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12 May 1970

Materiel Test Procedure 3-3-521
U. S. Army Infantry Board

U. S. ARMY TEST AND EVALUATION COMMAND
COMMON SERVICE TEST PROCEDURE

HUMAN FACTORS ENGINEERING

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1. OBJECTIVE

The objective of this Materiel Test Procedure (MTP) is to determine the adequacy of the human factors engineering (HFE) aspects of the test item, and its compatibility with the skills, aptitudes and limitations of the soldiers who will employ it.

2. BACKGROUND

HFE is the application of scientific principles concerning human physical and psychological characteristics to the design of equipment, so as to increase speed and precision of operations, provide maximum maintenance efficiency, reduce fatigue, and simplify operations. HFE requires the consideration of human characteristics such as separate anthropometrics (the study of human body measurements on a comparative basis), intellectual abilities, sensory capacities, mobility, muscle strength, basic skills, and the capacity to learn new skills.

The evaluation of HFE plays a major role in the conduct of a service test. Each man-machine relationship must be carefully observed to determine the efficiency and ease of operation, creature comfort, and limitations, when the test item is employed by a representative soldier in a simulated operational environment.

3. REQUIRED EQUIPMENT

Human factors evaluations normally will require no special tools or test equipment other than those accompanying the test item. Additional selections of required equipment shall be made by the test officer and the human factors engineer based on the nature of the test item and the particular human factors aspects to be tested.

4. REFERENCES

- A. USATECOM Regulation 70-1, Application of Human Factors Engineering, 16 October 1968.
- B. USATECOM Regulation 385-6, Verification of Safety of Materiel During Testing.
- C. USATECOM Regulation 750-15, Maintenance Portion of the Service Test.
- D. HEL-STD S-1-63(B), Maximum Noise Level for Army Materiel Command Equipment, 1965.
- E. HEL-STD S-4-65, Human Factors Engineering Requirements for the Development of U.S. Army Materiel, 1965.
- F. Report of Human Factors Engineering Seminar, (presented for U.S. Continental Army Command) Dunlap and Associates, Inc., 429 Atlantic Street, Stamford, Connecticut, 1960.

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- H. Morgan, Chapanis, Cook and Lund, Human Engineering Guide to Equipment Design, McGraw-Hill Book Co., 1963. (Sponsored by Joint Army-Navy-Air Force Steering Committee).
- I. Chapanis, A., Research Techniques in Human Engineering, The Johns Hopkins Press, 1959.
- J. McCormick, Ernest J., Human Factors Engineering, McGraw-Hill Book Company, Inc., 1964.
- K. MTP 3-3-500, Preoperational Inspection and Physical Characteristics.
- L. MTP 3-3-501, Personnel Training.
- M. MTP 3-3-503, Battlefield Mobility.
- N. MTP 3-3-517, Safety.
- O. MTP 3-3-519, Transportability.
- P. MTP 3-3-522, Ease of Assembly and Disassembly.
- Q. MTP 3-3-523, Troop Acceptability.
- R. MTP 3-3-524, Adverse Conditions.
- S. MTP 7-3-511, Air Drop Operations - Personnel and Individual Equipment.

5. SCOPE

5.1 SUMMARY

The areas of consideration relative to HFE designated in this MTP will aid in the evaluation of the overall man-machine relationship when the test item is employed by the soldier in a combat environment. As a result of observations, examinations, and measurements of specific design features, supplemented by the opinions of test soldiers, the test officer can arrive at a conclusion relative to soldier efficiency when operating the test item and identify any problem areas incident thereto. Where a test item is unduly complex USATECOM may assign a HF engineer to assist in test development. Where appropriate the test officer may request such assistance through channels.

During the service test, a specific subtest relative to HFE is conducted. In addition, concurrently during all testing, data is collected from all subtests as they relate to human factors. This HFE data is then evaluated and serves as the basis for conclusions and recommendations.

For convenience of organization, observation areas are keyed to the subtests normally applicable to Infantry weapons and equipment. Checklists are provided to aid the test officer in selecting appropriate areas for HFE evaluation.

a. Personnel and Personnel Training - The objective of this subtest is to determine (1) whether the test soldiers are representative of those who will use the test item in combat, and (2) the ability of test soldiers to complete the required training.

b. Operational Aspects - The objective of this subtest is to determine (1) the man-machine relationship relative to ease and efficiency of operation, and (2) HFE design deficiencies which tend to degrade operational performance.

c. Assembly and Disassembly - The objective of this subtest is to determine appropriateness of HFE design for ease of assembly and disassembly.

d. Battlefield Mobility - The objective of this subtest is to determine appropriateness of HFE design with respect to ease of portability and transportability in the field.

e. Maintenance - The objective of this subtest is to determine appropriateness of HFE design with respect to ease of maintenance.

f. Adverse Conditions - The objective of this subtest is to determine the suitability of the test item under adverse environmental conditions.

g. Troop Acceptability - The objective of this subtest is to reflect the attitudes, reactions, and comments of the test soldiers in reference to the suitability of the HFE design.

5.2 LIMITATIONS

While safety is an important factor in HFE, it is not discussed in this MTP since safety aspects are outlined in MTP 3-3-517, Safety.

6. PROCEDURES

6.1 PREPARATION FOR TEST

NOTE: General guidance in human factors evaluation is contained in Appendix A. Military human anthropometric data is contained in Appendix B.

a. A system and task analysis shall be performed in such detail as required by the nature and complexity of the test item.

b. Test personnel shall be briefed on HFE prior to the conduct of the tests.

c. Based on an analysis of the tests to be performed, the following shall be prepared in advance of the actual testing: data forms, checklists, questionnaires (opinions will be labeled as such, and separated from factual data), error forms and error-likely forms.

6.2 TEST CONDUCT

6.2.1 Personnel and Personnel Training (Ref MTP 3-3-501)

6.2.1.1 Personnel

a. The mental qualifications, aptitudes, skills, and status of training of proposed test soldiers will be evaluated to ensure that those selected to participate in the test are representative of those who will use the test item in the field.

b. Physical characteristics of the proposed test soldiers will be evaluated with respect to anthropometric data shown in Appendix B in order to

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identify those within and those not within the 5th through 95th percentile group. For this purpose, initial classification will be based on stature.

c. The design of the test item will be evaluated relative to its suitability for test soldiers although all are in the 5th through 95th percentile group. Limitations on use of the test item by these soldiers, and by soldiers not within the 5th through 95th percentile group, will be determined.

6.2.1.2 Training

During conduct of the personnel training (MTP 3-3-501), particular note will be made of the following:

a. Appropriateness of the training literature with respect to the intelligence level and aptitudes of representative test soldiers.

b. The ability of representative test soldiers to understand the training relative to assembly and disassembly, operation, and maintenance of the test item.

c. Suitability of the proposed POI and related lesson plans with respect to the intelligence level and aptitudes of representative test soldiers.

6.2.2 Operational Aspects

During the conduct of operational subtests special observations will be made and comments of test soldiers will be obtained relative to the active man-machine relationship. A checklist of specific areas for observation follows. The list is not all inclusive and is necessarily general in nature. The test officer will examine the particular test item and study, augment, and refine the list as necessary to determine specific areas of HFE applicability.

a. Overall ease of operation.

b. Any restrictions of body movements during operation.

c. Any fatigue producing body or limb positions imposed.

d. Operations requiring excessive physical effort.

e. Any awkward movements or error-likely situations imposed by location, design, or unnatural direction of movement of controls such as knobs, levers, cranks, locking devices, quick release devices, etc.

f. Suitability of the ratio of movement of a control to the movement of the controlled component (e.g., traversing controls of a mortar).

g. Suitability of arrangement of controls and mechanical assemblies with respect to logical order of use.

h. Suitability of controls with respect to size, shape, separation, displacement, resistance, and locking features.

i. Ease of identification of controls and control positions by sight and touch.

j. Visibility and legibility of indicators, and direct usability of information indicated.

k. Legibility, clarity, brevity, and general adequacy of instructional, safety, and identification labels.

l. Ease of identification of items of similar general configuration (e.g., practice and live rounds or grenades) by sight and touch.

m. Design for ease of setting ammunition fuzes and adjusting charge

increments.

- n. Any operational requirements which cannot be readily accomplished by all test soldiers in the 5th through 95th percentile group.
- o. Capability and limitations of use by soldiers in the lower and upper 5th percentile group.
- p. Capability of effective use by both right and left handed soldiers, and soldiers wearing eyeglasses.
- q. Capability of effective use by soldiers wearing any type of combat clothing and equipment normal for the temperate zone.
- r. Capability of effective use by soldiers wearing the protective mask and clothing.
- s. For individual weapons, configuration and balance with respect to pointing characteristics and ease of use in all normal firing positions.
- t. Discomfort and hazards from blast, noise, and recoil of weapons.
- u. Interference and hazards caused by ejection of cartridge cases or secondary missiles from weapons.
- v. Discomfort, hazards, or inefficiency of operation caused by excessive heating of a weapon from firing or heat absorption from exposure to the sun.

6.2.3 Assembly and Disassembly (ref MTP 3-3-522)

s. The procedures of common MTP 3-3-522, Ease of Assembly and Disassembly, describe test exercises and observations to be conducted in three phases as follows:

- 1) Training Tests - controlled exercises in assembly and disassembly incident to use of the test item under classroom conditions concurrently with the mechanical instruction phase of personnel training (MTP 3-3-501).
- 2) Field Observations - observations of assembly and disassembly incident to use of the test item under field conditions during conduct of operational tests.
- 3) Field Tests - controlled exercises in assembly and disassembly conducted under stress of simulated combat during operational tests.

b. During conduct of the tests described above, the suitability of HFE design of the test item for ease of assembly and disassembly will be noted and evaluated. The HFE checklist, paragraph 6.2.2, will be considered with respect to assembly and disassembly. Some additional areas for assembly and disassembly HFE consideration are listed below:

- 1) Brevity, clarity, and general adequacy of step-by-step assembly and disassembly instructions furnished with the test item.
- 2) Design to require assembly and disassembly of a minimum of components or parts.
- 3) Adequacy of means for identifying components and parts (labels or other markings).
- 4) Design to aid identification of mating parts and determination of sequence of assembly and disassembly without reference to instructions.
- 5) Design to preclude incorrect mating of parts.

- 6) The fit of mated parts and ease of verifying seating and locking.
- 7) Minimum use of small parts which could be easily mislaid or lost and, conversely, locking features to prevent loss.
- 8) Simplicity and reliability of fasteners and locking devices.
- 9) Number and simplicity of required tools.
- 10) Design for use of field expedients in lieu of special tools; suitability of recommended or devised field expedients.
- 11) Design consistent with human habit patterns (e.g., clockwise or down to tighten or lock, counterclockwise or up to loosen or release).
- 12) Capabilities of test soldiers with respect to manual dexterity required in handling and manipulating parts during assembly and disassembly.

6.2.4 Battlefield Mobility (Ref MTP 3-3-502)

Within the limitations imposed by the nature of the equipment, physical design should provide integral features and/or special provisions to facilitate lifting and carrying by the individual soldier with minimum loss of efficiency. During conduct of common MTP 3-3-502, Battlefield Mobility, measurements and observations will be made to determine HFE design characteristics which enhance or unduly limit the man-portability and man-transportability of the equipment. Some subjects for HFE consideration are listed below. These will be explored as appropriate for the particular test item.

- a. Weight, dimensions, and configuration with respect to anthropometric characteristics of representative test soldiers.
- b. Method of carry and means to secure during marches.
- c. Location, design, and texture of gripping areas and carrying handles.
- d. Location, configuration, and surface texture of areas which, although not specifically intended for the purpose, may be used for lifting and carrying heavy items.
- e. Mutual interference with individual equipment and clothing.
- f. Human limitations to endure strain, fatigue, and discomfort while carrying.
- g. Effect on combat readiness of the soldier.
- h. Handling characteristics during combat movements which require the soldier to run, jump, hit the ground rapidly, roll, and assume various firing positions.
- i. Capabilities and limitations for carrying over all types of terrain.
- j. Ease of carry and freedom from interference while carrying in air and ground vehicles.
- k. Ease of carry and delivery by individual parachutist.
- l. Human capabilities and limitations with respect to distance of carry.
- m. Weight, configuration, center of balance and load distribution of items which are transported by two or more men.

- n. Compatibility of design for use with standard individual load carrying equipment.
- o. Packaging, protection, or other preparation required to ready the item for field transport.

6.2.5 Maintenance (Ref TECOM Reg 750-15)

Human factors aspects will be observed during all operator and organizational maintenance performed on the test item, and note will be made of any maintenance difficulties or maintenance functions which could be reduced or eliminated by improved design of the test item with respect to the capabilities and limitations of the test soldier.

6.2.6 Adverse Conditions (Ref MTP 3-3-524)

During conduct of adverse climatic conditions testing, the effects of these conditions on the capability of the soldier to transport, operate, and maintain the test item will be noted. The extent to which decreased efficiency is attributable to normal human limitations, and the extent to which it may be caused by HFE design deficiencies of the test item will be determined.

6.2.7 Troop Acceptability (Ref MTP 3-3-523)

a. Acceptability or non-acceptability of an item by the individual soldier is often based on the influence of various human factors elements. The actual merits or deficiencies of physical design of the test item are not necessarily the decisive factors. Other important elements may include the soldier's physical limitations, habits, and experience; his intelligence, aptitudes, and skills; his attitude and motivation toward the test; and his psychological reactions for which no causal connection is apparent.

b. The results of conduct of common MTP 3-3-523, Troop Acceptability, as reflected in questionnaires, interviews, and spontaneous comments, will be screened and analyzed to identify and differentiate, insofar as possible, the human factors elements which influenced the individual responses. All comments will be evaluated and weighted for validity in light of the human factors which influenced the opinions. When any significant tendency toward non-acceptability is indicated, the troop acceptability data and the equipment design will be further studied in order to identify any HFE design deficiencies which were not revealed in other subtests.

6.3 TEST DATA

Photographs, motion pictures, video tapes, and fast frame photographs will be used as aids in evaluating human engineering aspects of the service test.

6.3.1 Personnel and Personnel Training

6.3.1.1 Personnel

a. In addition to the personnel data required by the commodity MTP, the following will be determined and recorded for each proposed test soldier:

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- 1) Armed Forces Qualification Test (AFQT) category.
- 2) Army Qualification Battery (AQB) scores.
- 3) Physical profile.
- 4) Civilian education.

b. The identity of the selected test soldiers falling within the 5th through 95th anthropometric percentile groups (stature) and those within the lower and upper 5th percentile group will be recorded.

c. A record will be made of any critical design dimension of the test item which does not adequately accommodate any anthropometric characteristic of the full range of selected test soldiers. These limiting characteristics will be described.

6.3.1.2 Training

The test data will be the considered opinions of test officer and instructors regarding the training aspects described in paragraph 6.2.1.2.

6.3.2 Paragraphs 6.2.2 through 6.2.7

The test data will be based on:

- a. Observations of the test officer and test NCO made throughout the service test.
- b. Spontaneous comments of test soldiers recorded throughout the service test.
- c. Replies to interviews and questionnaires.
- d. Any other relevant data recorded throughout the service test.

6.4 DATA REDUCTION AND PRESENTATION

a. All test data having a bearing on human factors will be extracted, collated, analyzed, and evaluated to determine (1) whether the design of the test item meets the established HFE criteria, and (2) the overall suitability of the item with respect to the physical, mental, and psychological capabilities and limitations of the human user.

b. The evaluation of the HFE aspects of the service testing will be presented as a portion of the test report. When opinions are presented, they will be identified as such, and separated from factual data.

APPENDIX A

HUMAN FACTORS EVALUATION

SYSTEM AND TASK ANALYSIS

Before any evaluation of the human factors in a test item can be undertaken, it is necessary to understand the man-machine relationship when the test item is employed by the soldier in a simulated combat environment. This requires a complete understanding of the equipment, personnel, facilities, and procedures required to accomplish the mission. The analysis should be done to the level of detail necessary for determining the human factors objective and developing the test and evaluation techniques.

TEST AND EVALUATION METHODS

Test personnel with a limited knowledge of human factors principles and with careful planning and preparation can conduct a satisfactory evaluation. Basic methods of performance measurement are used. These methods might include: (1) observation and measurement; (2) checklists for general guidance; (3) interview and questionnaire; and (4) comparative tests made under controlled conditions of environmental stress and task interference.

The most direct way of evaluating problems in human engineering is to visually observe the equipment and the human operators in an actual or simulated environment. Although the observational method is not the complete answer in all situations, it is used in some form and to some degree, alone or in combination with other methods, in every evaluation. The most commonly used methods and techniques are listed below:

- a. Operator Opinions -- obtained by interviews and questionnaires.
- b. Activity Sampling Techniques -- timing of operator activity and the steps required for completion of a work unit, e.g., activities and steps in emplacing, laying, and firing a mortar.
- c. Process Analysis -- a group of techniques for recording compactly the various steps involved in a process.
- d. Records -- records of tests previously made on the equipment; equipment failure and maintenance records.

CONDITIONS FOR TESTING

During the course of the commodity service test, human factors which cannot be measured quantitatively (e.g., operability), should be evaluated during those periods and under operational conditions most closely resembling conditions expected to be encountered by the system in actual use. The conditions outlined in the paragraphs which follow should be observed.

- a. Require the equipment to carry out those missions, and only those missions, for which it is intended or to which it is likely to be assigned.
- b. The tasks to be performed should be a fair sample of those to be

performed when the equipment is in actual use, and should be comparable in speed, number, and difficulty to those with which the equipment must cope in the future. The following steps should be taken to fulfill this requirement:

- 1) Require operators to work at realistic speeds. Demonstrations that permit operators to work at their own pace can make a system appear to be more accurate and to work more smoothly than it will work in actual service.
- 2) Give operators the same amount and kind of work that they will have in future operational situations. Systems that perform well at light or moderate loads may break down when higher loads are imposed.
- 3) Make all aspects of the task difficulty realistic; the problems should not be too easy, nor should they be problems to which the operators already know the answers.
- 4) Require operators to observe all the rules of realistic operation; even if some of the rules are not directly pertinent to the evaluation, they are necessary to duplicate the effects of the task on the performance of the system.

c. Make the physical and environmental conditions duplicate those to be found in the future use of the equipment. If extreme conditions of heat, cold, humidity, cramping of the body, long and fatiguing watches, etc., are to be encountered in operational use, these should be included in the conditions of the system evaluation. These conditions should produce, for the operators, the same tasks, stresses, motivation, and knowledge of results that they will be subjected to under operating conditions.

d. Make certain that the operators used in the evaluation represent those who will be operating the equipment in actual use, particularly with respect to such characteristics as age, physical characteristics, general ability, experience, and training. The following guides will be useful in accomplishing this objective:

- 1) Avoid the use of biased subjects -- those that may have some stake in the outcome of the evaluation. A person who wants one system to be better than another, or expects it to be, is prejudiced. No matter how much he tries to be fair, his prejudices influence his performance and his judgment.
- 2) Do not use "expert" equipment operator personnel as test operators, except as required to determine non-human performance factors. Personnel who are unusually experienced often tend to prefer the familiar and distrust the new and different. They may suffer from habit interference; having developed one set of habits with conventional systems makes it more difficult for them to use a new system effectively.
- 3) Motivate the operators to the same extent they are likely to be motivated in the future use of the system. If they feel they are just doing "exercises" they are likely to perform considerably below par. One way of obtaining realistic motivation is to provide quick and correct knowledge of results to the operators. They should have the same kind of feedback

from their activities as they would have in operational situations.

- 4) The following general rules for the training of operators should be observed:
 - a) Give operators adequate instruction in the tasks to be performed.
 - b) Provide an objective measure of training by scoring and recording their performance.
 - c) Continue training until further improvement is negligible.
 - d) When two systems are being compared, make certain that the personnel operating the two systems have comparable training in handling their respective tasks.

e. Both machines and men, but particularly men, are likely to vary in their performance over a period of time. To minimize the influence of this variability on the outcome of an evaluation, that is, to prevent it from unfairly biasing the results, the conditions of testing should be counterbalanced in every way that might possibly bias the results. To do so the evaluator should observe the following:

- 1) If possible, make a comparison of systems at exactly the same time. If this is not possible, then switch back and forth between systems in a predetermined counterbalanced order. In planning a counterbalanced order, avoid simple alteration because this might introduce a bias. Instead use an "ABBA" order, where "A" is one system and "B" is another.
- 2) Where possible, use the same men and the same machines in the evaluation of different systems. This minimizes the possibility that differences in outcome can be attributed to irrelevant differences among people and equipment. If systems are simultaneously compared, or if for some reason more than one crew is required, evaluations should be repeated, switching crew "A" to system "B."
- 3) Some systems, of course, are different because they are made up of different equipments that impose different tasks on operators. In this case, beware of habit interference which might be involved whenever two equipments or tasks require different habits or skills. If habit interference might be a factor, then it is better not to switch operators. Instead, operators of comparable skill in their respective tasks should be selected and kept on their respective equipments.

DATA COLLECTION

The timely and accurate recording of test data is enhanced by:

- a. Detailed data forms prepared in advance of the test and tailored to each specific subtest.
- b. Checklists as convenient reminders and aids for checking equipment

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design features against criteria.

- c. Carefully prepared questionnaires for obtaining operator opinion.
- d. Human Error Report Forms (Figure 1) for recording and analyzing operating errors as they occur.

HFE EVALUATION

Some general HFE design principles and guides to specific areas of observation are listed in the following paragraphs.

a. Physical Characteristics.

1) General

The locations, size, configuration and accessibility of equipment should be such that it is operable and maintainable by at least the 5th through the 95th percentile group of the user population. The 5th percentile of a particular dimension is a value such that 5 percent of the personnel are smaller than the value expressed and 95 percent are larger; conversely, the 95th percentile for a particular dimension is a value such that 95 percent of the personnel are smaller than the value expressed and 5 percent of the personnel are larger.

The anthropometric and dimensional data shown in Appendix B provide a basis for evaluating the appropriateness of the test item with respect to human factors criteria for the accommodation of equipment and workspace to the limiting physical characteristics of operating and maintenance personnel. Use of these data should take into consideration the following:

- a) The nature, frequency, and difficulty of the related tasks.
- b) The position of the body during performance of the tasks.
- c) Mobility or flexibility requirements imposed by the tasks.
- d) Increments in the design-critical dimensions imposed by the need to compensate for obstacles, projections, etc.
- e) Increments in the design-critical dimensions imposed by protective garments, padding, etc.

2) Application of HFE principles.

- a) Gross Dimensions -- (passageways, accesses, safety clearances, etc.) which must accommodate or allow passage of the body should be based on the 95th percentile values.
- b) Limiting Dimensions -- (reaching distance, displays, test-points, handrails, control movements, etc.) which restrict or are limited by extension of the body should be based on the 5th percentile value.
- c) Adjustable Dimensions -- (seats, supplementary lights, tripods, etc.) should be adjustable to accommodate the range of 5th through 95th percentile personnel.

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HUMAN ERROR REPORT FORM

- Name of Test _____
1. Name of task or subtest (if any) _____
Title or identifying number of written procedures _____
Page and paragraph number(s) in written procedures _____
 2. Tell exactly what equipment was involved. Be complete and specific, that is, give component (or part) and the tools or test equipment involved. (Use extra sheet of paper if needed for this or other items below.)
 3. Tell exactly what the person making the error was supposed to do or what the task required.
 4. What did he do, or fail to do, which was in error: Describe the error.
(Note: As a check on how well you have completed the above 4 items, given your description of the error, could someone else familiar with the equipment deliberately make the error you have described?)
 5. Did time-pressure, weather, hazards, or other test conditions contribute to the error? How?
 6. What had to be done (or what should have been done) to correct the error?
 7. What were the consequences of the error?
 8. What do you think would be the likely consequences of this error in the operational situation?
 9. Do you think this error would be less, about the same, or more likely in the operational situation? Why?
 10. What suggestions do you have to correct the above situation? Your suggestions might involve changing the equipment, the procedures, the MOS, or the training given beyond the MOS.

Name and Rank _____

Date _____

Figure 1. Human Error Report Form

b. Controls and Indicators.

1) General.

A control is any integral device used to align, adjust, or position a functional part of the equipment. Controls include such devices as knobs, levers, switches, pushbuttons, cranks, handwheels, thumbwheels, pedals, and set screws. Indicators are those devices which permit the user to determine the position or degree of alignment or adjustment of the functional part which responds to the control. Some commonly used indicators include electrical meters, optical reticles, level bubbles, and mechanical pointers with associated background scale markings.

The design, type, and location of controls and indicators are important factors affecting operator performance in most man-machine systems. The suitability of any control or indicator depends on its appropriateness for the task to which it is assigned.

2) Application of HFE principles.

When evaluating the suitability of controls and indicators, consider the following:

- a) The function of the control -- its purpose and importance, the nature of the controlled object or display, and the type, extent and direction of change to be accomplished.
- b) Requirement of the task -- speed, range, precision and force requirements, and the effect of reducing one of these to improve another.
- c) Informational needs of the operator -- locating and identifying the control or indicator, determining the setting, and sensing any change in position.
- d) Requirements imposed by the workspace.
- e) Direction of movement of the control in relation to the associated controlled object or indicator. For example, a clockwise movement of a control should normally result in a clockwise movement of the controlled component.
- f) The control-display (C/D) ratio -- the ratio of movement of the control to movement of the controlled object or indicator.
- g) Distribution of work load between right and left hands, and between hands and feet when applicable.
- h) Location with respect to logical order of use.
- i) Suitability of control with respect to size, shape, separation, displacement, resistance, and locking features.
- j) The specificity, accuracy, limitations, and direct usability.

- k) The visibility and legibility of the indicator with respect to location, accessibility, viewing distance, viewing angle, and illumination.
- l) Simplicity of the indicator. An indicator should be the least complex that fulfills the requirement. The scale should be designed to be read as precisely as the operator needs to perform his task, but no more precisely. More information than the operator needs should not be present on the scale, and the indicator should provide, if possible, information in immediately usable form; the operator should not be required to make mental conversions of the indicated values.

c. Labels.

1) General.

The legibility and accessibility of labels used for identifying and operating equipment are critical considerations in emergencies and other circumstances when the operator is pressed for time, and when operating infrequently used or unfamiliar equipment. All indicators, controls, test points, parts, assemblies, and items of equipment that must be located, identified, read, or manipulated should be appropriately and clearly labeled to facilitate rapid and accurate human performance.

Permanent means of labeling, such as etching, embossing, or engraving are preferred over printed, stamped or stencilled labels placed on the surface of the equipment.

The following aspects shall be considered for comparison to applicable criteria.

- a) The accuracy of identification required.
 - b) The time available for recognition or other response.
 - c) The distance at which the labels must be read.
 - d) The illumination level.
 - e) Orientation and location.
 - f) Content, including clarity, brevity, and proper use of abbreviations and symbols.
 - g) Visibility and legibility.
 - h) Design of label characters.
- 2) Application of HFE principles.
- a) Labels should be placed on or very near the items which they identify.
 - b) Labels should not obscure any other information needed by the operator, nor should labels be obscured by other units in the equipment assembly.
 - c) Labels should be located in a consistent manner throughout

the equipment and system.

- d) Locations should be such that labels are read horizontally from left to right. Vertical orientation should be used only when labels are not critical for safety or performance, and where space is severely limited.
- e) Labels should describe primarily the function of equipment items, and only secondarily their engineering characteristics or nomenclature.
- f) When the general function is obvious, only the specific function should be identified (e.g., elevation, as opposed to elevation selector).
- g) Labels should be clear and concise. The choice of words should be based on operator familiarity whenever possible.
- h) Common technical terms may be used for particular populations (e.g., maintenance technicians) even though they may be unfamiliar to other populations.
- i) Abstract symbols should be used only when they have a commonly accepted meaning to all test soldiers. Common, meaningful symbols (e.g., %, +, -) may be used as necessary.
- j) Abbreviations should be used only where necessary to reduce the amount of space required or to improve intelligibility. In such cases, standard abbreviations should be used.

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APPENDIX B
ANTHROPOMETRIC DATA
Table I. Standing Body Dimensions
(Inches)

KEY TO FIG. 1	DIMENSION	5TH PERCENTILE	MEAN	95TH PERCENTILE
A	Vertical Reach	77.0	83.6	90.3
B	Stature	65.2	69.1	73.1
C	Eye Height	60.8	64.7	68.6
D	Shoulder Height	52.8	56.5	60.2
E	Elbow Height	40.6	43.5	46.4
F	Wrist Height	31.0	33.5	36.1
G	Knuckle Height	27.7	30.0	32.4
H	Kneecap Height	18.4	20.2	21.9
I	Ankle Height	4.9	5.6	6.8
J	Chest Depth	8.0	9.1	10.4
K	Buttock Depth	7.6	8.8	10.2
L	Functional Reach	29.7	32.3	35.0
M	Depth of Reach	23.0	—	—

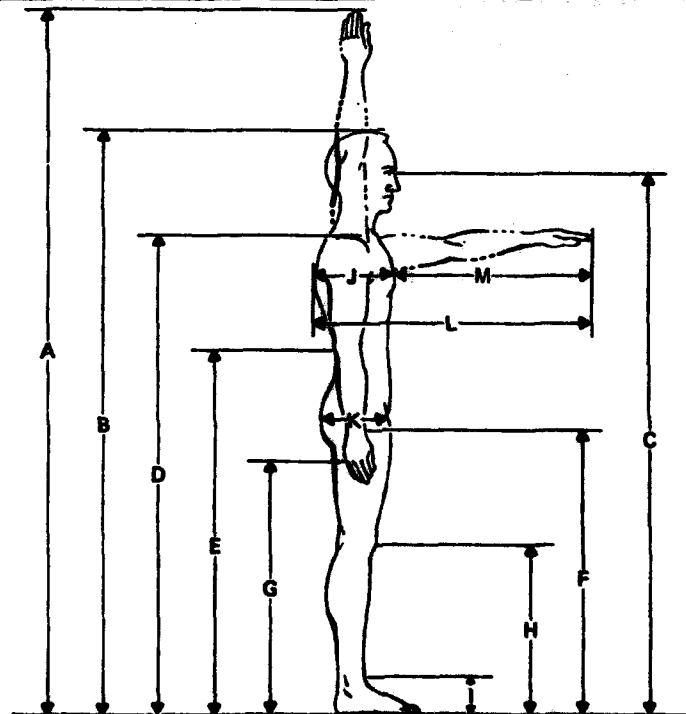


Figure 1. Standing Body Dimensions.

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Table II. Seated Body Dimensions
(Inches)

KEY TO FIG. 2	DIMENSION	5TH PERCENTILE	MEAN	95TH PERCENTILE
N	Seated Height	33.8	35.9	38.0
O	Eye Height	29.4	31.5	33.5
P	Shoulder Height	21.3	23.3	25.1
Q	Elbow-Rest Height	7.4	9.1	10.8
R	Thigh-Clearance Height	4.8	5.6	6.5
S	Knee Height	20.1	21.7	23.3
T	Buttock-Knee Length	21.9	23.6	25.4
U	Popliteal Height	15.7	17.0	18.2
V	Forearm-Hand Length	17.6	18.9	20.2
W	Buttock-Leg Length	39.4	42.7	46.1
X	Buttocks-to-Inside-Knee	17.7	18.9	20.2
Y	Elbow-to-Elbow Breadth	15.2	17.3	19.8
Z	Hip Breadth	12.7	14.0	15.4
AA	Shoulder Breadth	16.5	17.9	19.4
BB	Span	65.9	70.8	75.6

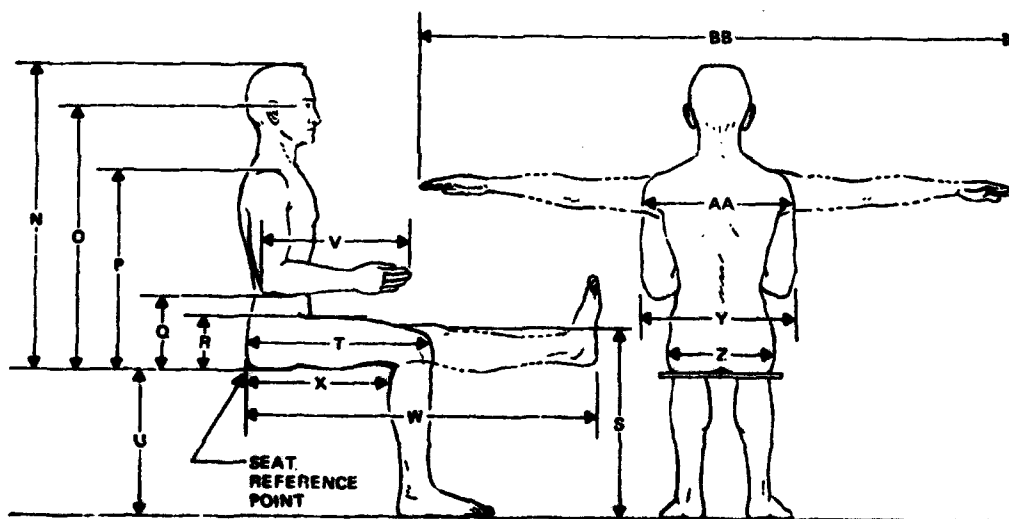


Figure 2. Seated Body Dimensions.

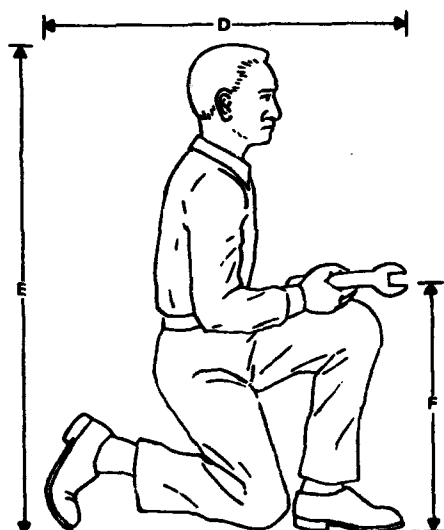
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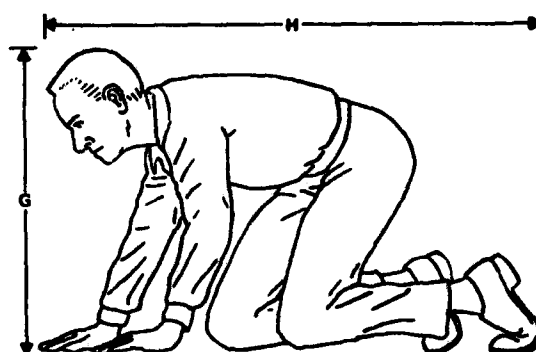
3A. SQUATTING



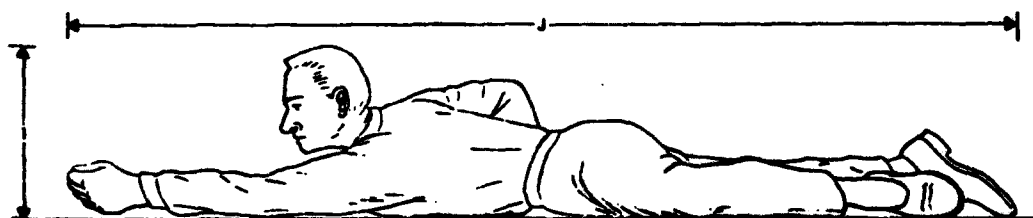
3B. STOOPING



3C. KNEELING



3D. KNEELING CRAWL SPACE



3E. PRONE WORK OR CRAWL SPACE

Figure 3. Clearance Dimensions

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Table III. Clearance Dimensions
(Inches)

KEY TO FIG. 3	DIMENSION	MINIMUM	PREFERRED	ARCTIC
3A.	<u>Squatting workspace:</u>			
A	Height:	48	--	51
B	Width:	27	36	40
3B.	<u>Stooping workspace:</u>			
C	Width:	36	40	44
3C.	<u>Kneeling workspace:</u>			
D	Width:	42	48	50
E	Height:	56	--	59
F	Optimum work point:	--	27	--
3D.	<u>Kneeling crawlspace:</u>			
G	Height:	31	36	38
H	Length:	59	--	62
3E.	<u>Prone work or crawlspace:</u>			
I	Height:	17	20	24
J	Length:	96	--	--

Table IV. Hand Dimensions
(Inches)

KEY TO FIG. 4	DIMENSION	5TH PERCENTILE	95TH PERCENTILE
A	Hand Length	6.9	8.0
B	Hand Width	3.7	4.4
C	Hand Thickness	1.05	1.28
D	Fist Circumference	10.7	12.4
E	Wrist Circumference	6.3	7.5

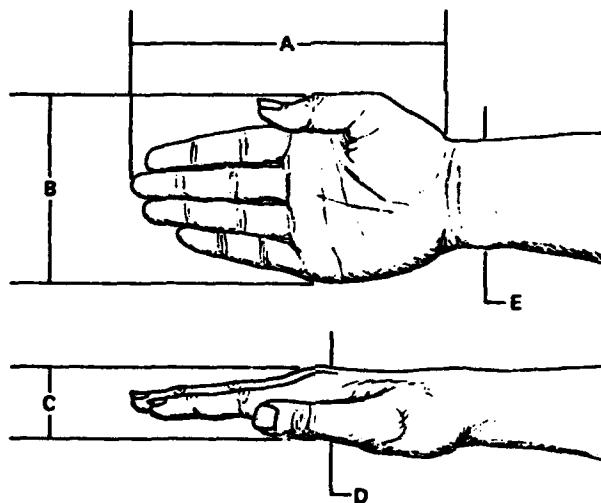


Figure 4. Hand Dimensions.

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