to the design and function of the space as part of a living environment.
- Door sets complete with frames shall be included as part of this subsystem
- Interior glazed units and vision panels shall be included as part of this subsystem
- Support and fittings for wall hung casework shall be provided in this subsystem.
- Subsystem shall be completely finished in accordance with the other provisions of this specification.

T: Review of drawings/specifications

2.2 Size, Weight, Dimensions

1) Dimensions

R: Capability of transporting the system to a site.

C: The overall dimensions of the subsystem's units shall comply with the applicable transportation regulations and codes.

T: Transportation regulations and codes.

R: All interior enclosure elements shall be able to be transported, erected, demounted, and relocated by manual labor.

C: Each person carrying, lifting, positioning installing) or otherwise manipulating a component shall be responsible for no more than 75 pounds (34 kg) of the components weight. Size of the component shall be commensurate with its weight so as to allow a sufficient number of personnel comfortable access to that component for lifting, carrying and positioning.

T: Review of drawings/specifications.

R: Fit within available space.

C: 1) Vertical dimensions of subsystem shall be designed to be compatible with the proposed system vertical modular dimensions

2) Subsystem in use shall not exceed () in thickness.

d) Thickness of partition at foot and head shall not exceed () in thickness. Values will be given as designed.

T: Observation/Measurement.

R: No installation or appearance problems at panel's interfaces.

C: Exposed joints, if applicable, shall be recessed and shall not protrude beyond the plane of the partition.

T: Observation.

R: Availability of different alternatives and acceptability of changes introduced by individuals.

C: Door widths shall be available in no less than (5) sizes from (2) feet to (3) feet.

Glazed panels shall have transparent and solid panels in a size and configuration compatible with the proposed systems.

T: Observation.

R: Doors shall be sufficiently large to admit personnel, furniture, and equipment through the entrance to the living units, to stairways, to bedrooms, bathrooms, toilet and lavatory areas, and mechanical spaces.

C: Minimum door widths shall be as follows:

3'-0" (.91 m) for main entrance into a living unit

2'-6" (.76 m) for all habitable rooms

2'-0" (.61 m) for toilets and bathrooms

2'-8" (.81 m) for a secondary entrance into a living unit

3'-0" (.91 m) for common stairways

T: Review of drawings/specifications.

2) Plumbness

R: Partitions shall appear vertical and properly aligned.

C: Plumb to within tolerances of 1/4" over height of partition.

T: Subsystem/measurement.

3) Flatness

R: No apparent deviation from complete flatness of the finished surfaces of partitions.

C: The surface of this partition shall not deviate from a flat plane by more than 1/360 of the vertical dimension of the partition, and shall exhibit no sharp transitions in surface within these limits.

T: Prototype/measurement/observation, ASTM, C314 (Vol. 17).

4) Weight

R: The weight of this subsystem shall not exceed the allowable floor loads of the structural subsystem.

C: The subsystem shall not add more than 25 psf to the dead load in the building.

T: Calculation.

- R: The weight of the elements shall not inhibit the relocatability of this subsystem of applicable.
- C: Unless special lifting devices are included as an integral part of the subsystem offered, no single panel, door panel or glazed panel shall weigh in excess of 250 lbs.
- T: The intent is to permit two men to manipulate individual elements of the subsystem, either with or without mechanical aids.

2.3 Strength

- R: The subsystem shall be able to withstand safely all possible loads that the building might experience in its life span under normal use.

- For load bearing interior enclosure:

- C: The subsystem shall resist safely with a factor of safety no less than 2 the following types of loading:
 - (a) Compressive loads - no less than designed (dead plus live loads)
 - (b) tensile loads - not less than designed
 - (c) transverse loads - capable of resisting 10 psf (48 kg/m^2) with a maximum deflection of $1/360$ of the height of the partition.
 - (d) impact loads - resist an impact of 60 ft-lbs with no damage to the surface or other part of this or any other system
 - (e) temporary - withstand loads encountered in the course of transportation, handling, installation, and relocation of the units of the subsystem.

- For non-bearing interior enclosure:

- (a) Deflection of the enclosure elements shall not exceed $h/120$ under the loading conditions of:
 - a. Dead plus the expected superimposed loads.
 - b. 5 psf (24 kg/m^2) over the entire surface of one side of the element, where "h" equals the unsupported height of the element.

T: ASTM, E72 (Vol. 18) and Calculations.

2.4 Durability

2.4.1 Surface Stability

1) Cleanability

R: Exposed surfaces should be cleanable and the cleaning process should not damage the original surface.

C: Difference in color between a reference sample and a washed sample should not be more than 3 NBS units.
- cleanability index of 1 or less.

T: Federal Test Method standard No. 141a, Method 429.1/
ASTM, D1729 (Vol. 46)/ASTM, D2244 (Vol. 46)
-ASTM, C756 (Vol. 17).

2) Washability

R: Provide easy removing of soil and dirt from the surfaces of the partitions,

C: Stains should be removed in less than 100 cycles of the ASTM, D3450 without erosion of the surface.

T: ASTM, D3450 (Vol. 27)

3) Scratching

R: Surfaces should resist scratching and gouging for their expected life.

C: 2H pencil shall not cut through the film to the substrate for a distance of at least (3.0 mm) in "normal use areas" and 3H pencil in "hard use areas".

T: ASTM, D3363 (Vol. 27)

4) Abrasion

R: Surfaces shall resist abrasive forces induced by normal use and maintenance.

C: Surface shall not wear through to the substrate in fewer than 1500 cycles with a bristle brush wetted with a soap solution.

- exposed surfaces shall lose no more than 800 mg/
1000 revolutions in "normal use areas" and no more
than 250 mg/100 revolutions in "hard use areas".

T: FTMS 141a, Method 6192 and FTMS No. 406; Method 1091 and ASTM, D968, D658 (Vol. 27).

5) Staining

R: Surfaces shall provide stain resistance

C: Surfaces shall resist the stains of staining reagents e.g. foods, cosmetics, beverages, pharmaceuticals, cleaning agents, solvents, etc. with difference in color after removing the staining agent not more than 3 NBS units.

T: ASTM, D2299 (Vol. 35)/FTMS No. 141a, method 4249.1

6) Spalling

R: Surface of the finished partition shall resist chipping

C: Surface should have the rating of "A" (no more than 50 chips of diameter of 1 mm in the 4 x 12 in.)

T: ASTM, D3170 (Vol. 27)

7) Blistering

R: Surfaces shall not show blistering appearance

C: Surfaces should not show blistering any more than the rating of Blister Size No. 8 (Few)

T: ASTM, D714 (Vol. 27).

8) Chalking

R: The surface of the finished partition should display no chalking or efflorescence under the normal use.

C: The degree of efflorescence of the surface should not be rated more than "flatting and glossing" after 8 cycles of exposure to the ASTM D1736.

T: ASTM, D1736 (Vol. 27) and ASTM, D2831 (Vol. 27).

9) Fading

R: Color of the surface should not change due to the normal use conditions.

C: No change in color due to maintenance and normal use more than 3 NBS units.

T: FTMS No. 141a, method 4249-1.

10) Indentation

- R: Finished surface should resist indentation under the normal use.
- C: The permanent indentation caused by impact energy of (1094 N/M) at any location will not be more than 10% of the net elastic maximum deflection.
- T: ASTM, F142 (Vol. 46).

11) Resilience

- R: Surfaces shall be resilient to resist indentations and minimize discomfort where required.
- C: 1) The residual indentation on a surface after the application of concentrated loading shall be no greater than .01 inch (0.26 mm).
- T: Review drawings/specifications, for carpeting: Federal Specification DDD-C-95 for all other surfaces; FTMS 501a method 3231 using a 50 pound weight (22.7 kg) for 15 minutes on a 1/4 inch (.64 cm) indenter.

12) Cracking, Grazing, Splitting and Delaminations

- R: The surface under the normal use should not exhibit cracking, grazing, splitting or delamination.
- C: Surfaces shall not crack, graze, split or delaminate that can be visually determined under normal use.
- T: FTMS, 191, Method Federal Specification DDD-C-95/FTMS, 501a, Method 5421.

2.42 Material Stability

1) Chemicals

- R: Surfaces of partitions should not be damaged by household chemicals and cleaning agents.
- C: Surfaces should not be affected by household chemicals and reagents that might be used or come in contact with the exposed surface during its lifetime depending on the location of the partition, e.g. distilled water, cold; distilled water, hot; ethyl alcohol (50% volume);

vinegar (3% acetic acid); alkali solution, acid solution; soap solution, detergent solution, lighter fluid and volatile reagents; fruit-piece of cut fruit, with cut portion placed face down on surface of floor; oils and fats (butter, margarine, lard, shortening, vegetable oils, etc); condiments (mustard, catsup); beverages (coffee, tea, cocoa). Effects will be measured in terms of discoloration change in gloss, blistering, softening, swelling, loss of adhesion, or special phenomena.

T: ASTM, D1308 (Vol. 27)/measurements.

2) Dimensional Stability

R: The subsystem surfaces will be stable under fluctuating temperature and humidity.

C: All surfaces of the partitions shall show linear dimensional change of not more than 0.20 cm/m.

T: Specifications/FTMS 501a, Method 6211, ASTM 2494, Federal specification DD-C-95.

3) Cohesiveness-Adhesiveness

R: Surfaces, and coatings shall remain attached to the substrate.

C: All coatings on exposed surfaces of this subsystem under 0.125 mm thick shall not delaminate and shall be rated no less than 3 on scratch test.

T: Federal specification M-MM-A-1/5a, paragraph 4.4.4.

4) Brittleness

R: Brittleness of the surface of partitions shall not be a problem under normal use.

C: Surface of partitions shall not show any fracture or break from an 8 oz. 37.5 mm outside diameter steel ball dropped from a height of 600 mm.

T: In accordance with MIL-T-1717 A (ships).

2.43 Life of Subsystem and Component Parts

- R: Maximum economical life of the subsystem.
- C: Major elements shall have a life expectancy equal to 20 years. Surface covering and coatings shall have a life cycle that is accepted by the trade norms.
- T: Specifications/drawings/market review (Comparison etc.)

2.5 Transmissions

1) Sound

- R: Control airborne transmission of sound for acoustical privacy between living units.
- C: This subsystem shall not impair the STC value of 40. Seals shall be provided to eliminate flanking paths which might impair this performance.
- T: ASTM, E90/ASTM, E413 (Vol. 18)
- R: Control impact generated sound transmission
- C: This subsystem shall not impair the masking of footstep sounds of contiguous rooms horizontally by an NC environment of 35.
- T: Impact sound transmission test by footfall method/ IBI-1-I, 1965/modification, ASTM, E492 (Vol. 18).

2) Heat

- R: Heat gain or loss through partitions should not cause a problem or discomfort for users.
- C: Average values of thermal transmittance, U , thermal conductance, C , inside surface coefficient, h_i , and outside surface coefficient, h_o , shall not exceed the standard values (not developed yet).
The partitions should have one-hour fire rating.
- T: ASTM, C236 and E119 (Vol. 18).

3) Moisture and Liquid

- R: Subsystem in use shall not transmit liquids across its thickness when subjected to washing or spills.
- C: Rate of WVT, water vapor permeance, and permeability shall not exceed the standard values (not developed yet)
- T: ASTM, C355 (Vol. 18)/ASTM, E96 (Vol. 18)

2.6 Dynamic and Operating Characteristics

1) Method of Operation:

- R: Door modules shall offer the following modes of operation:
 - left hand and right hand swing
 - single and multiple leaf
 - removable transom panels

2.7 Environmental Quality

1) Sound generation

- R: Construct subsystem so as to be free from rattles and squeaks.
- C: The measured sound pressure levels produced or transmitted by this subsystem in use when combined with the measured sound pressure levels produced or transmitted by all other subsystems in use shall be no greater than those defined by NC 35, except that sounds produced by expansion and contraction of this subsystem, by operation of the doors in any but the immediate space, and all pure tones shall be at least five (5) decibels below the sound pressure level otherwise produced or transmitted by this system at the corresponding frequency band.
- T: Measurement of Sound/USAS S1.2-1962 and ASHRAE Data Guid and Book, 1967, Chapter 31, and ASTM, E336 & E90 (Vol. 18).

2) Reverberations

- R: Partitions should absorb sound and cause no echo.
- C: When the specimen is in the form of an extended

plane surface, the sound absorption coefficients and the noise reduction coefficient, NRC, shall be not less than the standard values (not developed yet)
T: "ASTM, C423 (Vol. 18) and C384 (Vol. 18).

2.72 Illumination

1) Reflectance

R: Provide comfortable reflectance
C: The subsystem shall have reflectance within the range of (40-60).
T: ASTM, C523 (Vol. 18)/ASTM, LM-22 (Vol. 44).

2.73 Air

R: This subsystem shall not cause any air related discomforts or health hazards.
C: This subsystem shall not release odors deemed to be objectionable in any concentration reasonably predicted.
- It shall not release dust or fines that cause air contamination.
- It shall not absorb the air humidity leaving the space dry.
T: ASTM, D1354 and D1391 (Vol. 26)/D2553 (Vol. 30).

2.74 Pollutants

R: The use of the subsystem shall not cause pollution hazards...
C: The subsystem under the normal use shall not release any gases, vapors, particles or any other materials that are considered contaminants or hazardous by the ASHRAE or listed by the American Conference of Governmental industrial hygienists, at the recommended maximum allowable concentrations.
T: ASHRAE Handbook/List of toxic materials by American Conference of Governmental Industrial Hygienists.

2.8 Planning and Visual

1) Modularity

- R: Easy and fast erection and installation
 - Possibility of using other modular systems.
 - Easy replaceability.
- C: All components are modularly coordinated and joints fall on regular module.
- T: Measurement/review of plans and drawings.

2) Uniformity

- R: The available exposed surfaces should be matching and coordinated with each other.
- C: All exposed surfaces of this subsystem shall have a uniform and coordinated surface texture.
- T: Observation.

3) Variety of Colors

- R: The colors of exposed surfaces shall satisfy the different users tastes,
- C: The exposed surfaces shall be available in at least 5 visually compatible colors.
- T: Observations.

3.0 PRACTICAL

3.1 Cost

- 1 R: The interior enclosure system and its components shall be economical to transport, store, install, maintain, relocate, and repair.
- C: The required activities, manhours, skill requirements and the average purchase costs shall be as described with supporting evidence by the proposer and verified by the evaluators.
 - Initial cost may be increased in order to insure minimum on site maintenance of the interior enclosure system and minimum necessity for the replacement of components.
- T: Evaluation/analysis of drawings/specifications/calculations.

3.2 Interface

1) Fit

R: Control fit at partition base.

C: Accomodate with floor. Partitions shall be designed so as to accomodate tolerances in floor system as specified elsewhere, and provide adequate seal for acoustic and/or fire-rating purposes.

T: Subsystem/Detail/Observation

R: Control fit at junction between partition and at ceiling

C: Accomodate ceiling to provide seal with ceiling in accordance with acoustic and fire requirements if applicable.

Head-relief moulding, if applicable, shall be designed to accomodate ceiling tolerances as specified elsewhere.

T: Detail/System Prototype/Observation.

R: Subsystem shall be designed to provide a seal when butted against out-of-system exterior wall elements. Seal shall be adequate to achieve acoustic performance and fire-rating performance if applicable.

T: Observation.

R: Trim pieces, if applicable, shall be designed to accomodate tolerances of out-of-system partitions and out-of-system exterior walls.

T: Detail/Prototype/Observation.

R: Provide capability to accomodate Out-of-System built elements.

C: This subsystem's partition surfaces shall be capable of accepting the following Out-of-System applied finishes:

2) Attachment

- R: Attach subsystem at floor and ceiling
- C: Subsystem shall be designed to be attached to building structure at floor and/or at ceiling.
No other attachments shall be used.
- T: Detail/Prototype/Observations.

3) Tolerances

- R: The subsystem shall have acceptable tolerances that will not make erection a problem nor make the production cost very high (because of the high precision).
- C: Tolerances shall comply with the following standards:
 - In 10 ft. $1/4"$
 - Bay 20 ft max. $3/8"$
 - In 40 ft. or more $3/4"$

- T: Subsystem/Physical/Measurement

4) Relocatability

Every part of this subsystem shall be removable without damage to other subsystems, except for minor repairable damage to finished floor and ceiling.

5) Sequence of Erection

System shall be designed to be installed in a substantially complete raw space after mechanical and toilet modules have been installed. Installation of this system shall not delay the progress of finishing of the space, except inasmuch as provided for in the General Conditions for the project.

3.3 Services

1) Repairability and Replaceability

- R: Any element of this subsystem, partition panels, door panels, glazed panels, shall be able to be repaired or replaced with no more than 4 manhours of labor - without requiring the use of special materials - at the use location.
- T: Demonstration, observation.

2) Interchangeability

R: Panels, door panels, and glazed panels shall be designed to be interchangeable one with the other.

T: Demonstration, observation.

3) Disturbance to Other Systems and Occupants

R: Changes and relocations in this subsystem shall not require work in any room or space otherwise unaffected by the planning change in order to achieve the specified performance after the planning change.

T: Observation.

(C) CEILING FINISHES

1.0 SAFETY

1.1 Life

1.11 Fire

1) Flame Spread

R: Control Flame Combustion along the exposed surface

C: Flame spread of the exposed surfaces of this subsystem in use shall not exceed (25). If a fully automatic fire protection sprinkler system is provided, the flame spread rating shall not exceed (200).

T: ASTM, E-84 and E-162 (Vol. 18)

2) Fire Resistance

R: Confine a fire so that it can be controlled

C: The exposed surfaces at use position shall have 1 hour rating at least

T: ASTM, D2859 (Vol. 32), E119 (Vol. 18)

3) Combustibility/Fuel Contributed

R: Withstand high temperature without ignition.

C: Surfaces of this subsystem shall not flame after an exposure of thirty (30) seconds and shall not exhibit a temperature rise in excess of (12.22°C) above the furnace air temperature when exposed to a furnace temperature of (750°C)

T: ASTM, E84 (Vol. 18) & E136 (Vol. 18)

4) Smoke Production and Toxic Substance

R: Non-Production of smoke or toxic fumes.

C: This subsystem shall have a maximum smoke development of 150 and shall not produce any toxic vapor or particles under temperatures of up to (315°C)

T: ASTM, E84 (Vol. 18), Toxic Materials listed by the American Conference of governmental industrial hygienist at the recommended maximum allowable concentrations.

1.12 Toxicity Characteristics

- R: Non-toxic.
- C: Materials used in this subsystem shall not be toxic or give off toxic vapor or particles under the normal conditions of use or at temperatures up to (315°C).
- T: ASTM, E84 (Vol. 18), Materials listed by the American Conference of governmental industrial hygienists at the maximum allowable concentrations.

1.13 Radiation Characteristics

- R: No radiation hazard
- C: Materials used do not include any radio active materials or do not emit radiation under the normal use or when exposed to high temperatures.
- T: ASTM, D2954 & E261 (Vol. 45)

1.14 Azoic Characteristics

- R: This subsystem in use shall not be subject to vermin or organic deterioration, or provide life support for any organisms.
- C: This subsystem shall provide resistance to:
 - a) termites attack of rating not less than 9
 - b) fungal and algal growth so that the rating of degree of surface disfigurement is not less than 8
 - c) mold growth of rating not less than 8
- T: (a) ASTM, D3345 (Vol. 22) (b) MSTM, D3274 & D3456 (Vol. 27)
(c) MSTM, D3273 (Vol. 27)

1.15 Electrical Characteristics

- R: Provide safety against electricity and electrostatic shocks.
- C: Shall conform to the requirements of the National code, and develop no static electricity potential, greater than three kilovolts.
- T: National Electrical Safety Code, ASTM, F150 (Vol. 46)/ AATCC Test method 134-1969, AATC Technical manual, Vol. 46, 1970, Electrostatic propensity of carpets, American Association of textile chemists and colorists, Research Triangle Park, North Carolina.

1.16 Hazardousness

- R: No development of life endangering situations or by-products under normal use.
- C: This subsystem shall comply with "American standard specifications for making buildings and facilities."
- T: ASA A117.1-1961 "American standard specifications for making buildings and facilities".

1.2 Property

1.21 Fire

1) Fire Endurance

No requirements.

1.22 Theft Security

Not applicable.

1.23 Vandalism Security

It is the contribution of:

toughness, touch, stain resistance, washability,
cleanability, scratch resistance, effect of chemicals....

The evaluation of vandalism security shall be, therefore, the summation of the effects of the above factors. The tests and the norms for it will be the tests and norms specified for each factor separately.

1.24 Resistance to Misuse

It is the contribution of strength attributes (e.g. compression, tension...etc) plus the durability attributes (e.g. scratch resistance, brittleness, corrosion, ... etc)

The sum of the evaluation of these factors will constitute the evaluation rating for the "Resistance to Misuse".

1.3 Specific Restrictions

- R: The production and installation of this subsystem should cause no jurisdictional disputes.
- C: The subsystem should comply with all applicable enforceable union requirements.
- T: Observation/Specifications

2.0 FUNCTIONAL

2.1 General Functional Performance Characteristics

The subsystem shall comprise all wall to wall ceiling finishes including coatings, tiles, or any other forms of coverings.

The subsystem will have to provide acoustical finish as well as light reflecting surfaces.

2.2 Size, Weight, Dimensions

1) Dimensions

R: Fit within available space.

C: Dimensions of the subsystem shall be designed to be compatible with the proposed floor plan module.

. Subsystem's thickness will fit into ceiling recesses (if applicable) within tolerances (specified Sec. 3.1)

. Joints of the subsystem shall not protrude beyond the plane of the finished surface.

T: Measurements

2) Flatness

R: The bare eye should not recognize any changes in the flatness of the finished surface

C: The surface of the finished plane shall not deviate from a flat plane by more than $(1/360)$ of the small dimension of the area covered.

T: Measurement, ASTM, C314 (Vol. 17)

3) Weight

R: The weight of this subsystem should not harm the load carrying capacity or the strength of the supporting elements.

The weight of a component of this subsystem shall be able to be lifted manually by labourers.

C: The weight of this subsystem shall not exceed the specified design value.

T: Calculations/Measurements/Specifications.

2.3 Strength

No requirements.

2.4 Durability

2.41 Surface Stability

1) Cleanability

R: Finished surfaces should be cleanable and cleaning process should not damage the original surface.

C: 1) The exposed surface of this subsystem in use, when compared with the reference samples and with any other specimen subjected to this test, shall not differ in color beyond the color tolerance limits established for this subsystem, or by more than three (3) NBS units, whichever is greater, and when compared with the specimen prior to test shall not exhibit a change in color of more than three (3) NBS units. Variegated irregular or translucent finishes shall be evaluated for acceptability of color change only visually, subject to review by the Project Manager.

2) The exposed surface of this subsystem in use shall not exhibit a change in gloss value of more than five (5) units.

T: Test Method Standard No. 141a, Method 6141/Federal Test Method Standard No. 141a, Method 6123; gloss evaluation shall be by Federal Test Method Standard 141a, Method 6101; all visual evaluations shall be made from a distance of thirty-six (36) inches, at any angle, with the sample illuminated as in use/ASTM, D1729 and D2244 (Vol. 46)/ASTM, C756 (Vol. 17).

2) Washability

R: Provide easy removal of soil and dirt from the finished surfaces.

C: Stains should be removed in less than 100 cycles using ASTM, D3450 test without erosion of the surface.

T: ASTM, D3450 (Vol. 27).

3) Scratching

R: Surfaces should resist scratching and gouging for their expected life.

C: 2H pencil shall not cut through the film to the substrate for a distance of at least (3.0 mm).

T: ASTM, D3363 (Vol. 27)

4) Abrasion

R: Surfaces shall resist abrasive forces induced by normal use and maintenance.

C: Surface will not wear through to the substrate in fewer than 1500 cycles with a bristle brush wetted with a soap solution. Exposed surfaces shall lose no more than an average of 800 milligrams per 1,000 revolutions.

T: FTMS 1412 Method 6142/FTMS No. 406, Method 1091/ASTM, D968, D658/FTMS No. 414a, Method 6192.

5) Staining

R: Surfaces shall provide stain resistance.

C: Surfaces shall resist the stains of staining reagents e.g. foods, cosmetics, beverages, pharmaceuticals, cleaning agents, solvents, etc. with difference in color after removing the staining agent not more than 3 NBS units.

T: ASTM; D2299 (Vol. 35)/FTMS No. 414a, Method 4249.1

6) Spalling

R: Surface of the finished ceiling shall resist chipping

C: Surface should have the rating of "A" (no more than 50 chips of diameter of 1 mm in the 10 x 30 cm)

T: ASTM, D3170 (Vol. 27)

7) Blistering

R: Surfaces shall not show blistering appearance.

C: Surfaces should not show blistering any more than the rating of Blister Size No. 8 (Few)

T: ASTM, D714 (Vol. 27)

8) Chalking

- R: Finished surfaces should display no chalking or efflorescence under normal use.
- C: The degree of efflorescence of the surface should not be rated more than "flatting and glossing" after 8 cycles of exposure.
- T: ASTM, D1736 (Vol. 27) and ASTM, D2831 (Vol. 27).

9) Fading

- R: Color of the surface should not change due to the normal use conditions.
- C: No change in color due to flat abrasion test more than 3 NBS units.
- T: ASTM, D2814 (Vol. 32)/FTMS No. 141a, method 4249-1.

10) Indentation

- R: Provide resistance to point impact.
- C: 1) Surfaces of this subsystem that are exposed to view shall withstand .033 kg.m (3 lb. in) of impact on their exposed surface without any indentation greater than 1.2 mm, measured twenty-four (24) hours after impact, and without any splitting or other permanent damage.
- T: Falling Ball Impact/Federal Test Method Standard No. 406, Method 1075.
- C: 2) Any component part of this subsystem, one (1) surface of which is exposed to view, subject to contact with any part of the Space Dividers subsystem shall withstand .2kg.m (18 lb.in) of impact on its exposed surface without any indentation greater than 1.2 mm, measured twenty-four (24) hours after impact, and without any splitting or other permanent damage.
- T: Federal Test Method Std. No. 406, Method 1075.

11) Cracking, Grazing, Splitting and Delaminations

- R: The surface under the normal use should not exhibit cracking, grazing, splitting or delamination.

- C: Surfaces shall not crack, graze, split or delaminate when exposed to 40 standard fading hours.
- T: FTMS, 191, Method Federal Specification DDD-C-95/FTMS, 501a, Method 5421.

2.42 Material Stability

1) Chemicals

- R: Finished ceiling surfaces should not be damaged by household chemicals and cleaning agents.
- C: The surfaces should not be affected by household chemicals and reagents that might be used or come in contact with the surface during its lifetime depending on the location of the surface; e.g. distilled water, cold; distilled water, hot; ethyl alcohol (50% volume); vinegar (3% acetic acid); alkali solution, acid solution; soap solution, detergent solution, lighter fluid and volatile reagents; fruit-piece of cut fruit, with cut portion placed face down on the surface; oils and fats (butter, margarine, lard, shortening, vegetable oils, etc); condiments (mustard, catsup); beverages (coffee, tea, cocoa). Effects will be measured in terms of discoloration, change in gloss, blistering, softening, swelling, loss of adhesion, or special phenomena.
- T: ASTM, D1308 (Vol. 27)/measurements.

2) Thermal

- R: The finished surfaces will be stable under fluctuating temperature and humidity.
- C: Finished surfaces (depending on material) shall show linear dimensional change of not more than 2 mm/m.
- T: Specifications/FTMS 501a, Method 6211, ASTM 2494, Federal specification DD-C-95.

3) Cohesiveness-Adhesiveness

- R: Ceiling coverings, surfaces, and coatings shall remain attached to the supporting elements.

C: All coatings on exposed surfaces of this subsystem under 0.125 mm thick shall not delaminate and shall be rated no less than 3 on scratch test.

T: Federal specification M-MM-A-1/5a, paragraph 4.4.4

4) Friability

R: Control friability.

C: Any component part of this subsystem, one (1) surface of which is exposed to view in use, composed of any materials except metal or sheet glass, shall not lose more than fifty percent (50%) in weight in ten (10) minutes.

T: "Strength Properties of Acoustical Materials", ASTM, C-367 (Vol. 18)

5) Corrosion

R: All metallic parts (if any) shall resist corrosion.

C: Avoid contact of dissimilar metals which are likely to produce electrolytic corrosion.

- surfaces having corrosion tendency in the presence of moisture and oxygen shall be treated so that such corrosion shall be prevented.

T: ASTM Corrosion Resistance Test.

2.43: Life of Subsystem and Component Parts

R: Maximum economical life of the subsystem

C: Building surface covering and coatings will have a life cycle commensurate with acceptable trade norms.

T: Specifications/drawings/market review (Comparison etc)

2.5 Transmission

1) Sound

R: Control impact generated sound transmission

C: This subsystem shall not impair the masking of footstep sounds on finished surfaces of contiguous rooms vertically by an NC environment of 35.

T: Impact sound transmission test by footfall method/ IBI-1-I, 1965/modification. ASTM, E492 (Vol. 18).

2) Moisture and Liquid

R: Subsystem in use shall not transmit liquids across its thickness when subjected to washing.

C: Permeability shall not exceed the standard values (not developed yet).

T: ASTM, C355 (Vol. 18)/ASTM, E96 (Vol. 18)

2.6 Dynamic and Operating Characteristics

No requirements.

2.7 Environmental Quality

2.7.1 Acoustic

1) Sound generation

Not applicable

2) Reverberation

R: Ceilings should absorb or reflect sound in accordance with Acoustic requirements.

C: When the specimen is in the form of an extended plane surface, the sound absorption coefficients, and noise reduction coefficient, NRC, will be not less than the minimum standard values (not developed yet).

T: ASTM, C423 (Vol. 18) and C384 (Vol. 18)

2.7.2 Illumination

1) Reflectance

R: Provide comfortable reflectance

C: The subsystem shall have reflectance within the range of (80-92).

T: ASTM, C523 (Vol. 18)/ASTM, LM-22 (Vol. 44).

2) Emittance

Not applicable.

2.73 Air

R: This subsystem shall not cause any air related discomforts or health hazards.

C: This subsystem shall not release odors deemed to be objectionable in any concentration reasonably predicted.

- It will not release dust or fines that cause air contamination.

- It will not absorb the air humidity leaving the space dry.

T: ASTM, D1354 and D1391 (Vol. 26)/D2553 (Vol. 30).

2.74 Tactile

No requirements.

2.75 Pollutants

R: The use of the subsystem shall not cause pollution hazards.

C: The subsystem under the normal use shall not release any gases, vapors, particles or any other materials that are considered contaminants or hazardous by the ASHRAE or listed by the American Conference of Governmental industrial hygienists, at the recommended maximum allowable concentrations.

T: ASHRAE Handbook/List of toxic materials by American Conference of Governmental Industrial Hygienists.

2.8 Planning and Visual

1) Modularity:

R: Easy and fast erection and installation

- possibility of using other modular systems
- easy replacability

C: All components are modularly coordinated (if applicable) and joints fall on regular module.

T: Measurements/review of plans and drawings.

2) Uniformity

R: The available exposed surfaces should be matching and dimensionally coordinated with each other.

C: All exposed surfaces of this subsystem shall have a uniform and coordinated surface texture.

T: Observation.

3) Variety of Colors

R: The colors of exposed surfaces shall satisfy the different users tastes.

C: The exposed surfaces shall be available in at least 5 visually compatible colors.

T: Observation.

3.0. PRACTICAL

3.1 Interface

1) Fit

R: Control fit at interfaces.

C: Accommodate partitions, stairs, corridors, etc.

- accommodate joints between individual components (if applicable).

- trim pieces shall accommodate tolerances (if applicable)

T: Measurements/Observations.

2) Attachment

R: Provide enough attachments for the subsystem.

C: Structural elements will be attached to coverings which will be attached to structural elements of roofs or the above floors only.

3) Tolerances

R: The subsystem, if modular, shall have acceptable tolerances that will not make erection a problem nor make the production cost very high (because of the high precision).

C: Tolerances shall comply with the following standards

In 10 ft. 1/4"

Bay 20 ft. max. 3/8"

In 40 ft. or more 3/4"

T: Measurements.

4) Relocatability

No requirements.

3.2 Service

1) Repairability and Replacability

R: Maximum use of the subsystem

C: Every part of the subsystem shall be able to be repaired or replaced within no more than the original time of installation plus $\pm 25\%$.

T: Demonstration/observation.

2) Interchangeability

R: Flexibility of using the components of the subsystem.

C: Components, if modular, shall be interchangeable one with another.

T: Demonstration.

3) Disturbance to Other Systems and Occupants

R: Convenience of use of the subsystem all through its life span.

C: Changes and relocations will not require work in any space or room other than that affected by the changes.

T: Observations

4) Required Maintenance

R: Subsystem shall be maintained inexpensively.

C: Normal service Maintenance shall be simple so that local (semi-skilled labor) and commonly available tools may be used.

T: Drawings/Specifications

5) Personnel

R: Avoid the need for special (skilled) personnel.

C: All erection, replacements, maintenance, repair and relocation work for the subsystem must be done by local (semi-skilled labor) and commonly available tools.

T: Specifications/Calculations/Drawings.

CHAPTER III

EVALUATION PROCEDURE

To facilitate the evaluation procedure, an evaluation matrix-form is suggested (Fig. 1). The fourteen columns of the matrix are explained as follows:

- 1) NAME OF SUBSYSTEM - e.g. Floor finish, interior partitions, etc.
- 2) GENERAL CRITERIA - i.e. Safety, function, and practical criteria
- 3) TECHNICAL PERFORMANCE CRITERIA - e.g. Life safety, strength, durability, etc (in the sequence shown in Chapter II)
- 4) TECHNICAL PERFORMANCE ATTRIBUTES - e.g. Flame spread, toxicity characteristics, flatness, etc (in the sequence shown in Chapter II).
- 5) WEIGHT OF GENERAL CRITERIA - It is the relative weight of importance of the "General Criteria" (i.e. Safety, Function and Practical). This relative weight is to be assigned in percent, e.g. property safety = $x_1\%$, Function = $x_2\%$, and practical = $x_3\%$, where $x_1 + x_2 + x_3 = 100\%$. It should be noted that "life safety" is an absolute criteria (yes/no), therefore, no weight has been assigned for it.
- 6) WEIGHT OF TECHNICAL PERFORMANCE CRITERIA - It is the relative weight of importance of the non-absolute technical performance criteria under each of the "General Criterion" separately. e.g. under the general criterion of "Function" there are "dimensions, flatness, etc; the relative weight of each will be given in percent and will be equal to $x_{21}\%$, $x_{22}\%$ $x_{2n}\%$ respectively, where $x_{21} + x_{22} + \dots + x_{2n} = 100\%$. In the same way the different technical performance criteria under "safety" and "practical" will be assigned their relative weights of importance.
- 7) WEIGHT OF PERFORMANCE ATTRIBUTES - It is the relative weight of importance of the performance attributes under each of the "Technical Performance Criterion" separately. Like the above,

it will be given in percent. e.g. under "property safety" the performance attributes (i.e. fire endurance, theft security, etc) will be assigned the weights of $x_{111}\%$, $x_{112}\%$, $\dots x_{11n}\%$, where $x_{111} + x_{112} + \dots x_{11n} = 100\%$. In a similar manner the weights of the rest of the performance attributes under each of the performance criterion (i.e. function and practical) will be assigned.

- 8) COMBINED WEIGHT - It is the product of the multiplication of the weight assigned for the performance attribute under consideration, the weight assigned for the "General Criteria", and the weight of the "Technical Performance Criteria" under which this performance attribute falls.
- 9) MEASURABLE RATING - It is the values objectively measured by the testing method(s) specified for each performance attribute.
- 10) MINIMUM DESIRABLE RATING - It is the standard values (norms) that constitute the lower limit of acceptance for each performance attribute.
- 11) ACTUAL SCORE - It is the product of multiplying the "Measurable Rating" by its "Combined Weight".
- 12) DESIRABLE SCORE - It is the product of multiplying the "Minimum Desirable Rating" by its "Combined Weight".
- 13) TOTAL: ACTUAL/(DESIRABLE) - It is the summation of the Actual Score (Desirable Score) for each "Technical Performance Criteria" to ease the comparison and the evaluation of a subsystem.
- 14) REMARKS - In this - column positive or negative deviation from the "Minimum Acceptable Value" for each attribute will be noted. Also, subjective judgement, depending on each case, may be given.

By using this matrix, which needs only very simple mathematics, a system can be assigned a numerical value, that can be measured against

the minimum acceptable value. In this manner, the system might be accepted or rejected without a need to be compared with an alternative. If alternatives are available, the method is still useful by comparing the values assigned for the alternatives, and the choice can be numerically determined.

As an illustration of the evaluation system, an example is given in Figure 2. Having performed this evaluation operation a system qualifies only if its "Total Actual Score" for each "Technical Performance Criteria" exceeds its "Total Desirable Score", providing that the system has passed the absolute criteria of "Life Safety".

However, we should not ignore the need for the subjective evaluation, since a system might be accepted under the above criteria while some of its individual "Technical Performance Attributes" do not pass the "Minimum Desirable Rating". Thus, in individual cases, the subjective evaluation of the importance of each technical performance attribute that failed to pass the minimum desirable rating, as well as the number and degree of failures of these failed attributes, is of great concern.

Figure 2

NAME OF SUBSYSTEM	GENERAL CRITERIA	TECHNICAL PERFORMANCE CRITERIA	TECHNICAL PERFORMANCE ATTRIBUTES	WT. OF GENERAL CRITERIA	WT. OF TECH. PERF. CRITERIA	WT. OF PERF. ATTRIBUTE	COMBINED WT.	OBJECTIVELY MEASURED RATING	MIN. DESIRABLE RATING	ACTUAL SCORE	DESIRABLE SCORE	TOTAL ACT. DES.	REMARKS
SAFETY	Life safety (absolute criteria)	Fire Flame Spread Toxicity Hazardousness etc.	YES/NO	30%	10%	20% 5% $\Sigma 100\%$	6%	20	25 or less	passed			
FUNCTION	Property Safety	Fire Endurance Vandalism security etc.	30%	50%	10%	15% 10% $\Sigma 100\%$	1.5%						-57-
PRACTICAL	Strength	Compressive Tensile etc.	20%	15%	10% 10% $\Sigma 100\%$								
PRACTICAL	Interface	Fit Tolerance etc.	20%		$\Sigma 100\%$								

CHAPTER IV

SUMMARY AND CONCLUSIONS

In this study it was emphasized that the specification of the required functions to be performed by an object (component, subsystem, or system) is more advantageous than the specification of its material, dimensions, design, etc. In building, this approach allows for: expressing the users' needs in more technical and precise terms, thereby allowing greater possibility of satisfying these needs; providing an objective basis for selection between available products; allowing for innovation and development of new products, and allowing for more flexibility in the design as compared with the traditional method that imposes a specific solution for each aspect of design.

In order to develop a performance specification, against which any system (or subsystem) can be measured, three main requirements are to be determined. These are: the users' requirements, the technical performance criteria that express and assure the satisfaction of the users' requirements, and the method of testing these technical performance criteria.

The above has been done for the interior construction of residential buildings (i.e. floor finishes, interior partitions, and ceiling finishes). The study and presentation of the proposed technical performance specifications were guided by the form of technical performance requirements developed by the U.S. Corps of Engineers (CERL) in 1972.

A matrix-form was suggested to facilitate the evaluation of building "fabric". The evaluation technique is based on "Acceptance/Rejection" on absolute criterion (i.e. life safety) and by assigning a minimum desirable numerical value for each of the non-absolute criteria. In the latter case,

"fabric" is measured against that value without having to be compared with another alternative. Although the evaluation method has a definite objective value as an acceptance criteria, the method still permits the subjective evaluation, whenever it is needed in individual cases.

It is suggested that the method is simple and useful. However, there are still some standard minimum desirable values as well as the relative weights of the different criteria that need to be developed by authorities in order to bring this method into practice on a standardized basis. The establishment of Standard and Guidelines for the above is recommended for future research.

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