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APPLICATION OF HUMAN ENGINEERING DESIGN CRITERIA TO MEDICAL EQUIPMENT

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The similarities between medical equipment and military materiel suggests that the current active consideration of generating a human engineering design criteria for medical equipment might focus on MIL-STD-1472B as an initial structuring tool. This report discusses benefits and shortfalls of general human engineering design standard usage, potential adaptation of some of the criteria of MIL-STD-1472B to medical equipment, precautions in adopting such provisions and several possible approaches that might be taken.

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FORWORD

This technical note provides an abbreviated summary of an invited presentation given at the human engineering session of the Thirteenth Annual Meeting and Exhibit of the Association for the Advancement of Medical Instrumentation, 29 March 1978, at Washington, DC.

APPLICATION OF HUMAN ENGINEERING DESIGN CRITERIA TO MEDICAL EQUIPMENT

INTRODUCTION

There are many similarities between medical equipment and military materiel such as instrumentation, test equipment and other items which are found in military settings typified by cockpits, command, control and communication rooms and maintenance/diagnostic areas. These similarities suggest that the benefits of applying human engineering standards to military items might be spun off to the design of medical equipment.

Several differences between the military and medical environments suggest some caution in certain areas if utilization of military human engineering standard practice is considered for adaptation to medical equipment.

The intent of this report is to very briefly outline the purpose of a standard in general, describe the contents of the current military standard for human engineering, touch on some benefits of its use, provide some general observations regarding sections of that standard as they might apply to medical equipment, and note some caveats regarding such adaptation.

THE PURPOSE OF A HUMAN ENGINEERING STANDARD

Stated in the briefest terms, a standard, as we will be using the term, is a limit on design. A standard—or in this case, a human engineering standard—is not intended to restrict design options or stifle innovation. Design limits are set around those bounds which have been found to be appropriate for human use of a product in an effective, simple, efficient, safe and reliable manner. In other words, a human engineering design standard can be considered to be a set of consumer advocate criteria.

INFLUENCING DESIGN

A human engineering standard is not very different from other standards in the means it uses to influence design. It expresses design requirements quantitatively and qualitatively (see Figure 1). Quantitative provisions are expressed as minimum or maximum dimensions, masses, times, temperatures, luminous intensities, electric currents or measures derived from these basic units. Definitive criteria, free from ambiguity, are typically stated in quantitative terms. For example, it would be more meaningful to specify a maximum noise limit in dB(A) than to merely state that noise levels should be minimized.

Provisions of standards can also be described on the basis of their effectivity—whether the provision is mandatory or advisory. In typical usage, "shall" expresses a binding provision, while "should" is used to indicate an advisory provision.

	REQUIREMENTS	
	QUANTITATIVE	QUALITATIVE
MANDATORY		
ADVISORY		

Figure 1. How a human engineering standard influences design.

Providing they reflect minimum essential requirements, and if a customer must prescribe design criteria on a one-time basis prior to design, human engineering provisions are best prescribed on a mandatory basis in quantitative terms. On the other hand, if minimum control of design is required to give maximum flexibility to a design concept effort, human engineering design criteria, expressed in qualitative/advisory form would likely be more suitable.

CONTENT OF AN EXISTING HUMAN ENGINEERING STANDARD

Table 1 summarizes the content of MIL-STD-1472B (3). The purpose of listing the contents is to illustrate categories of human engineering design criteria currently used by the Services, which could serve as a "strawman" for drafting a human engineering standard for medical equipment which is understood to be under active consideration.

TABLE 1

Content of MIL-STD-1472B

MATERIEL ORIENTED	FUNCTION ORIENTED
CONTROL-DISPLAY INTEGRATION	ANTHROPOMETRY
VISUAL DISPLAYS	ENVIRONMENT
AUDIO DISPLAYS	MAINTAINABILITY
CONTROLS	LABELING
GROUND WORKSPACE	REMOTE HANDLING
SMALL SYSTEMS AND EQUIPMENT	HAZARDS AND SAFETY
OPERATIONAL AND MAINTENANCE GROUND/SHIPBOARD VEHICLES	
AEROSPACE VEHICLE COMPARTMENTS	

CRITERIA SOURCES

The basis for criteria addressing the categories above are rooted in research (e.g., maximum noise limits), population stereotypes (e.g., some manual control directions), arbitrary decisions (e.g., paint specifications for panel colors) and common sense (e.g., requirements for emergency shut-off controls, markings, etc.).

BENEFITS

Application of human engineering design criteria to routine design problems by use of a standard has proven quite effective. It has avoided "reinvention of the wheel" for questions which tend to arise on a repetitive basis from system to system such as color coding, direction of control movement, consistency of panel layout, general dimensioning and the like. It has also placed into the hands of the designer the criteria against which his product will likely be tested. It has fostered consistency in application of basic human engineering and has avoided restating accepted standards in design documentation from system to system.

Along with other benefits which will not be touched on here, the formating of the services' human engineering design criteria as a military standard affords users the means to comment directly on the content during the lifetime of the standard and during updates through their respective industry groups. In other words, the users are involved in shaping the standard.

Finally, the standard can be tailored for application to specific design and performance objectives such that non-applicable provisions can be deleted or values altered where appropriate if mutually agreed by buyer and seller. Other benefits of using a human engineering standard are listed below in Table 2, along with some representative problem areas which can arise if care is not taken in the application process.

TABLE 2

Human Engineering Standards

BENEFITS	PRECAUTIONS
SAVES TECHNICAL MANPOWER	TIME REQUIRED FOR EXTENSIVE CHANGES
CONVENIENT AND INEXPENSIVE TO CITE	COMPLETENESS OF CONTENT
READILY AVAILABLE	INTERPRETATION PROBLEMS
PROVISIONS FAMILIAR TO HFE SPECIALISTS	DOESN'T SPECIFY PERFORMANCE
INSURES MUTUAL UNDERSTANDING	IMPROPER CITATION
REPRESENTS A GENERAL CONCENSUS	OCCASIONAL CONFLICTS
STANDARDIZES WITHIN AND BETWEEN SYSTEMS	IMPROPER APPLICATION
USES CONVENTIONAL INSTRUMENT	
FACILITATES PREPARATION OF DERIVATIVE DOCUMENTS	

APPLICATION TO MEDICAL EQUIPMENT DESIGN

The possibility of using the current military standard as a strawman for structuring a human engineering standard for medical equipment suggests that careful consideration be given to both advantages and potential precautions.

Casual examination of the major detail design paragraphs of MIL-STD-1472B will disclose a number of general areas common to both military systems and medical equipment where much of the criteria used by the services may be directly applicable to medical equipment. These areas include control/display integration, design of controls, visual and some auditory displays, and consideration of the functional concerns, such as maintainability, labeling and the like. Medical equipment, in many instances, will tend to have the same type of operator interaction hardware as military equipment; including switches, light emitting displays, auditory signals, CRT displays, labeling practices, handles, coding, plotters and other considerations. Again, major sections of MIL-STD-1472B are devoted to these items of common interest and are probably, for the most part, directly usable for medical equipment human engineering design criteria.

MIL-STD-1472B has been coordinated with the Office of the Surgeon General, Department of the Army, and Navy and Air Force counterparts for initial issue and revisions and notices. Such reviews would generally consider procurement of medical equipment as well as medical aspects of conventional military systems.

A substantial portion of the dimensional criteria and data in MIL-STD-1472B is based on anthropometric surveys of Army and Air Force nurses, measured in 1977 and 1968, respectively. Therefore, consideration of an extremely important segment of the medical equipment user community is already embedded in salient sections of the Tri-service human engineering standard.

It is possible that the medical equipment community might already have some conversance with MIL-STD-1472B since it is used, in one form or another, by some agencies outside the Department of Defense, such as NASA and the US Postal Service.

SOME PRECAUTIONS

Considering MIL-STD-1472B as a candidate for source material to structure a human engineering standard for medical equipment should be approached with care in three basic areas—population differences, environmental criteria and degree of user training.

Until several years ago, the content of MIL-STD-1472B was largely based on research data obtained from studies and experiments involving male subjects. With the addition of Notice 1 and 2 (the latter of which is currently in coordination), provision for women in MIL-STD-1472B is now reasonably covered; however, several areas are not completely addressed as of now—primarily the weight lifting, force exertion and carrying criteria. As a general statement with regard to this consideration, any use of MIL-STD-1472B as a strawman for developing human engineering criteria for medical equipment should be based on (a) use of Notices 1 and 2, (b) awareness that a few areas are still largely based on male data, and (c) understanding that the general criteria attempts to accommodate applicable 5th percentile female through 95th percentile male dimensions and other characteristics.

It should also be kept in mind that much of the material in the current standard was gathered from research on and applied to a narrower age group than those who might be using medical equipment in the civilian sector. For example, the 1966 anthropometric survey of Army men reflected by MIL-STD-1472 involved a mean age of 22.17 years with standard deviation of

4.64 years; the 1977 anthropometric survey of Army women also used by MIL-STD-1472B involved a mean age of 23.1 years with standard deviation of 5.4 years. The probable difference in user age distribution should be kept in mind although it is difficult to nail down any practical significance of such differences at this point.

The second area of precaution involves consideration of human engineering criteria for work environment--primarily acoustic noise and illumination provisions. For example, maximum noise levels permitted for Army systems without use of hearing protection must be below 85 dB(A). The Occupational Safety and Health Administration (OSHA), for example, sets this level at 90 dB(A) and makes allowances for exposure time. It is suspected that maximum allowable noise levels where medical equipment would be used, for example in surgical facilities, might be somewhat different than the categories used for military applications based on speech intelligibility.

Illumination criteria could be considered in the same light. Most military applications might require different visual tasks than medical equipment applications, possibly giving rise to different criteria -- particularly where one visualizes use of medical equipment within surgical facilities.

Finally, the general type of training by the user populations--military and medical equipment users--may tend to differ. This should be taken into account where appropriate; e.g., labeling terminology permitted, presumed facility in working with metric units, and use of coding and other conventions which may be prevalent within the ranks of medical equipment users.

POSSIBLE APPROACHES

To construct a human engineering standard for medical equipment from the ground up, one could consider applicable handbook material for structuring into design standard provisions tailored to medical equipment. Several good handbooks are readily available and include MIL-HDBK-759 (Human Factors Engineering Design for Army Materiel) (2), Air Force Systems Command Design Handbook 1-3 (Human Factors Engineering) (4), and the Joint Army-Navy-Air Force Steering Committee Human Engineering Guide to Equipment Design (6).

Other approaches which could be considered include supplementing MIL-STD-1472B with medical equipment human engineering design criteria or constructing an interim standard by extraction of relevant provisions of MIL-STD-1472B. The first of these approaches was implemented by Marshall Space Flight Center which generated Design Standard 512A (5), supplementing MIL-STD-1472B with zero-g criteria. The second approach was taken by the US Postal Service Laboratory 72-5, Human Engineering Design Criteria for Postal Systems and Equipment (1), which extracted relevant provisions from MIL-STD-1472B, tailored as required for postal systems.

It would appear that a good starting point to develop an interim human engineering standard for medical equipment might be to take the same option as the Postal Service Laboratory--use of a tailored version of MIL-STD-1472B, deleting non-applicable provisions, changing those required for correlation with equipment applications, and adding requirements as needed in keeping with this objective. This approach, if desired, could be used to develop an interim human engineering standard for medical equipment in a minimum amount of time and with minimum effort. Changes and revisions, of course, would be undertaken when human factors information and utilization practices are well enough in hand to warrant formulation of standardizing doctrine specific to the field.

Discussion of the above approaches should not necessarily be interpreted as a recommendation to employ MIL-STD-1472B as a basis for structuring a medical equipment *human engineering design standard, but as a suggestion* as to how a group might proceed, given that such a standard might be desired and providing that MIL-STD-1472B is accepted as a reasonable baseline approach. It should be kept in mind that other options are open, such as preparation of a handbook or guide.

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