Ministry of Defence

INTERIM

Defence Standard

00-25 (PART 10)/
Issue 1 31 December 1992

HUMAN FACTORS
FOR DESIGNERS OF EQUIPMENT
PART 10: CONTROLS

AMENDMENTS ISSUED SINCE PUBLICATION

AMD NO	DATE OF ISSUE	TEXT AFFECTED	SIGNATURE & DATE

Revision Note

Historical Record

This Defence Standard has its origins in "Human Factors for Designers of Naval Equipment" (A naval handbook in two volumes) published in 1971.

Arrangement of Defence Standard 00-25

Human Factors for Designers of Equipment

Part 1 - Introduction
Part 2 - Body Size
Part 3 - Body Strength and Stamina
Part 4 - Workplace Design
Part 5 - Stresses and Hazards
Part 6 - Vision and Lighting
Part 7 - Visual Displays
Part 8 - Auditory Information
Part 9 - Voice Communication
Part 10 - Controls
Part 11 - Design for Maintainability
Part 12 - Systems

Two or more Parts may apply to any one equipment and it is therefore essential that all Parts be read and used where appropriate.

HUMAN FACTORS FOR DESIGNERS OF EQUIPMENT

PART 10: CONTROLS

PREFACE

i This Part of the Defence Standard presents descriptive detail, technical data and diagrams relating to some of the important issues concerned with the application, design, selection and specification of control devices.

ii This Part of the Defence Standard is published under the authority of the Human Factors Subcommittee of the Defence Engineering and Equipment Standardization Committee (DEESC).

iii This Standard should be viewed as a permissive guideline, rather than as a mandatory piece of technological law. Where safety and health is concerned, particular attention is drawn to this Standard as a source of advice on safe working limits, stresses and hazards etc. Use of this Standard in no way absolves either the supplier or the user from statutory obligations relating to health and safety at any stage of manufacture or use.

iv Users of this Standard shall note that some material may be claimed to be subject to copyright in this or other countries. Copyright where known is acknowledged.

v This Standard has been devised for the use of the Crown and its contractors in the execution of contracts for the Crown. The Crown hereby excludes all liability (other than liability for death or personal injury) whatsoever and howsoever arising (including, but without limitation, negligence on the part of the Crown its servants or agents) for any loss or damage however caused where the Standard is used for any other purpose.

vi This Standard has been agreed by the authorities concerned with its use and shall be incorporated whenever relevant in all future designs, contracts, orders etc and whenever practicable by amendment to those already in existence. If any difficulty arises which prevents application of the Defence Standard, the Directorate of Standardization shall be informed so that a remedy may be sought.

vii Any enquiries regarding this Standard in relation to an invitation to tender or a contract in which it is incorporated are to be addressed to the responsible technical or supervising authority named in the invitation to tender or contract.

viii This Part of the Defence Standard is being issued as an INTERIM Standard. It shall be applied to obtain information and experience of its application. This will then permit the submission of observations and comments from users using DGDQA Form 0825 enclosed.

A review of this INTERIM Standard should be carried out within 12 months of publication. Based on the comments received the author and/or committee responsible for the preparation of the Defence Standard shall judge whether the INTERIM Standard can be converted to a normal Standard or decide on what other action should be taken.

CONTENTS

CONTENTS (Contd) PAGE

HUMAN FACTORS FOR DESIGNERS OF EQUIPMENT

PART 10: CONTROLS

Section One General

0 Introduction

This Part of the Defence Standard gives guidance on the identification, application, selection and specification of control devices, for use in military systems and equipment. It is a complex issue reflecting a balance between the environment in which the tasks operators are required to carry out, and the level of technology with which they are provided. Designers who have a specific application in mind and who wish to select an appropriate control function would be advised to view the selection principles of control devices, matching the control to its intended task, the control/display relationship the control coding and panel layout. Traditional controls, as well as those permitting interaction between an operator and computer based systems shall be selected in the light of design constraints, such as the restrictions imposed by the wearing of protective clothing or limitations in military vehicle interiors.

1 Scope

This Part of the Defence Standard specifies requirements on the optimum size, shape and operating dynamics, ie operating torque and displacement for a range of controls and enables designers to select the control most relevant to the task. Recommendations are also given on the spacing necessary for each control to permit it to be operated without interference with others adjacent to it. Additionally, this Part of the Defence Standard considers the optimum characteristics of specialized controls, particularly those designed for the input of data to, or the interaction with, computer based equipment. Flight controls for aircraft are not considered within the scope of this Part of the Defence Standard. Designers are referred to Defence Standard 00-970.

2 Related Documents

2.1 The documents referred to in this Part of the Standard, together with additional publications, providing greater coverage on particular aspects of the subject are listed below:

Def Stan 00-25	Human Factors for Designers of Equipment
Def Stan 00-970	Design and Airworthiness Requirements for Service Aircraft - Aeroplanes
MIL-STD-1472D	Military Standard, Human Engineering Design Criteria for Military Systems, Equipment and Facilities
MIL-HDKB-759A	Military Handbook, Human Factors, Engineering Designs for Army Material, Designed by the US Army Human Engineering Laboratory for US Army Missile Command
McCormick F J and Sanders M S:	Human Factors in Engineering and Design McGraw-Hill Book Company
Van Cott H P and Kinkade R G	Human Engineering Guide to Equipment Design (USA) American Institute for Research, Washington DC, Library of Congress, Card No 72 -600054

2.2 Related documents can be obtained from

DOCUMENT	SOURCE
Defence Standards	Ministry of Defence Directorate of Standardization Kentigern House 65 Brown Street GLASGOW G2 8EX Tel: 041-224 2531/2
Military Specifications	United States Department of Defence Standardization Division Armed Forces Supply Centre Washington 25 DC

2.3 Reference in this Part of the Standard to any related document means in any invitation to tender or contract the edition and all amendments current at the date of such tender or contract unless a specific edition is indicated.

3 Definitions

For the purpose of this Part of the Defence Standard the definitions listed at annex A apply.

4 Identification System Used

4.1 To assist the user of this Part of the Defence Standard, an alphanumeric identification system has been applied to the controls.

4.2 The first part comprises of a letter which identifies the control function, followed by a single number which refers to the general control type.

4.3 The second part is a number which identifies an individual type of control. This identification system remains constant throughout the sections of this Part of the Defence Standard:

eg Control functions	:	C-.--	Data entry
Control types	:	-5.---	Keyed
Individual control	:	--.22	Keypad
Identification reference		C5.22	

4.4 The classification and identification of control types outlined above and detailed in table A will permit the designer to select the general class of control relevant to his purposes. It should be noted that this classification has been used for illustrative purposes only and that the control functions are not necessarily mutually exclusive.

5 Control Function

5.1 Continuously variable operation see Table B (A-.--). These are controls which permit the setting of a machine or system to operate at any point or value along a continuum and controls which permit the continuous alteration of a machine state. An example of the former would be a radio volume gain control which allows the user to increase or decrease the sound output gradually and to stop at an infinite number of positions within its operating range. An example of the latter would be a joystick, which when used in the tracking of a target permits continuous adjustment of guidance parameters acting in the system.

5.2 Discrete operation see Table C (B-.--). These are controls which permit the selection between two or more mutually exclusive operating functions. For example, switching a machine 'on' or 'off' is a discrete operation, as is the selection of different modes of system activity.

5.3 Data entry see Table D (C-.--). Controls designed for the input of information, eg to computer based systems.

Table A

Classification & Identification of Control Devices

CONTROL FUNCTION clause 5	CONTROL TYPES clause 6	INDIVIDUAL CONTROL clause 7	REFERENCE
Continuously Variable Operation A	1 Rotary	- 01 Knobs 02 Thumbwheels 03 Cranks 04 Handwheels	A1 A1.01 A1.02 A1. 03 A1. 04
	2 Linear	- 05 Levers 06 Sliding Levers 07 Pedals	A2 A2.05 A2.06 A2.07
	3 Multi axis	- 08 Joysticks	A3 A3.08
	4 to 7 Not applicable	-	-

Table A - Contd

Classification & Identification of Control Devices

CONTROL FUNCTION clause 5	CONTROL TYPES clause 6	INDIVIDUAL CONTROL clause 7	REFERENCE
Discrete Operation B	1 Rotary	- 09 Selector switches 10 Thumbwheels 11 Key operated switches 12 Keylocks	B1 B1.09 B1.10 B1.11 B1.12
	2 Linear	- 13 Toggle switches 14 Levers 15 Push-pull controls 16 Slide switches	B2 B2.13 B2.14 B2.15 B2.16
	3 Not applicable	-	-
	4 Push button	- 17 Buttons 18 Legend switches 19 Foot operated switches 20 Rocker switches	B4 B4.17 B4.18 B4.19 B4.20
	5 to 8 Not applicable	-	-
Data Entry C	1 to 4 Not applicable	-	-
	5 Keyed	- 21 Keyboards 22 Keypads 23 Keysets 24 Multifunction keysets	C5 C5.21 C5.22 C5.23 C5.24
	6 Voice activation	- 25 Voice recognition systems	C6 C6.25
	7 On screen spatial	- 26 Touch displays 27 Light pens	C7 C7.26 C7.27
	8 Off screen spatial	- 28 Digitizing tablets 29 Mouse 30 Rolling ball	C8 C8.28 C8.29 C8.30

6 Control Types

6.1 Rotary operation (-l.--). Controls typically mounted on a spindle which require a circular or turning movement to alter the state of a machine or system.

6.2 Linear operation (-2.--). Controls requiring linear displacement in one axis in order to alter a single parameter of the system.

6.3 Multi axis operation (-3.--). Controls suitable for varying a continuous input on two or more dimensions simultaneously by manipulating the control in more than one axis.

6.4 Push button operation (-4.--). Controls for selection between two operational states by the application of force perpendicular to the surface of the control. May be finger, hand or foot operated.

6.5 Keyed (-5.--). A specialized assembly of push buttons organized to permit rapid sequential information input into a machine. Normally groups of letters or digits, 'alphanumeric' characters, are selected but keys may also be allocated specialized functions.

6.6 Voice activation (-6.--). A method of data entry such that information is entered into the system by means of voiced commands from the operator. Also known as Direct Voice Input (DVI) speech recognition systems.

6.7 On screen spatial, spatial designation devices (-7.--). Where pointing is directed at the surface of the visual display screen.

6.8 Off screen spatial, spatial designation devices (-8.--). Where pointing is remote from the display, but addressed towards a surface corresponding spatially to that of the display.

NOTE: For the purpose of this Part of the Standard, spatial designation devices are those whereby the displacement of a stylus or other pointing device across a surface results in a corresponding displacement of an index or cursor on a visual display. Such devices may be used either to input coordinates to the system or as a means of reading coordinates from the visual display.

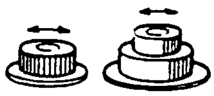
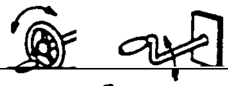
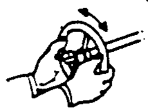
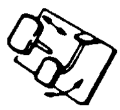
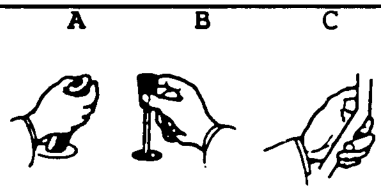
7 Individual Controls

7.1 Individual control types can only be defined usefully by describing their precise method of operation and this is achieved most clearly by means of diagrams or written descriptions where diagrams are less appropriate.

7.2 Continuously variable operation (A-.--)

Table B

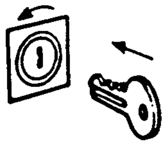
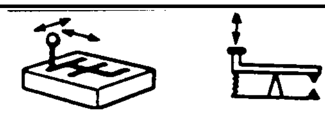
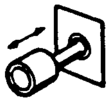
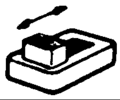
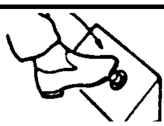
Rotary, Linear and Multi axis Operation

A Continuously Variable	DIAGRAM	COMMENT
A1 Rotary		
A1.01 Knob		'Ganged', concentrically mounted
A1.02 Thumbwheel		
A1.03 Crank		
A1.04 Handwheel		
A2 Linear		
A2.05 Lever		
A2.06 Sliding Lever		
A2.07 Pedal		
A3 Multi axis		
A3.08 Joystick		A Whole Hand B Thumb and Finger C Thumb

7.3 Discrete operation (B-.--)

Table C

Rotary, Linear & Push Button Operation

Discrete	DIAGRAM	COMMENT
B1 Rotary		
B1.09 Selector switch		
B1.10 Thumbwheel		
B1.11 Key operated switch		
B1.12 Keylock		Associated with latch systems
B2 Linear		
B2.13 Toggle switch		
B2.14 Lever		
B2.15 Push-pull control		
B2.16 Slide switch		
B4 Push button		
B4.17 Button		
B4.18 Legend switch		Button with inscribed legend. May be illuminated
B4.19 Foot operated switch		
B4.20 Rocker switch		

7.4 Data entry (C-···)

Table D

Keyed, Voice Activation, On Screen & Off Screen

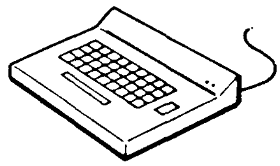
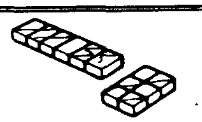
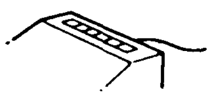
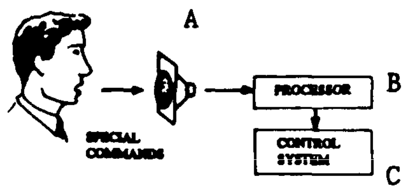
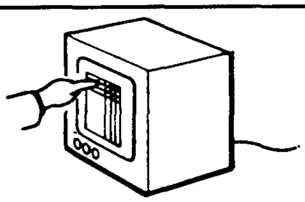
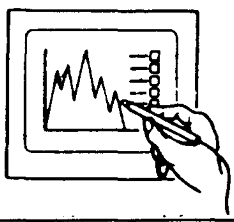
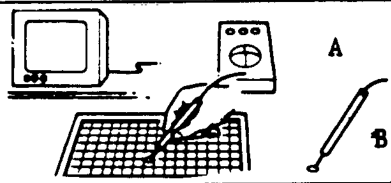
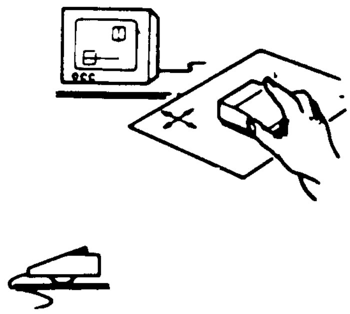
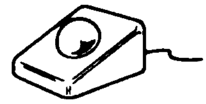
C Data Entry		DIAGRAM	COMMENT
C5.21	Keyboard		An arrangement of push buttons or touch-sensitive surfaces for the entry and manipulation of commands, text and alphanumeric characters into a computer or data handling system
C5.22	Keypad		A pad of numeric keys telephone type layout
C5:23	Keyset		An array of keys with dedicated functions
C5.24	Multi-function keyset		An array of keys, the function of which will change according to the system's mode of operation
C6	Voice Activation		A Special commands B Processor C Control system
C6.25	Voice recognition system		A data entry method employing voice/speech commands to input information to computerized equipment
C7	On screen spacial		
C7.26	Touch display		Operator designates points on a Cathode-Ray Tube (CRT), eg by directly contacting the screen surface with a finger or probe
C7.27	Light pen		Operator uses a pen-sized probe, the position of which is sensed when held close to the surface of a CRT, permitting designation on the display

Table D - Continued

C Data Entry	DIAGRAM	COMMENT
C8 Off screen spatial **C8.28 Digitizing tablet**		**A Graticule** **B Stylus**
C8.29 Mouse		**A displayed cursor is moved proportionally to the movement of a device in contact with a flat surface. One typical type of mouse consists of a hard, heavy ball, or two wheels positioned at right angles to each other within a small housing. Multifunction buttons may also be incorporated.**
C8.30 Rolling Ball		

8 Selection for Specific Applications

8.1 Control coding. The identification of controls by Location, Labelling, Colouring, Shape and Size.

8.2 Location coding is the most effective coding method under conditions in which the control cannot be seen because of low illumination levels or because the control is not positioned in the field of view. Even when the control is visible, location can supplement visual coding and coding of controls in this way is to some extent the natural result of good workspace design (see Part 4 of this Defence Standard). When location coding is used for controls which cannot be seen they should be positioned in front of rather than behind the operator.

8.3 Labelling is the simplest method of coding having the advantage of requiring little or no training for use by the operator. However, labels must meet the visual requirements of the operator in terms of size, illumination and contrast if they are to be adequate (see Parts 6 and 7 of this Defence Standard). It must be possible for the operator to read the legend while performing his task and the labels should be appropriate, brief, clear and unambiguous, containing the basic information needed.

8.3 (Contd)

Labels should be located either on the controls or adjacent to them, normally above, except with controls placed above the operator's head in which case location below is more appropriate. They should be sufficiently close to the control for there to be no confusion as to which label goes with which control. Location must be systematic, as uniform as possible and consistent between panels.

8.4 Colours may be used to discriminate between controls and the use of the same colour can indicate related controls.

NOTE: Colour coding should only be used as a supplement to other coding methods, as colour blind operators may otherwise be unable to distinguish controls.

Avoid the use:

(a) of more than five colours;

(b) when ambient illumination itself appears coloured.

Emphasis should be placed on:

(a) RED for Emergency Controls;

(b) Sharply Contrasting Colours for Critical Controls.

8.5 Shapes may be used to discriminate between controls and the use of the same shape can indicate related controls. Shape coding permits touch discrimination when controls cannot be directly observed but also aids in visual identification. Shapes should be selected which are easily distinguishable from one another since the use of shapes which are easily associated with the controlled function aids the operator in learning. When shape coding is used the coded feature should not interfere with control manipulation. The shapes used should be identifiable regardless of the position or size of the control: simple shapes are easier to discriminate than complicated ones and are less difficult to decontaminate under Nuclear, Bacterial and Chemical (NBC) conditions.

8.6 Size of a control may be used as a means of distinguishing it from others. Although not as effective as shape coding it does provide useful visual or tactile cues. Operators can learn to discriminate a limited number of sizes, usually only two or three by touch, eg small, medium and large. Code sizes should be consistent when controls have similar functions on different items of equipment.

8.7 Choice of a particular method of coding is essential for the designer to take into account the demand imposed by the nature and conditions of the operator's whole task at the time that the control must be identified. For example, colour coding and labels will not be useful if the operator must constantly maintain attention to a visual display while selecting the control.

As a guide, the designer should consider the following factors before selecting a coding method:

8.7 (Contd)

(a) existing codes, perhaps implicit in the workspace design, eg controls placed next to associated displays;

(b) space available for coding;

(c) illumination of the workspace, affecting the usefulness of visual codes;

(d) the speed and accuracy with which controls must be identified, touch is slower and usually less accurate than vision;

(e) the number of controls to be coded, labels are infinitely variable, colour may only permit five classes of control to be distinguished;

(f) standardization of coding methods within a workspace.

NOTE: If in doubt, experiments should be performed to ensure that controls are readily distinguishable under the expected conditions of use.

8.8 Desirable functions and characteristics (see tables E and F)

Table E

Desirable Functions of Controls, Types A & B

CONTROL FUNCTIONS	CONTROL TYPES										
	A CONTINUOUS VARIABLE OPERATION					B DISCRETE OPERATION					
	1 Rotary			2 Linear	3 Multi axis	1 Rotary		2 Linear		4 Push Button	
	01	02	03/04	05/06	08	09	10	13	14	17	20
	Knobs	Thumb Wheels	Hand Wheels	Levers (including sliding levers)	Joysticks	Selector Switches	Thumb Wheels	Toggle Switches	Levers	Push Buttons	Rocker Switches
SYSTEM POWER ON/POWER OFF	–	–	–	–	–	3	–	1	1*	2	1
3 STATE 'OFF'–'STANDBY'–'ON'	–	–	–	–	–	1	–	2	–	–	3
SELECT ONE OF A NUMBER OF RELATED FUNCTIONS	–	–	–	–	–	–	–	2	–	1	2
SELECT ONE OF A NUMBER OF MUTUALLY EXCLUSIVE FUNCTIONS OF ANY ORDER	–	–	–	–	–	–	–	–	–	1	–
SELECT ONE OF 3–24 DISCRETE ALTERNATIVES: SEQUENTIAL ORDER	–	–	–	–	–	1	–	–	–	–	–
SELECT DIGITS: DISCRETE	–	–	–	–	–	2**	2**	–	–	1 keyboard or keypad	–
SET VALUES ON: CONTINUOUS SCALE	1	2	2	2	–	–	–	–	–	–	–
SET VALUES IN: DISCRETE STEPS	–	–	–	–	–	1	1	–	–	1	–
INITIATE MOMENTARY TEST FUNCTION	–	–	–	–	–	2	–	1 (spring biased)	–	1 (non-latching)	2 (spring biased)
EMERGENCY STOP	–	–	–	–	–	–	–	3	1*	1 (hand operated)	3
ENGAGE/DISENGAGE	–	–	–	–	–	–	–	–	–	–	–
ADJUST LIGHT/SOUND LEVEL CONTINUOUSLY	1	2	–	1 (sliding lever)	–	–	–	–	–	–	–
TRACKING IN SINGLE AXIS	3	–	2	1	–	–	–	–	–	–	–
TRACKING IN 2/3 AXIS	–	–	–	–	1	–	–	–	–	–	–

Note: Information applicable to table E are on page 16

Table F

Desirable Characteristics of Controls, Types A & B

	CONTROL TYPES										
CONTROL CHARACTERISTICS	A CONTINUOUS VARIABLE OPERATION					B DISCRETE OPERATION					
	1 Rotary			2 Linear	3 Multi axis	1 Rotary		2 Linear		4 Push Button	
	01	02	03/04	05/06	08	09	10	13	14	17	20
	Knobs	Thumb Wheels	Hand Wheels	Levers (including sliding levers)	Joysticks	Selector Switches	Thumb Wheels	Toggle Switches	Levers	Push Buttons	Rocker Switches
CONTROL SETTING SPEED	MEDIUM	SLOW	SLOW	FAST	-	MEDIUM	SLOW	VERY FAST	MEDIUM TO SLOW	VERY FAST	VERY FAST
RECOMMENDED NUMBER OF CONTROL SETTINGS	-	-	-	-	-	3 - 24	3 - 10 +	2 - 3	++	*	2
PANEL SPACE REQUIREMENTS FOR LOCATION AND OPERATION	MEDIUM	SMALL	LARGE	MEDIUM TO LARGE	MEDIUM TO LARGE	MEDIUM	SMALL	SMALL	MEDIUM TO LARGE	SMALL	SMALL
LIKELIHOOD OF ACCIDENTAL OPERATION	MEDIUM	MEDIUM	MEDIUM	HIGH	HIGH	LOW	MEDIUM	MEDIUM TO HIGH	MEDIUM	MEDIUM	LOW TO MEDIUM
EASE OF VISUALLY IDENTIFYING CONTROL POSITION	ϕ FAIR	ϕ POOR	FAIR	FAIR	-	GOOD	FAIR TO POOR	GOOD	FAIR TO GOOD	POOR (unless backlit)	FAIR
EASE OF NON-VISUALLY IDENTIFYING CONTROL POSITION	POOR	POOR	POOR	FAIR	-	GOOD	POOR	GOOD	FAIR	POOR (unless latching)	FAIR
EASE OF 'CHECK-READING' THE CONTROL WHEN IN AN ARRAY OF SIMILAR CONTROLS	ϕ FAIR TO POOR	POOR	POOR	GOOD	-	GOOD	FAIR	GOOD	GOOD	POOR (unless backlit)	FAIR
REFERENCE CONTROL SELECTION DESIGN STANDARD	A101	A102	A103 A104	A205 A206	A308	B109	B110	B213	B214	B417	B420

NOTE: The information below is applicable to table E and F. The control function table E adheres to the Army, Navy and RAF ground station applications. Designers of flight controls for aircraft are referred to Table 1 of Defence Standard 00-970.

KEY: In the Desirable Functions of Controls table E '1' indicates the most preferred control, '3' the least preferred.

- * Use of lever for heavy duty power circuits or for 'dead-man's handle' application
- ** Controls should be used only if sequential selection of digits is acceptable
- * For values greater than ten, a horizontal array of thumbwheels, graduated from 0-9 should be used
- ** Depends on the configuration of the lever unit, eg linear operation vs 'gearbox' application
- ϕ Only if the control makes NO MORE THAN ONE ROTATION. Rotary knobs should have a pointer attachment
  Preferred for applications requiring a high operating torque

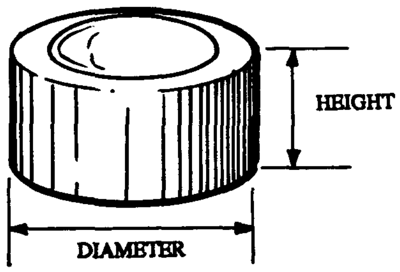
Section Two. Preferred Physical Specifications for Continuous Variable Controls

9 Knob (A1.01)

9.1 Characteristics for Rotary Knobs. They are suitable for high precision adjustments in the control of continuous variables, when little force is necessary for operation, ie for small potentiometers.

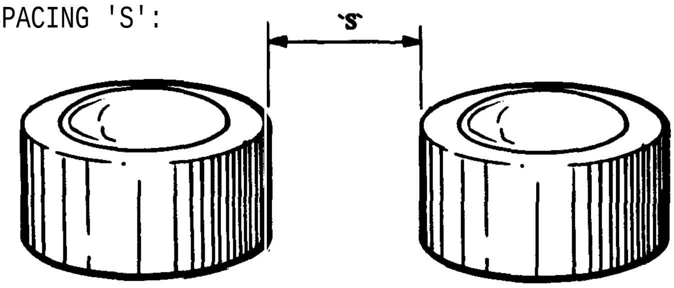
9.2 Location. With careful positioning, recessing or covering can reduce the likelihood of accidental activation.

9.3 Recommended Dimensions.



Fingertip Grasp		Thumb & Finger Encircled		Palm Grasp		
Height	Dia	Height	Dia	Height	Dia	
13mm	10mm	131mm	25mm	80mm	38mm	Minimum
25mm	100mm	25mm	75mm	120mm	75mm	Maximum

EDGE SPACING 'S':



For Setting Individually		For Simultaneous Setting With Two Hands		
Bare Hands	Gloved Hands	Bare Hands	Gloved Hands	
25mm	25mm	50mm	90mm	Minimum
50mm	90mm	75mm	100mm	Optimum

Fig 1 Knob Dimensions

9.4 Shape. The knob shape will normally be round, this will assist in finger positioning. It should not have sharp edges. The rim should have a textured surface that would facilitate a secure grip in operation, ie for small knobs, a knurled surface, medium size, a ribbed surface and those for high torque application indentations on the rim. Knobs serving the same function should have the same shape throughout the system.

9.5 Displacement Resistance. Fine adjustment requirement for high precision in setting is limited to a maximum arc of rotation of approximately 120° by wrist movement. The recommended operating torque for single knob application is: Knob diameter <25 mm, Resistance 32 mNm, >25 mm, Resistance 43 mNm maximum. For knobs in rows, columns or matrices a torque of between 14 & 28 mNm is to be adopted. However, the torque of 43 mNm takes account of the wearing of heavy gloves and is only satisfactory when the sensitivity of the control is kept as low as possible. The turning resistance offered by the control is to be determined on the basis of the function of the control. 'Stickiness' in operation of fine setting is not desirable.

9.6 Direction of Motion. This is to follow recognized stereotype practices, ie clockwise to increase values. The exception to this standard practice is flow control valves where the automatic reaction is to turn clockwise in order to shut off.

9.7 Other Requirements. Knob mounting is to be held securely onto its shaft. If by set screws, (accessible by a screw driver) into indentations or flats on the shaft.

9.8 Adjacent scale markings. When the knob movement is limited to less than 360 degrees, a scale mark may be located around the control on the panel. An index line should be placed on the knob to indicate the control position index. The null gap should be between the two end stop points.

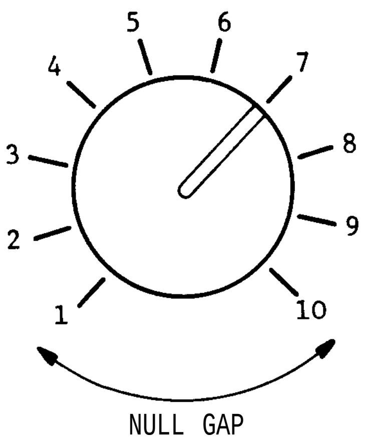


Fig 2 Knob Scale Markings

9.9 Ganged Knob Dimensions and Clearance Settings

(a) Spacing

FOR SETTING INDIVIDUALLY		FOR SIMULTANEOUS SETTING WITH TWO HANDS		
BARE HANDS	GLOVED HANDS	BARE HANDS	GLOVED HANDS	
25 mm	25 mm	50 mm	90 mm	MINIMUM
50 mm	90 mm	75 mm	100 mm	OPTIMUM

Fig 3 Ganged Knob Settings

H_1	H_2	D_1	D_2	
16 mm	13 mm	13mm	22mm	MINIMUM
-	-	-	100 mm	MAXIMUM

Fig 4 Ganged Knob Dimensions

H_1 = Height of Upper Knob

H_2 = Height of Lower Knob

D_1 = Diameter of Upper Knob

D_2 = Diameter of Lower Knob

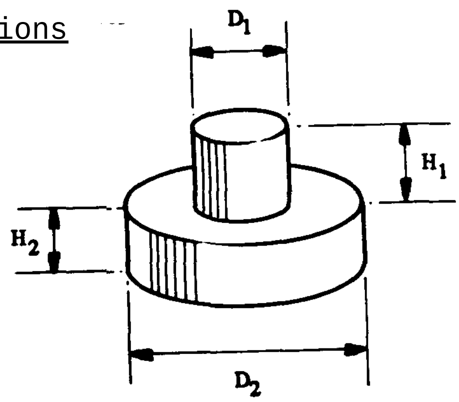


Fig 5 Ganged Knob

(b) Shape. In most instances comments relating to single knobs also apply to ganged knobs;

(c) Displacement resistance

<25 mm DIAMETER	>25 mm DIAMETER	
32 mNm	43 mNm	MAXIMUM

Fig 6 Displacement Resistance

9.9 (Contd)

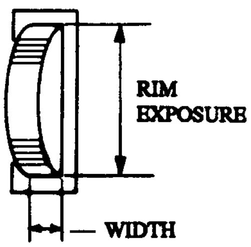
(d) Direction of motion. See clause **9.6.**

10 Thumbwheels (A1.02)

10.1 Characteristics of Thumbwheels. They have greater compactness than rotary knobs. They cannot be operated as rapidly as the rotary knob, nor do they identify set control positions unless linked to an associated visual display.

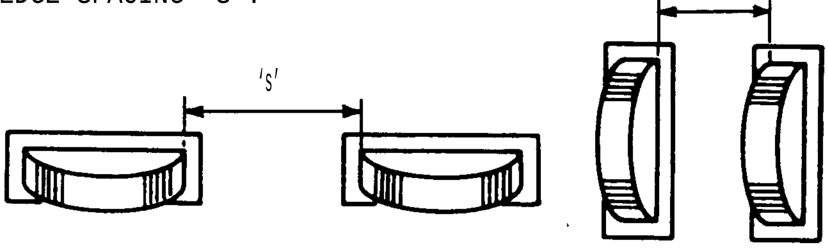
10.2 Location. They are to be positioned horizontally or vertical mounted in the workspace after assessing the suitability of the location.

10.3 Recommended Dimensions.



Rim Exposure	Width	
25mm	3mm	Minimum
100mm	23mm	Maximum

EDGE SPACING ‘S’:



Horizontally Mounted	Vertically Mounted	
75mm	38mm	Minimum With Gloves
50mm	25mm	Minimum

Fig 7 Thumbwheel Dimensions

10.4 Shape. The thumbwheel shape will normally be round with the rim surface corrugated, knurled or fluted for friction in operation. It should not have sharp edges.

10.5 Displacement Resistance. To prevent accidental operation the thumbwheel is to offer some resistance to turning, a resistance between 1.7N & 3.3N is suggested. The operating torque is determined by the diameter of the thumbwheel; for the smaller sizes the maximum torque for operation is to be 21 mNm and for the larger size the maximum torque is to be 42 mNm.

10.6 Direction of Motion. Increases in the controlled variable are normally to the right on horizontally mounted and upward on vertically mounted thumbwheels. Where thumbwheels are used to govern vehicle motion, ie 'dive' in a remotely operated submersibles the forward movement on a longitudinal mounted thumbwheel should cause a downward forward motion.

10.7 Other Requirements. A click stop and index mark is to be provided where the thumbwheel has an ‘OFF’ position.

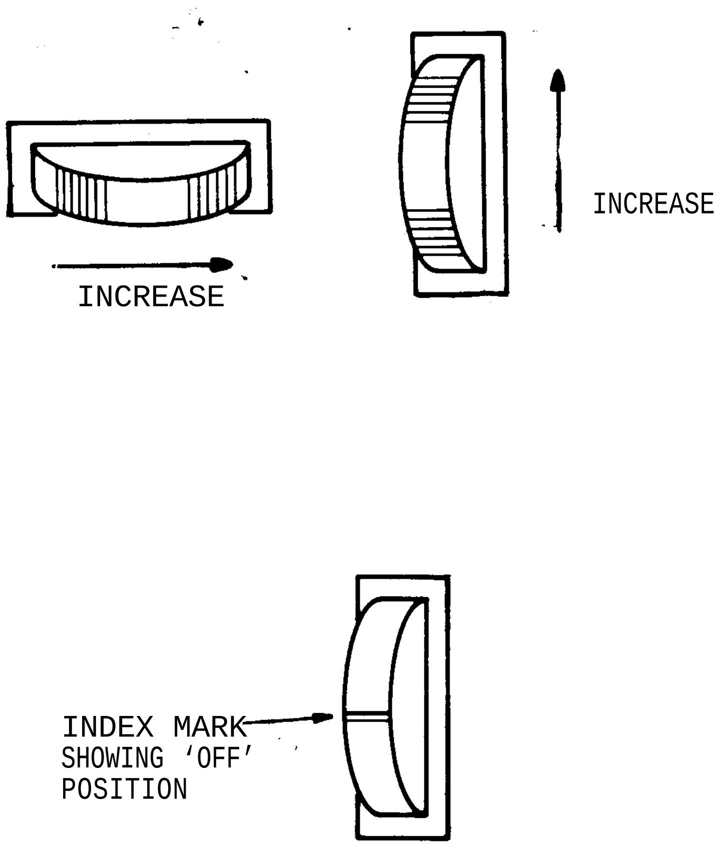


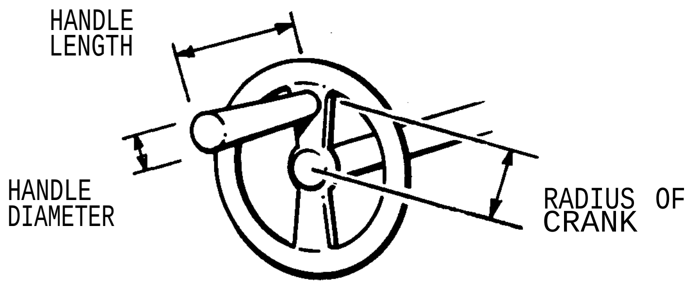
Fig 8 Single Rotary Knob Operation

11 Cranks (A1.03)

11.1 Characteristics of Cranks. They are suitable where multiple revolutions of a control are required. Simultaneously operated hand cranks are the preferred two axes controller (ie for adjustment in ‘x’ & ‘y’ axis) where extreme precision is necessary in the setting of crosshairs or reticles. They are not suitable for the tracking of moving targets.

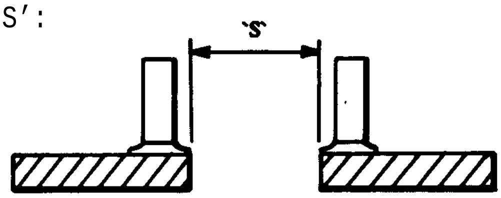
11.2 Location. Is to be located where they can be reached comfortably and conveniently. If large forces are to be exerted the designer may consult Part 3 of this Standard to determine the posture and hence crank location, appropriate for the required force. Standing operated cranks are to be positioned between 900-1200 mm above the floor. Cranks designed for rapid turning are to be mounted so that their turning axes are between 60° & 90° from the frontal plane of the body’s centreline.

11.3 Recommended Dimensions.



Load		Handle Length	Handle Diameter	Radius Of Crank
Light Load <22N (wrist & finger movements)	Minimum	25mm	10mm	13mm
	Maximum	75mm	16mm	125mm
Heavy Load >22N (arm movements)	Minimum	75mm	25mm	125mm
	Maximum	>95mm	38mm	510mm

EDGE SPACING ‘S’:



Adjacent Cranks Used Simultaneously	Cranks Operated Sequentially	
75mm	50mm	Minimum
125mm	100mm	Optimum

Fig 9 Crank Dimensions

11.4 Shape. Handwheel or bar formed with a handle. The provision of a handle maximizes the area in contact with the hand and it is to have a protective shaped guard at the base. A handle is normally designed to turn freely about its shaft to aid rapid rotation, although a fixed handle may sometimes be preferred for precise adjustment.

11.5 Displacement Resistance. The degree of resistance will normally be determined by the required speed of rotation and by the strength of the operator, both of which will influence the dimensions of the crank. In general, increases in the degree of resistance will reduce the maximum turning rate. Inertia will assist in the maintenance of a constant rate of rotation.

11.6 Direction of Motion. Hand cranks are turned clockwise for the maximum speed of operation.

11.7 Other Requirements. For safety the location is to be out of the way of passers by. It should be balanced to prevent the weight of the handle from turning the crank from its setting. Being multirotational, position is not an indication of control setting.

12 Handwheels (A1.04)

12.1 Characteristics for Handwheels. They are suitable where two handed operation is required due to high operating force, opening/closing of pressure tight hatches or high torque valves. Both hands are to be available for this task. Speed of operation is typically slower than achievable with cranks operated single handed.

12.2 Location. This is based on where the operator is to work seated or standing. The following handwheel positions are recommended:

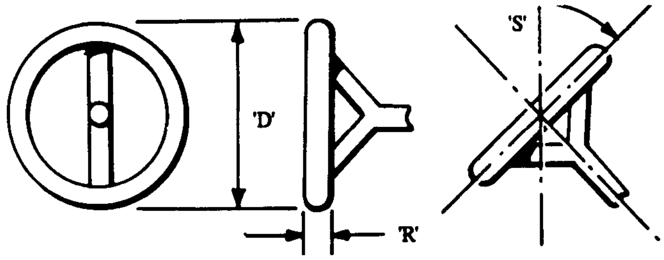
(a) operator seated with wheel plane Vertical:
Centre of wheel 450 mm above top of seat and 550 mm from seat back;

(b) operator seated with wheel plane Horizontal:
Centre of wheel 300 mm above top of seat and 550 mm from seat back (Optimum);

(c) operator standing with wheel plane Vertical:
Centre of wheel 1075 mm above floor;

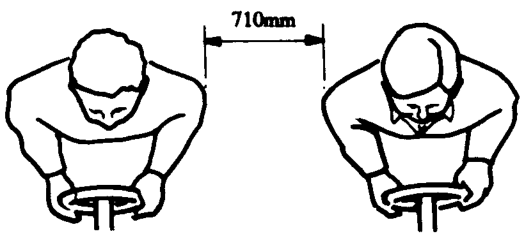
(d) operator standing with wheel plane Horizontal:
Rim of wheel 1375 mm above floor.

12.3 Recommended Dimensions.



Wheel Diameter 'D'		Rim Dia 'R'	Slope 'S'
Vertical (wall panel)	200-510 mm	19-32 mm	Vehicle Steering Light 39° Heavy 45-90°
Horizontal (overhaed)	200-400 mm	19-32 mm	
Horizontal (floor panel)	300-1520 mm	19-32 mm	

EDGE SPACING:



Minimum Hand Clearance Around Rim	75 mm
Elbow-to-Elbow Clearance	710 mm
Overhead Valve Rim-to-Rim Clearance	100-150 mm

Fig 10 Handwheel Dimensions

12.4 Shape. Is the shape correct in relation to adjacent/similar controls? It is to also be shaped to facilitate a good grasp and not have any sharp edges.

12.5 Displacement Resistance. Operating force at the periphery of the handwheel is normally 245N maximum for two-handed operation however, a range of 9-127N may be adopted if one hand operation is at all likely. For small arcs of movement, inertial resistance is to be minimized. Effective use of the handwheel is limited to 60° of arc which is the maximum that can be achieved without removing the hands from the handwheel.

12.6 Direction of Motion. This is to follow recognized stereotype practices, ie clockwise to increase values. The exception to this standard practice is flow control valves where the automatic reaction is to turn clockwise in order to shut off.

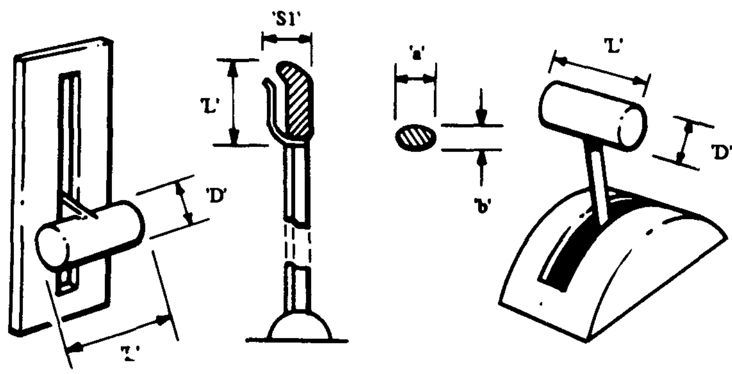
12.7 Other Requirements. For safety in steering wheel applications the use of a collapsible steering column, recessing the wheel hub and providing it with a broad pad may be a design requirement. Two hands are better than one for applying force and for tracking/steering accuracy. One hand performance is adversely affected in conditions of vibration. These factors are to be taken into account. Accidental activation is best prevented by locking the handwheel in place. Resistance and careful selection of location may also be used to prevent accidental activation. Grasp of the handwheel is facilitated by indentations, knurling or high friction covering such as leather. The location for seated operation of steering wheels is to take into account the operator's need to see over the wheel and access and egress. The wheel axis is to be centred on the operator's body centre-line and sloped to allow both of the hands and arms about equal access. The operator is to be able to steer vehicles equipped with power steering to a safe stop in the event of failure. Vehicle steering ratios are to be such that no more than 3.5 turns are required to achieve maximum turning limits.

13 Levers (A2.05)

13.1 Characteristics for Levers. Their state of activation is visible and adjustments can be made rapidly. Three functional characteristics are:
(a) heavy duty;
(b) high force;
(c) throttle levers.

13.2 Location. The location and position of levers relative to the operator are to be compatible with reach limits, mobility, natural movements and strength capabilities (see Parts 2 & 3 of this Standard).

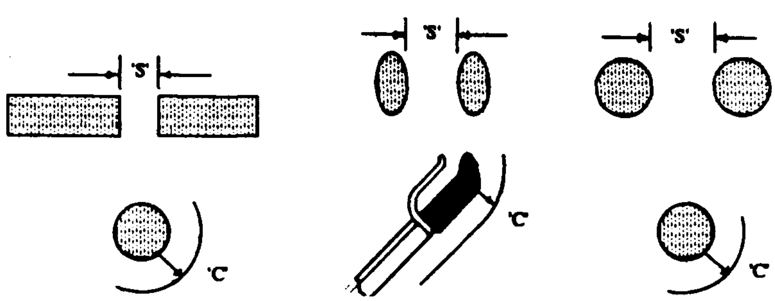
13.3 Recommended Dimensions.



Handle Length = ‘L’ Handle Diameter = ‘D’ Span = ‘S1’

Heavy Duty	High Force	Throttle Levers
'L' 70 mm	'L' 100 mm	'L' 70 mm
'D' 19 mm	x-sect'a'38x'b'25	‘D’ 19 mm min 28 mm max
	‘S1’ 75 mm	

EDGE SPACING:



Edge Spaceing = ‘S’ Clearance = ‘C’

‘S’ 20 mm Minimum & 30 mm Glove Min	‘S’ 75 mm Minimum	‘S’ 50 mm for Spherical or Cylindrical Shape
‘C’ 50 mm Minimum	‘C’ 60 mm Minimum	‘C’ 50 mm Minimum

Fig 11 Lever Dimension

13.4 Shape. The length of the lever is to be determined after considering the mechanical advantage of the system, operator position and the limitations of the 5th percentile operator. Handle shape can be cylindrical, spherical or shaped to fit the hand grip as required but with no sharp edges. Anti-slip texturing may be applied.

13.5 Displacement Resistance.
(a) Heavy duty - an operating resistance between 4.5 - 45N and minimum displacement of 50 mm is to be adopted.
(b) High force - an operating resistance of 187N and maximum displacement (in the worst case of a seated operator) of 355 mm is to be adopted.
(c) Throttle levers - an operating resistance between 9 - 135N and displacement between 50 - 350 mm is to be adopted.

13.6 Direction of Motion. It is recommended that levers be pulled OFF (brakes pulled ON) towards the operator. Heavy duty levers are only to be used in an up/down orientation.

13.7 Other Requirements. Labelling of lever function and direction of motion is to be provided. Limb support, where practical, could be provided for fine or continuous adjustment.

13.8 Dimensions. For levers with spherical handles, ie ball shaped knob on lever shaft, the following dimensions are to be adopted.

HANDLE DIAMETER		
FINGER GRASP	HAND GRASP	
13 mm	38 mm	MINIMUM
38 mm	75 mm	MAXIMUM

Fig 12 Lever Handle Diameters

13.9 Heavy duty levers. These devices are to permit use of at least three fingers.

L : Handle Length : 70 mm Minimum
D : Handle Diameter : 19 mm Minimum

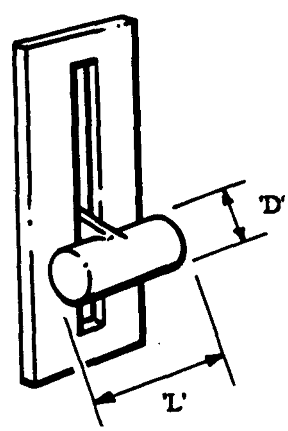


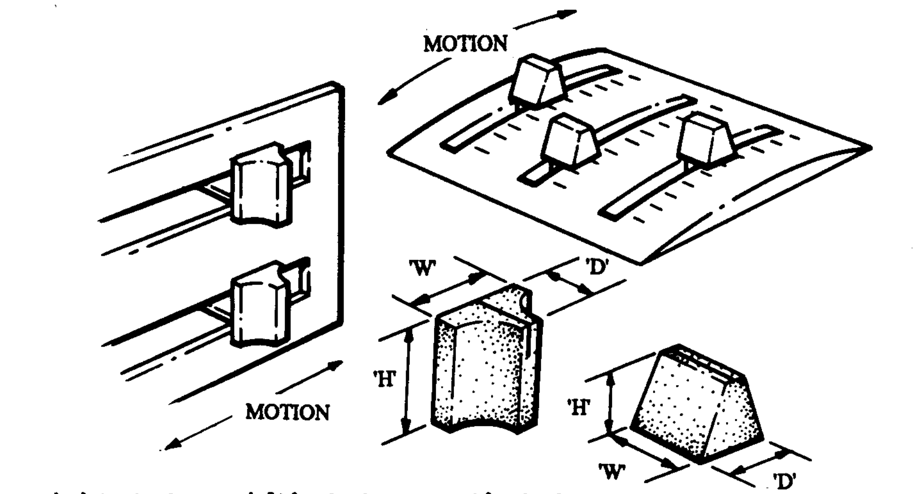
Fig 13 Heavy Duty Lever

14 Sliding Levers (A2.06)

14.1 Characteristics for Sliders. They provide an alternative to rotary knobs, particularly in column/matrix array when a clear visible identification of the relative setting positions is rapidly obvious or when continuous smooth adjustment in operation is required. Adjustments can be made rapidly, but the control is prone to inadvertent movement.

14.2 Location. The location and position of sliders, either as single units or in banks, are to be compatible with reach limitations and the natural movements of the human operator (see Part 2 of this Standard). Panel mounted banks of more than five controls are to be inclined to the horizontal and be symmetrical about the operators body centreline.

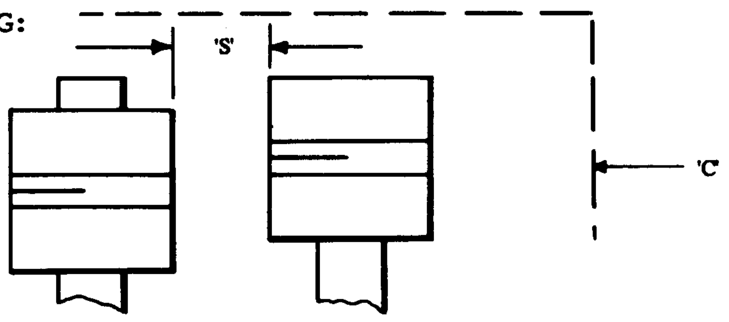
14.3 Recommended Dimensions.



Height='H' Width='W' Depth='D'

'H' 18mm	'W' 15mm	'D' 13mm	Minimum Bare Handed
'H' 25mm	'W' 20mm	'D' 20mm	Gloved Hand Operation

EDGE SPACING:



Edge Spacing='S' Clearance='C'

'S' 20mm	'C' 25mm	Bare Handed Operation
'S' 25mm	'C' 30mm	Gloved Hand Operation

Fig 14 Sliding Lever Dimensions

14.4 Shape. Sliding lever handles should be tab-shaped with the long dimension of the control perpendicular to the axis of motion.

14.5 Displacement Resistance. Sliders should adopt the following resistances 2.8N Minimum; 110N Maximum.

14.6 Direction of Motion. In general a functional increase should be governed by movements of the control up, to right and forward. It is recommended that sliders used in vehicle control should be as follows:

Panel orientation	Control movement	Vehicle response
Vertical	Up/down	Surface/dive
Horizontal	Left/right	Turn to port/starboard Trim to port/starboard
Longitudinal	Forward/backward	Go ahead/astern Pitch Nose down/up Fast/Slow

14.7 Other Requirements. Labelling of lever function and direction of motion should be provided. Where practical limb support should also be provided for fine or continuous adjustment.

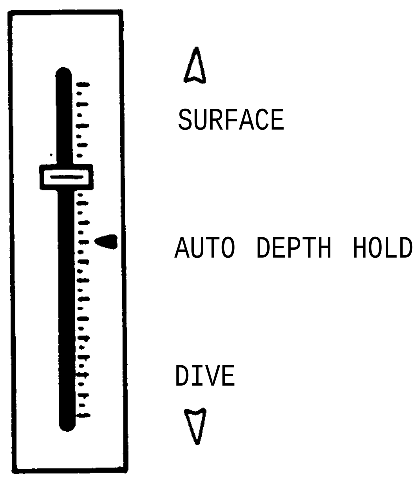


Fig 15 Sliding Lever

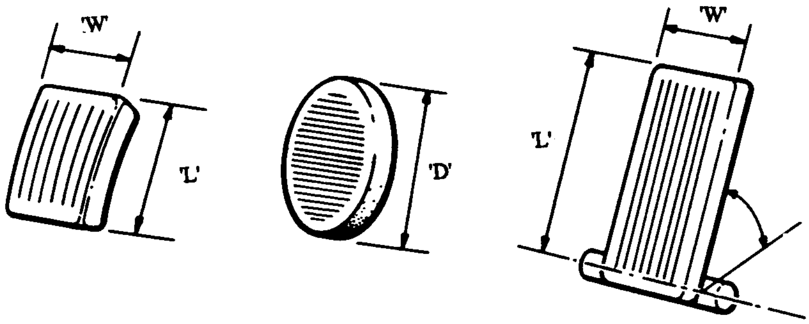
15 Pedals (A2.07)

15.1 Characteristics for Pedals. These require the operator to be seated and may be used when the operator's hands are occupied. Precise control is difficult with a single foot but this can be improved by the use of both feet as in a rudder bar.

15.2 Location. Pedals are to be so placed to be compatible with reach limitations and the natural movements of the operator (see Part 2 of this Standard) to avoid unnatural and awkward body positions.

15.3 Recommended Dimensions.

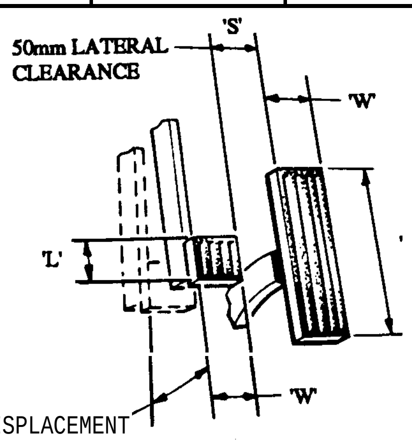
Suspended   Floor Hinged



Width='W'   Length='L'   Diameter='D'

'W' 50mm	'L' 90mm	'D' 60mm	Minimum for Suspended
'W' 65mm	'L' 150mm		Minimum Floor Hinged

EDGE SPACING 'S':



'S' 50mm Minimum To Avoid Accidental Operation

'S' 180mm Should Be Adopted For Heavy Duty Footwear To Pass Between Pedals

Fig 16 Pedal Dimensions

15.4 Shape. Pedals can be a variety of shapes, but in some applications, flanges to support the heel or toecaps can be useful. Tread to prevent slip is to be provided. For brake and clutch application, suspended type rectangular or circular shape is recommended. For Accelerator application a rectangular oblong shape can be used.

15.5 Displacement Resistance. Brake 45N - 70N maximum, with a movement displacement of 50 - 100 mm. Clutch 450N maximum, with a movement displacement of 40 - 180 mm maximum. Accelerator 45N - 90N maximum, with a movement displacement arc of 30° maximum for ordinary shoes and 20° for heavy boots.

15.6 Direction of Motion. A push force is used to activate the control.

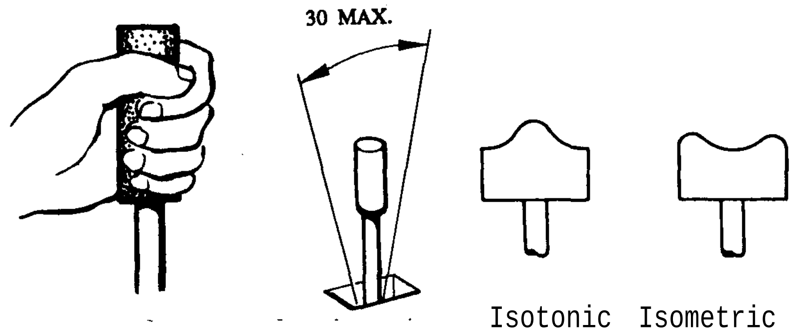
15.7 Other Requirements. For aircraft rudder/brake applications consult establishments with aircraft pedal design expertise. See Defence Standard 00-970.

16 Joystick (A3.08)

16.1 Characteristics for Joystick. These may be used when continuously variable control is required in two axes simultaneously. The design configuration of joysticks is dependent on how they will be manipulated, with the whole hand, finger and thumb, or thumb alone. In functional terms joysticks may be divided into two main classes, force sensitive (Isometric) and displacement sensitive (Isotonic).

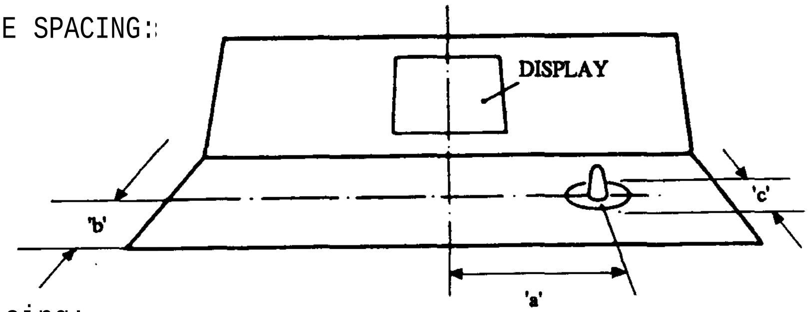
16.2 Location. This will depend on the requirements of the task, the position and other activities the operator must perform and the space required for the installation of the control and its operation.

16.3 Recommended Dimensions.



	Whole hand Min	Whole hand Max	Thumb & Finger Min	Thumb & Finger Max	Isotonic Thumb Maximum	Isometric Thumb Min	Isometric Thumb Max
Grip Dia	30mm	50mm	6.5mm	16mm	10mm	15mm	22mm
Shaft Lth	110mm	180mm	70mm	150mm			

EDGE SPACING:



Spacing:	Display ℄ to Controller 'a'	Control to Front Edge 'b'	Space Around Control 'c'
Min	0mm	120mm	
Max	400mm	250mm	Max stick excursion +100mm

Fig 17 Joystick Dimensions

16.4 Shape. The shape of joystick will depend on how it is to be manipulated.

16.5 Displacement Resistance. Maximum operating force for Isometric, whole hand grip, 118N. Thumb & finger, 3.3-4.5N. Thumb, 9-22N. Maximum operating arc for Isometric is recommended at 30° and Isotonic 45°.

16.6 Direction of Motion. Multi axial and is to move in the expected direction for the response.

16.7 Other Requirements. For cursor control for the designation of points on a visual display, isotonic joysticks are more suitable. For dynamic tracking tasks either type is suitable, depending on how it is to be manipulated. Use whole hand grip, when it is necessary for the operator to perform additional functions with the controlling hand. Support may be provided for wrist/forearm of the operator. Sharp edges are to be avoided at those points which will be gripped.

16.8 Joystick System Control

(a) Control law. The control law of a joystick system will reflect the dynamics of the mechanical construction of the device itself, but may be manipulated by the designer by electronic means to optimize the performance of the entire system. The mechanical construction of a device will influence its dynamic characteristics. The following factors will have a direct bearing on the force/displacement characteristics of a device:

(i) Linearity;

(ii) Breakout;

(iii) Deadspace;

(iv) Stiffness;

(v) Friction, viscous and static;

(vi) Mass or inertia;

(vii) Backlash.

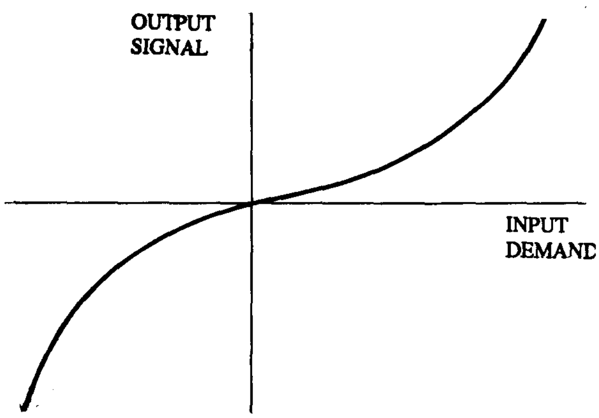


Fig 18 Joystick input/output Control Law

It is possible to obtain measures of these parameters for a given joystick, definitions of optimal levels cannot be given as they will tend to be task specific.

16.8 (Contd)

(b) Signal shaping. Target acquisition requires a relatively high controller sensitivity compared with fine tracking. These different requirements may be accommodated in a rate controlled system by the incorporation of non–linearity in the input-output relationship of the joystick. This is normally best achieved by electronic shaping of the output signal of the controller.

In acquisition, a large demand is required to achieve a high rate of movement of the controlled element. Shaping will result in large demands giving rise to disproportionately large system responses. In fine tracking, small demands around the origin are required and can be associated with less sensitivity; this pattern is inherent in the shaping network shown.

Control laws and control sensitivities should be similar in the different axis of operation, and the sense of the control, the directional relationship between input demand and system response, should meet with the expectations of the operator.

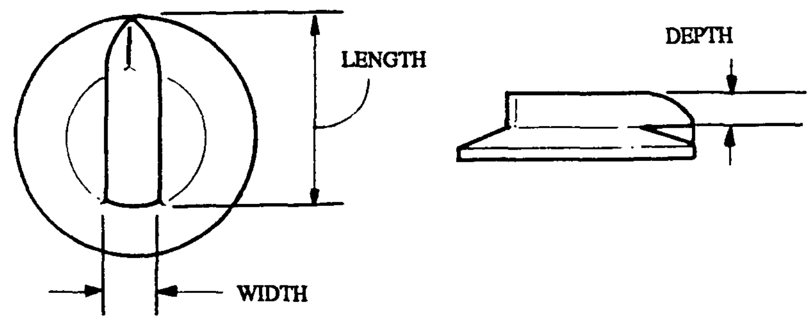
Section Three. Preferred Physical Specifications for Discrete Controls, Rotary

17 Selector Switches (B1.09)

17.1 Characteristics for Selector Switches. The use of rotary selectors is recommended for three to mutually exclusive operating modes.

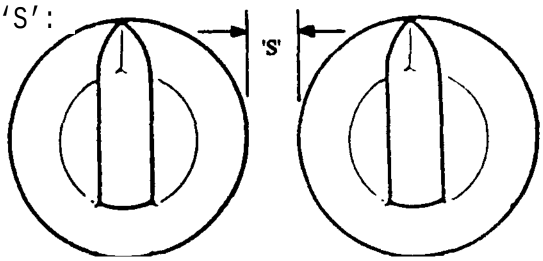
17.2 Location. The vertical position of rotary selectors is recommended, this will depend on the requirements of the task and is to be compatible with reach limitations and the natural movements of the human operator (see Part 2 of this Standard).

17.3 Recommended Dimensions.



Length 'L'	Width 'W'	Depth 'D'	
100mm If Gloves Are Worn l13mm	25mm	75mm	Maximum

EDGE SPACING 'S':



Where Adjacent Controls Operated Simultaneously	Where Adjacent Controls Operated Serially	
75mm	25mm	Minimum
125mm	50mm	Preferred

Fig 19 Selector Switch Dimensions

17.4 Shape. Bar shaped with index tapered point should normally be used, this has the advantage of prompt visual identification of control position.

17.5 Displacement Resistance. Switch resistance should be elastic, building up towards each discrete position then dropping suddenly. Thus the control is to snap into position with an audible click, without the possibility of stopping between adjacent switching positions. Operation torque of l15mNm minimum to maximum of 226mNm for the smaller size, or 680mNm for the larger sizes.

17.6 Direction of Motion. Setting values should increase with a clockwise motion. Operating position should be orientated around the switch according to the following schemes, adopted from MIL STD 1472D.

Table G

Desirable Switch Postitioning

No of Switch Settings	Recommended Starting Positions, in '°' Degrees — Operation with Left Hand	Either	Right Hand	Recommended Angular Displacement Between Positions, in Degrees '°'
3	16°	320°	264°	40°
4	351°	302°	253°	39°
5	328°	286°	243°	37°
6	306°	207°	234°	36°
7	286°	255°	225°	35°
8	267°	242°	217°	34°
9	249°	229°	209°	33°
10	232°	217°	202°	32°
11	216°	206°	195°	31°
12	0, 90, 180°	0, 180°	180, 270 or 360°	30°

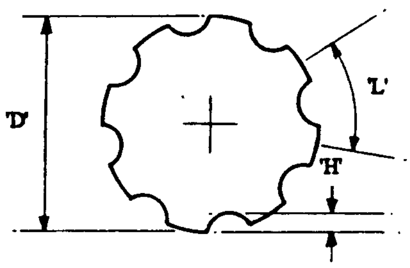
17.7 Other Requirements. The knob attachment is to preclude the possibility of the knob slipping on being replaced with index out of position. Moving pointer with a fixed scale shall be used. The Parallex between pointer and scale is to not exceed 25% of distance between index marks. This can be done by mounting the pointer close to the scale.

18 Thumbwheels (B1.10)

18.1 Characteristics for Thumbwheels (discrete selection). The use of thumbwheels is recommended for up to 10 mutually exclusive operating modes. Each wheel should be graduated from zero to nine.

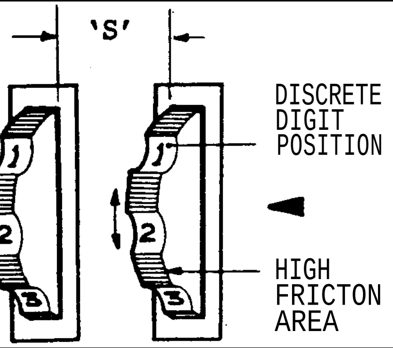
18.2 Location. It is recommended for inputting numerical sequences that the thumbwheels be mounted with the centre-line horizontal. Vertical panel mounting is preferred, this will depend on the requirements of the task and should be compatible with reach limitations and the natural movements of the human operator (see Part 2 of this Standard).

18.3 Recommended Dimensions.



Diameter 'D'	Trough Distance'L'	Width 'W'	Depth 'H'	
30mm	11mm	5mm	3mm	Minimum
75mm	19mm	10mm	6mm	Maximum

EDGE SPACING 'S':



	Single Operated Adjacent Controls	Where Adjacent Controls Are Operated Serially	
'S'	25mm	15mm	Minimum

Fig 20 Discrete Thumbwheel Dimensions

18.4 Shape. In contrast to continuous operation thumbwheels, each discrete position on the circumference should have a concave surface, inscribed with the position digit and separated by a high friction area raised from the periphery of the thumbwheel. It should not have any sharp edges.

18.5 Displacement Resistance. Discrete thumbwheels resistance should be elastic, building up towards each discrete position then dropping suddenly. Thus the control should snap into position with an audible click, without the possibility of stopping between adjacent switching positions. Operation torque of 1.7N minimum to maximum of 5.6N should be provided.

18.6 Direction of Motion. A downward, left or backward movement of the control should be associated with a decrease in setting.

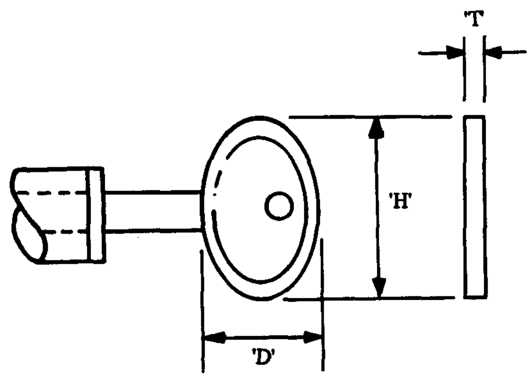
18.7 Other Requirements. Internal illumination of units should be provided when ambient illumination is below 3.5 cd/m^2 (see Part 6 of this Standard). In conditions of adequate ambient illumination, bold black digits engraved on a light concave background may be used (see Part 7 of this Standard) with a character height of 5 mm minimum.

19 Key Operated Switches (B1.11)

19.1 Characteristics for Key Operated Switches. These are used only to restrict operation of equipment to authorized personnel.

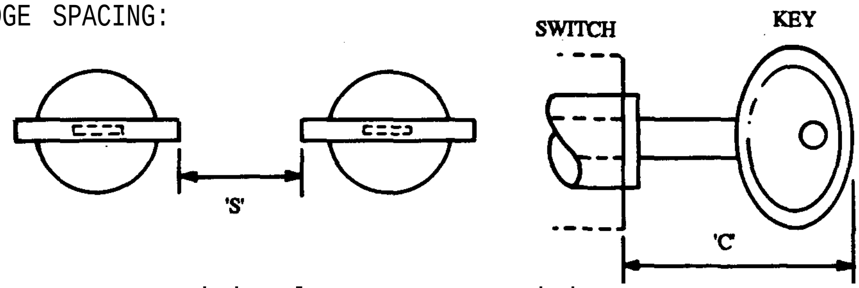
19.2 Location. Assess if proposed is suitable.

19.3 Recommended Dimensions.



Height 'H'	Depth 'D'	Thickness 'T'	
131mm	131mm	2mm	Minimum
75mm	38mm	7mm	Maximum

EDGE SPACING:



'S'= spacing 'C'= clearance 20mm Minimum

'S'	25mm Minimum	40mm Maximum (with gloves)

Fig 21 Key Operated Switch Dimensions

19.4 Shape. Most common shapes are acceptable. It is preferred that duplicate keys have the same shape.

19.5 Displacement Resistance. The resistance of l15mNm Minimum, to 680mNm Maximum should be used. Key angular displacement for two function switches, ie 'ON - OFF' 30° Minimum, 90° Maximum. The total angular displacement for multifunction key operation switches should not exceed 120°.

19.6 Direction of Motion. Switch orientation, two function switches with the 'OFF' position in the vertical position and multifunction switches with the 'OFF' at 300°, activation in a clockwise turn.

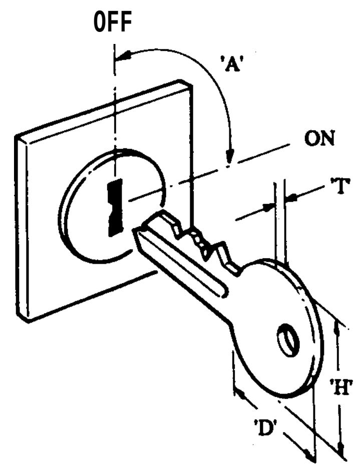
19.7 Other Requirements. It is preferred that the key is only removable in the 'OFF' position and that positional markings/labels should be provided. In the outdoor environment weatherproofing is recommended.

20 Keylocks (B1.12)

20.1 Characteristics for Keylocks, associated with latch systems. These are used only to restrict access to doors, cabinets and drawers to authorized personnel.

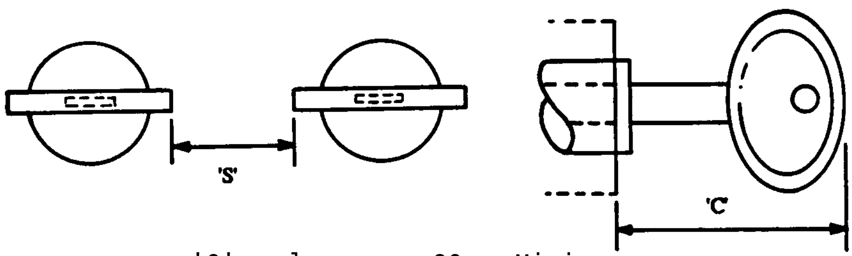
20.2 Location. Assess if the proposed position is suitable, with sufficient clearance for the hand to turn the key without interference.

20.3 Recommended Dimensions.



Height 'H'	Depth 'D'	Thickness 'T'	
13mm	13mm	2mm	Minimum
75mm	38mm	7mm	Maximum

EDGE SPACING:



'S'= spacing 'C'= clearance 20mm Minimum

'S'	25mm Minimum	40mm Maximum (with gloves)

Fig 22 Keylock Dimensions

20.4 Location. Keylocks should conform to the following guidelines:

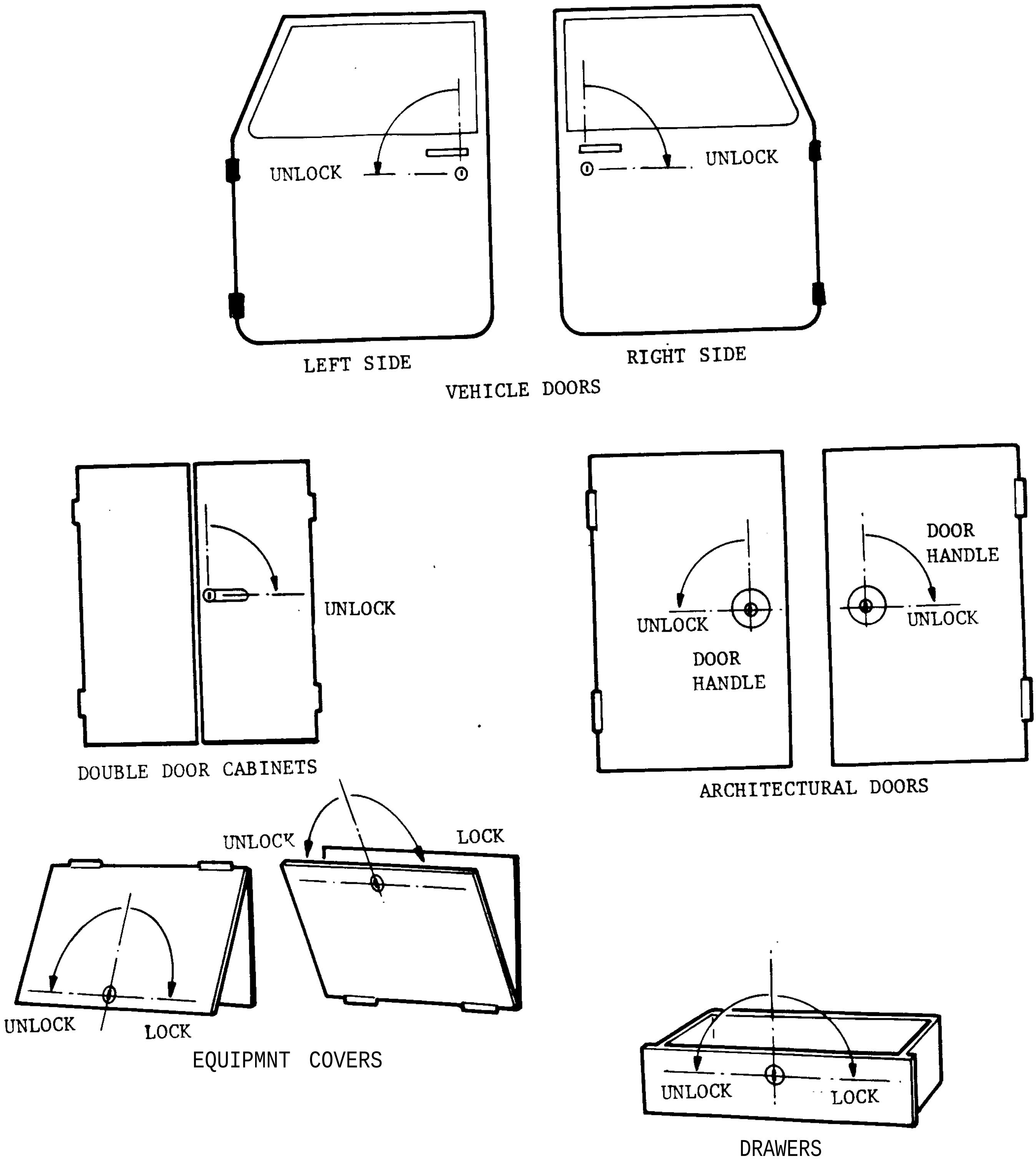


Fig 23 Keylock Location

20.5 Shape. Most common shapes are acceptable. It is preferred that duplicate keys have the same shape.

20.6 Displacement Resistance. The resistance of l15mNm Minimum, to 680mNm Maximum should be used. Key angular displacement for two function switches, ie 'ON -OFF' 30° Minimum, 90° Maximum.

20.7 Direction of Motion. Keylocks should conform to the following guidelines: key orientation for vehicle doors; the vertical position to 'LOCK' and turn towards the door-hinge to 'UNLOCK'. Door and drawer locks are normally right-handed. With key orientation vertical turning to the right to activate the latch.

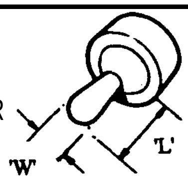
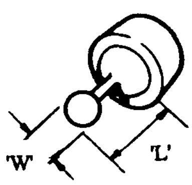
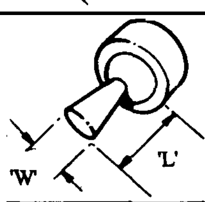
20.8 Other Requirements. Vehicle door keylocks should be designed to lock with the key to prevent the operator from locking himself out. In the outdoor environment weatherproofing is recommended. Reversible keys should be used, keys which will operate with the lock either way up. However, if keys with teeth on only one side are used they should be inserted with the teeth in the up position.

21 Toggle Switches (B2.13)

21.1 Characteristics for Toggle Switches. These are used for selecting between two, or at the most three, operating modes. With three positions centre is normally 'OFF'. They provide a very clear visible indication of operating condition and are used when space is limited, but they can be prone to accidental activation.

21.2 Location. Assess if the proposed position is suitable, with sufficient clearance for the hand.

21.3 Recommended Dimensions. The length and width of toggle switches should conform to the following for a variety of toggle shapes.

TYPE	Width 'W' TIP Min	Width 'W' TIP Max	Length 'L' Bare Finger Min	Length 'L' Bare Finger Max	Length 'L' Gloved Hand Min	Length 'L' Gloved Hand Max
TOGGLE DIAMETER 	4.5mm	7.8mm	13mm	30mm	38mm	50mm
BALL DIAMETER 	4.5mm	7.8mm	13mm	30mm	38mm	50mm
PADDLE DIAMETER 	7mm	19mm	13mm	50mm	38mm	50mm

EDGE SPACING: Horizontal array (→) switch '℄' to '℄'	Bare finger Min	Bare finger Max	Gloved hand Min	Gloved hand Max
Single Switch Operation	19mm	30mm	32mm	43mm
Sequence Operation	19mm	25mm	32mm	38mm
Simultaneous Operation	19mm	28mm	32mm	41mm
Vertical array (↓) Upper row, toggle 'DOWN' Lower row, toggle 'UP'	25mm		38mm	

Fig 24 Toggle Switch Dimension

21.4 Shape. Toggle, Ball & Paddle shapes are acceptable.

21.5 Displacement Resistance. The switch should be provided with an elastic resistance which gradually increases and then drops as the switch control snaps into position with an audible click without the possibility of stopping between adjacent switching positions. Smaller size switches are to have a resistance of 2.8 - 4.5N, and larger size switches a resistance of 2.8 – 11N. Angular displacement for two position switches is 30° Minimum - 120° Maximum for three position switches is 40°-0-40° Minimum, 60°–0-60° Maximum.

21.6 Direction of Motion. A vertical direction of motion is preferred, 'DOWN' corresponding to 'ON', 'INCREASE' and 'GO' in the UNITED KINGDOM.

NOTE: The USA switching norms are reversed.

21.7 Other Requirements. To prevent accidental activation, channel or barrier guards can be considered with tip clearance of 13 mm minimum, up to 32 mm maximum for gloved operation.

22 Selection Levers (B2.14)

22.1 Characteristics for Selection Levers. These should be used when large mechanical forces are necessary in selecting operating mode and/or when operating position must give a clear visible indication. The necessity to operate with a positive movement makes levers useful in safety critical operations, ie power on/off. If spring biased to 'OFF', these should be used to operate a power cut-off which will deactivate a system in the event of operator incapacitation or inattention, ie a 'dead man's handle'.

22.2 Location. The location and position of selection levers relative to the operator should be compatible with reach limits, mobility, natural movements and strength capabilities (see Parts 2 & 3 of this Standard).

22.3 Recommended Dimensions. For discrete selection lever configurations, designers should refer to similar illustration for relevant shapes and dimensions (see **13** (A2.05)).

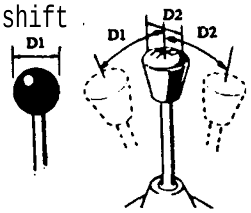
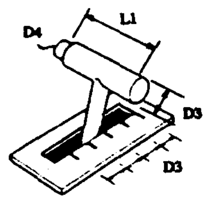
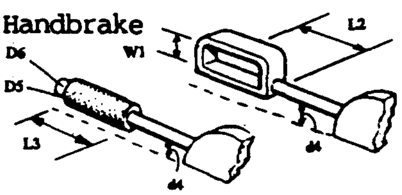
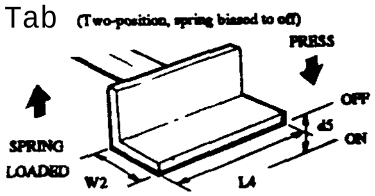
Lever Applications	Dimensions & Clearance 'C'
Gear shift 	Spherical Knob 'D1' 30mm Minimum-44mm Maximum 'C' 80mm Minimum Cone Knob 'D2' 30Min-40mm Max 'C' 80mm Minimum
Automatic Transmission 	Cylindrical Handgrip 'L1' 70mm Minimum 'D3' 19Min-28mm Max 'C' 70mm Minimum Release Button 'D4' 15mm Minimum-20mm Maximum 'C' 50mm Minimum
Handbrake 	Internal Handgrip 'L2'110mm Mimnimum 'W1' 50mm Minimum Cylindrical & Release Button 'L3'100mm Minimum 'D5' 25mm Minimum-32mm Maximum 'D6' 15mm Minimum-20mm Maximum 'C' 50mm Minimum
Tab (Two-position, spring biased to off) 	Tab 'L4' 25mm Minimum-45mm Maximum 'W2' 19mm Minimum-30mm Maximum 'C' 50mm Minimum

Fig 25 Selection Lever Dimensions

22.4 Shape. The length of the selection lever can be determined after considering the mechanical advantage of the system, operator position and the limitations of the 5th percentile operator (see part 2 of this Defence Standard). Handle shape can be either cylindrical, spherical or shaped to fit the hand grip as required but with no sharp edges. Anti-slip texturing may be applied.

22.5 Displacement Resistance. Displacement & Resistance values should conform to the following:

Gear shift;
Displacement, Centre-forward/back 'D1' 125 mm Minimum 250 mm Maximum.
Centre-right/left 'D2' 125 mm Minimum 250 mm Maximum.
Resistance, Centre-forward/back 'd1' should not exceed 127N.
Centre-right/left 'd2' should not exceed 88N.

Automatic Transmission;
Displacement between settings 'd3' 25 mm Minimum 50 mm Maximum.
Resistance of lever with release button depressed, 90N Min 127N Max

Handbrake;
'd4' Displacement should be restricted to a nominal range of 100-125 mm
Lift up Resistance, 98N Minimum 245N Maximum.

Tab;
'd5' Displacement On-off 25 mm Minimum 75 mm Maximum
Press down Resistance, 4.5N Minimum 27N Maximum.

22.6 Direction of Motion. It is recommended that for Gear shift levers that from neutral left/forward to 1st, backward to 2nd, right/forward to 3rd, etc, and must be lifted to go into 'Reverse'. Automatic Transmission neutral forward to increase, and backward to decrease. Handbrakes should be pulled ON towards the operator. Tab levers downward for the 'ON' position.

22.7 Other Requirements. To prevent accidents it is to be impossible for vehicles Gear shift to 'jump' out of gear, and Automatic Transmission is not to rest between settings.

23 Push-Pull Controls (B2.15)

23.1 Characteristics for Push-Pull Controls. This is a compact control for the selection of two or three mutually exclusive functions. Three position controls should only be used when selection of the wrong position is not critical. Where panel space is limited, two related but distinct functions, ie 'ON-OFF' and 'GAIN', may be governed by a push-pull/rotary knob.

23.2 Location. The location and position of push-pull control relative to the operator should be compatible with reach limits, mobility, natural movements and strength capabilities (see Parts 2 & 3 of this Standard).

23.3 Recommended Dimensions.

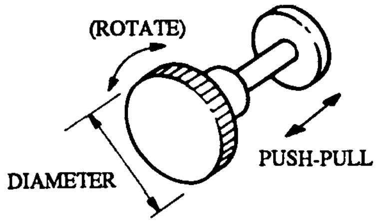
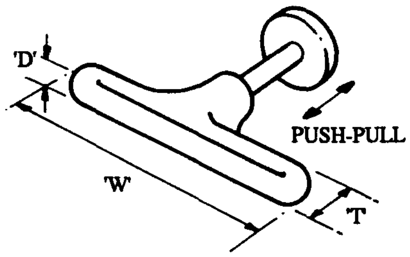
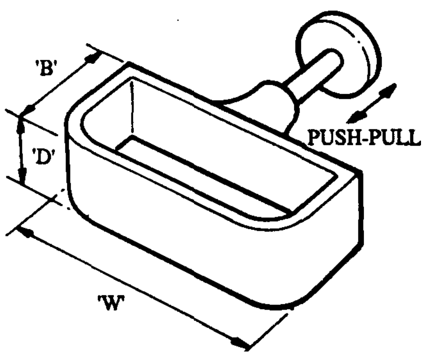
Control Type	Dimensions & Clearance
Low Resistance 	Diameter: 19mm Minimum Rotation: clockwise = gain Edge spacing:adjacent controls 40mm(55 gloved) Minimum Clearance:behind control, when pushed in, to panel surface. 25mm(28 gloved) Minimum
'T'Bar 	‘W’= width: 100mm Minimum ‘D’= depth: 16 Min 38mm Max ‘T'= thickness:10 Min 25mm Max Edge spacing:adjacent controls Horizonal array 13mm Minimum vertical array 40mm(50 gloved) Minimum Clearance:behind control, when pushed in, to panel surface. 40mm(46 gloved) Minimum
‘D’Bar 	‘W’= wth:100mm(125 gloved) Min ‘D’= depth: 16 Min 38mm Max ‘B’= grasp breath: 35mm(45 gloved) Maximum Edge spacing:adjacent controls horizonal array 13mm Minimum vertical array 40mm(50 gloved) Minimum Clearance:behind control, when pushed in, to panel surface is covered with grasp breath.

Fig 26 Push-Pull Control Dimensions

23.4 Shape. The shape of the push-pull control can be determined after considering the mechanical advantage of the system, operator position and the limitations of the 5th percentile operator (see Part 2 of this Defence Standard). It is not to have any sharp edges, anti slip texture can be considered.

23.5 Displacement Resistance. Displacement, the movement from the front of the control in the push position to the front of the control in the pull position, should be Low resistance, 15 mm Minimum 30 mm is preferred.
'T' & 'D' Bar, 25 mm Minimum 50 mm is preferred.

Resistance, Push-pull force for two finger operation of 18N is desirable. Four finger operation 45N Maximum should be adopted.

23.6 Direction of Motion. A pulling motion should correspond to 'ON' or system activation, a pushing motion should correspond to 'OFF' or system deactivation.

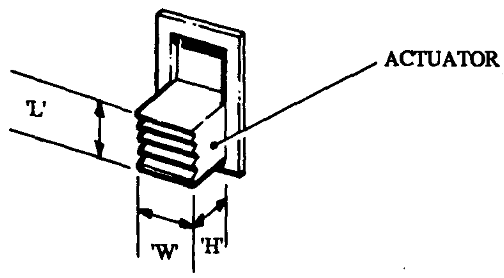
23.7 Other Requirements. The shaft should normally be non-rotating, except where the handle requires an initial turn to disengage or unlock the control or when a combined type is used.

24 Slide Switches (B2.16)

24.1 Characteristics for Slide Switches. These may be used for sequential selection between two or three discrete positions and are particularly useful when arranged in a matrix where they permit easy visible indication of operating position. They are less compact than rotary selectors.

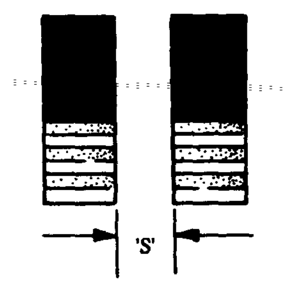
24.2 Location. The location and position of slide switches, either as single units or in banks, should be compatible with reach limitations and the natural movements of the human operator (see Part 2 of this Standard). Mounting is normally vertical, except where equipment function makes horizontal mounting more appropriate.

24.3 Recommended Dimensions.



Actuator Height 'H'	Width 'W'	Length 'L'
6mm(13mm Gloved) Minimum	6mm Minimum	5mm Minimum

EDGE SPACING 'S':



Single Switch Single Finger	Sequence Operation Single Finger	Simult Operation Different Fingers
19mm Minimum	13mm Minimum	16mm Minimum
50mm Maximum	25mm Maximum	19mm Maximum

Fig 27 Slide Switch Dimensions

24.4 Shape. The shape is rectangular with a ribbed surface for friction in operation. It is not to have any sharp edges.

24.5 Displacement resistance. Resistance should be elastic, building up towards each position then dropping. The following resistance can be adopted. Small switches (<9 mm 'H' x 10 mm 'W' x 10 mm 'L') 2.8n min 4.5n max. Large switches (>9 mm 'H' x 10 mm 'W' x 10 mm 'L') 4.5n min 11n max.

24.6 Direction of Motion. 'Down' or towards the operator is to correspond to 'ON'.

24.7 Other Requirements. It is recommended where there are more than two positions that an index mark on the left-hand side be considered.

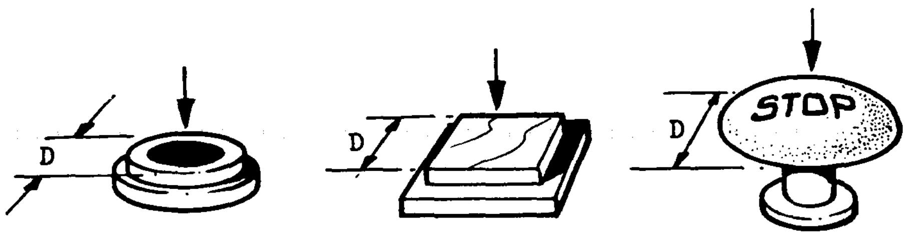
25 Push Buttons (B4.17)

25.1 Characteristics for Push Buttons. Finger operation, momentary contact (push & hold 'ON'/release 'OFF'), alternate action (push 'ON'/ push 'OFF') these are particularly useful for frequently operated control functions and require little time and effort to activate. Primary applications are in the simple switching between two conditions. A disadvantage that their state of activation is not readily visible. Emergency applications when rapid and positive action is required, mushroom shaped buttons operated by striking with the fist or palm of the hand should be used.

25.2 Location. Push buttons are to be located within easy reach of the operator taking into account such constraints as acceleration restraint systems and protective clothing requirements.

25.3 Recommended Dimensions.

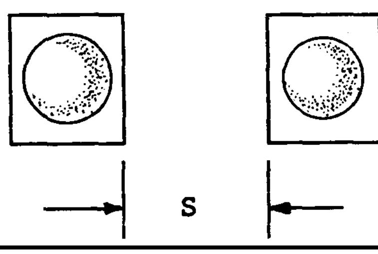
Finger/Thumb Fist/Palm



Diameter ='D'

Finger Operation	Thumb Operation	Palm Operation
10mm(20 Gloved) Min	19mm(25 Gloved)Min	40mm(50 Gloved)Min
25mm Maximum	25mm Maximum	70mm Maximum

EDGE SPACING 'S':



Single Button & One Finger	13mm(25mm gloved)Min	50mm Max
Sequence Oper'n/Single Finger	6mm Min	13mm Max
Simult. Oper'n/Different Fingers	6mm Min	13mm Max
Fist/Palm Oper'n	25mm Min	150mm Max

Fig 28 Push Button Dimensions

25.4 Shape. Push buttons can be round, square or rectangular in shape, with a concave friction surface to prevent the bare or gloved digit slipping. It is not to have any sharp edges. The mushroom type is to be used for EMERGENCY STOP control only.

25.5 Displacement Resistance. Resistance can be elastic, starting low and building up rapidly and then drop suddenly with control activation. The following displacement for finger tip operation 2 mm Min 6 mm Max and Fist/palm 3 mm Min 38 mm Max can be adopted.

The following resistances for: Single finger operation 2.8N Min 11N Max, Simultaneously operation using different fingers 1.4N Min 5.6N Max and Fist/palm operation 2.8N Min 23N Max can be adopted.

25.6 Direction of Motion. Pushing the button down should correspond to 'ON' or system activation. Striking the mushroom EMERGENCY STOP control type is to deactivate the system.

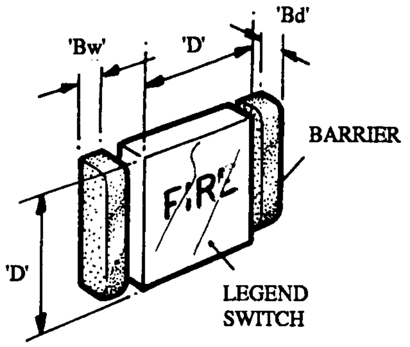
25.7 Other Requirements. To prevent accidental activation, the button can be recessed into the control panel. Locating of mushroom EMERGENCY STOP controls away from any other controls may help prevent accidental activation. Finger or thumb operated push buttons should possess a high friction or concave surface to prevent the bare or gloved digit slipping. Where prevention of accidental activation is important, a channel or cover guard is to be provided. The guard is not to interfere with the function of the control. The three main types of push button function are latching, push-on and lock-on. Activation may be indicated by an audible click, where possible, accompanied by a sudden drop in resistance. The button can remain depressed until the circuit is deactivated. Control position is not easily identifiable visually, so either backlighting or a display indicating control position may be used for critical functions or dimly lit workplaces.

26 Legend Switches (B4.18)

26.1 Characteristics for Legend Switches. These are a special type of push button switch and are used to display qualitative information on system status, which requires the operator to activate the control associated with it. Appropriate to use when functional grouping or matrix of control switches and indicators is required, but space is very limited. There are two main types 'Illuminated', where the legend is visibility illuminated when the switch is activated or 'Permanent' where the legend is visible whatever the state of the switch.

26.2 Location. Legend switches are to be located within easy reach of the operator taking into account such constraints as acceleration restraint systems and protective clothing requirement.

26.3 Recommended Dimensions.



Switch Dimension 'D'	Barrier Width 'Bw'	Barrier Depth 'Bd'
19mm(25mm Gloved)Min	3mm Minimum	5mm Minimum
38mm Maximum	6mm Maximum	6mm Maximum
EDGE SPACING: Should Correspond To Barrier width'Bw'		

Fig 29 Legend Switch Dimensions

26.4 Shape. Legend switches can be square or rectangular in form. It is not to have any sharp edges.

26.5 Displacement Resistance. Activation of the control can be indicated by a positive tactile or auditory cue, ie a 'click'. In the case of integral illuminated the legend is to be lit.

		RESISTANCE		DISPLACEMENT	
		MINIMUM	MAXIMUM	MINIMUM	MAXIMUM
STANDARD LEGEND SWITCHES		2.8N (5.6N for use in moving vehicles)	16.7N	3mm	6 mm
Membrane/ Tactile Legend Switch	'Dome Snap Action' Contact	1.5N	2.5N	0.7mm	1.0 mm
	'Conductive Membrane Contact'	2.ON	3.ON	0.5 mm	1.0 mm

Fig 30 Legend Switch Displacement Resistance

26.6 Direction of Motion. Pushing the button down is to correspond to 'ON' or system activation.

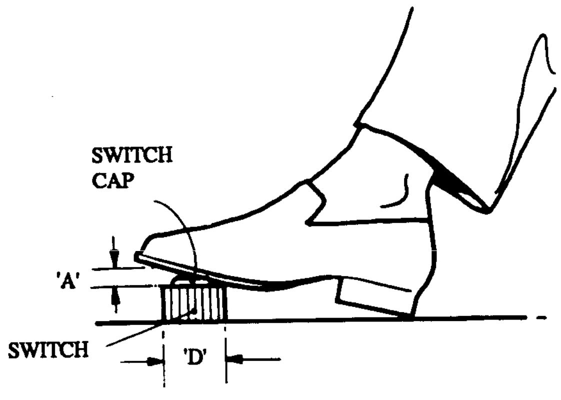
26.7 Other Requirements. 'Illuminated'; The switch illumination is to be replaceable from the front of the panel by hand with the legend covers keyed to prevent the possibility of interchanging the legends. The illumination reliability should be greater than 100,000 hrs 'Mean Time Between Failure' (MTBF).

27 Foot Operated Switches (B4.19)

27.1 Characteristics for Foot Operated Switches. These are a special type of push button switch and are used where the operator's hands are occupied and normally located out of his view. Applications are to be limited to infrequent operations.

27.2 Location. Located within the operator's leg reach (see Part 2 of this Standard). The position of the foot switch is to permit operation by the toes and the ball of the foot, rather than the heel. It ought to be clear of any obstruction so that the ball of the foot can centre on the switch and the heel rest on the floor.

27.3 Recommended Dimensions.



Diameter ='D'   Cap Displacement ='A'

'D' 13mm(30mm for NBC overboots) Minimum

EDGE SPACING:

More than one switch is NOT recommended.
Should it be necessary then the following should be used.
Horizontally edge spacing of 75mm Minimum
Vertically edge spacing of 120mm Maximum

Fig 31 Foot Operated Switch Dimensions

27.4 Shape. Normally round. It is not to have any sharp edges.

27.5 Displacement Resistance. Resistance ought to be elastic, starting low and building up rapidly and then drop suddenly with an auditory ‘click’ as the control is activated. The following Displacement of 13 mm (25 mm using heavy footwear) Min 65 mm Max, Resistance of 45N with foot resting on the switch (18N with foot NOT resting on the switch) 90N Max should be adopted.

27.6 Direction of Motion. Pushing the switch cap down is to correspond to ‘ON’ or system activation.

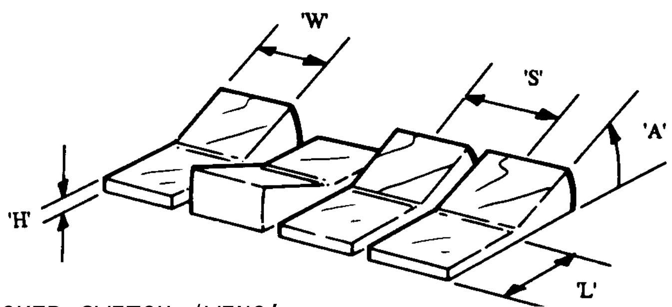
27.7 Other Requirements. The switch cap is to have a high friction surface. A safety requirement is that rubber cap covers should not be used.

28 Rocker Switches (B4.20)

28.1 Characteristics for Rocker Switches. These are available as an alternative to the toggle switch in the selection between two conditions, especially where the protruding handle of the toggle switch presents a hazard. The operating position of a rocker switch is not as readily visible as that of the toggle switch. The three position rocker switch should only be used where a rotary switch is inappropriate, ie due to limitation in available panel space. More than three positions are not to be used.

28.2 Location. Vertical orientation of rocker switches can be adopted except where compatibility with the controlled function or equipment location makes a horizontal orientation more appropriate.

28.3 Recommended Dimensions.



ROCKER SWITCH ‘WING’

Width='W' 6mm Minimum 20mm Maximum
Length =’L’ Of One Wing Of The Switch 13mm Min 18mm Max
SPACING ‘S’ ‘S’= Centre-to-Centre Spacing 28mm(40mm Gloved) Minimum

Fig 32 Rocker Switch Dimensions

28.4 Shape. Normally rectangular wing shape. It is not to have any sharp edges.

28.5 Displacement Resistance. Resistance should gradually increase and then drop as the switch snaps into position with an auditory 'click' as the control is activated. When the wing is depressed, height 'H' = 3 mm Min 5 mm Max, the raised wing angle 'A' should be 30° Min 50° Max. Resistance of 2.8N Min 11N Max should be adopted.

28.6 Direction of Motion. For vertical orientation, activation of the switch by pressing down the lower wing should correspond to 'ON'. When horizontal orientation, activation of the switch by pressing down the right hand wing should correspond to 'ON'.

28.7 Other Requirements. Conspicuous switch positions cues may be provided by alternate colour or contrast for 'ON' and/or 'OFF' settings. An illuminated 'ON' position is useful as another feedback cue (see Parts 6 and of this Standard).

PREFERRED PHYSICAL SPECIFICATIONS FOR DATA ENTRY CONTROLS

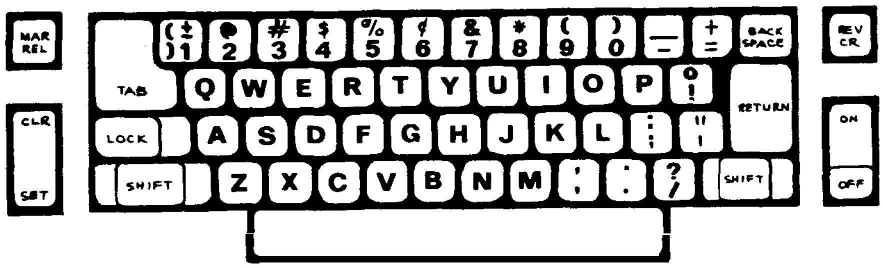
29 Keyboards (C5.21)

29.1 Characteristics for Keyboards. These have the advantage of wide user acceptance in the context of data entry, changing to alternative character sets by the use of a shift key. The standard typewriter, QWERTY key configuration is used where a general purpose entry requirement cannot be satisfied by numeric keypads.

29.2 Location. The keyboard should be located horizontally or at approximately the level of the elbow of the seated operator and directly in front of the operator. Where possible the keyboard is to be detachable to permit the operator to place it where it is most comfortable.

29.3 Recommended Dimensions.

Layout Of Keys For Typical Typewriter



KEY SIZE, For Low Level Vibration Environment		
Bare Handed 10mm Minimum	19mm Maximum	14mm Preferred
Gloved 15mm Minimum		22mm preferred
KEY SIZE, Vehicle Applications		
Bare Handed 10mm Minimum	25mm Maximum	
Gloved 19mm Minimum	25mm Maximum	

EDGE SPACING:

Preferred For Sequential Oper'n Edge-Edge Spacing 6.5mm

A Spacing Of 13mm Will Reduce Risk Error In Vibration

Fig 33 Keyboard Dimensions

29.4 Shape. Keys may be circular, square or rectangular with a dished top surface. They are not to have any sharp edges.

29.5 Displacement Resistance. Keys should exhibit elastic resistance, but resistance characteristics may be determined by the operational requirements of the equipment.

Displacement for Alphanumeric operation	1.3 mm Min 6.3 mm Max
Numeric and Dual function operation	0.8 mm Min 4.8 mm Max
Membrane 'tactile' keys	0.7 mm Minimum

Resistance for sequential Alphanumeric operation	0.25N Min 1.5N Max
Numeric input, vehicle application	2.8N Min 6.7N Max
Membrane 'tactile' keys	2N Min

29.6 Direction of Motion. Touching/striking the key down should activate the key action then the key should return to its normal position.

29.7 Other Requirements. Keys within a keyboard should exhibit uniform characteristics. Under conditions of vibration it is desirable for the key to incorporate positive tactile feedback to indicate activation, ie 'snap' action. For military applications the entire keyboard is to be designed with NBC decontamination requirements in mind. The advantage in the use of membrane 'tactile' keys that have 'wipe over' covers, which still permit key activation are to be considered.

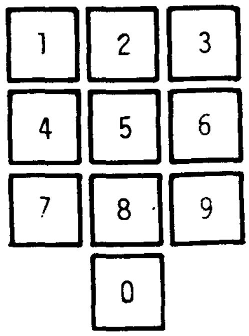
30 Keypads (C5.22)

30.1 Characteristics for Keypads. The keypad is used when numeric information only is to be entered into the system. It occupies a smaller area than the alphanumeric keyboard and can be used more rapidly than the QWERTY layout for numeric entry.

30.2 Location. The keypad can be mounted horizontally or vertical depending on the operational requirements. When horizontal it should be located at approximately the level of the elbow of the seated operator and directly in front of the operator. Where possible the keypad should be detachable to permit the operator to place it where it is most comfortable. When mounted vertically, provision should be made for the operator to steady the hand during operation.

30.3 Recommended Dimensions. If mounted vertically, minimum key size should be 19 mm to permit operation with the thumb whilst the remaining fingers steady the hand.

Typical Telephone Key Layout



KEY SIZE, For Low Level Vibration Environment		
Bare Handed 10mm Minimum	19mm Maximum	14mm Preferred
Gloved 15mm Minimum		22mm Preferred
KEY SIZE, Vehicle Applications		
Bare Handed 10mm Minimum	25mm Maximum	
Gloved l9mm Minimum	25mm Maximum	
EDGE SPACING: Preferred for sequential oper'n edge-edge spacing 6.5mm; A spacing of 13mm will reduce risk error in vibration		

Fig 34 Keypad Dimensions

30.4 Shape. Keys may be circular, square or rectangular with a dished top surface. They are not to have any sharp edges.

30.5 Displacement Resistance. Keys should exhibit elastic resistance, but resistance characteristics may be determined by the operational requirements of the equipment.

Displacement for Alphanumeric operation	1.3 mm Min 6.3 mm Max
Numeric and Dual function operation	0.8 mm Min 4.8 mm Max
Membrane ‘tactile’ keys	0.7 mm Minimum

Resistance for sequential Alphanumeric operation	0.25 Min 1.5N Max
Numeric input, vehicle application	2.8N Min 6.7N Max
Membrane 'tactile’ keys'	2N Minimum

30.6 Direction of Motion. Touching the key down should activate the key action then the key should return to its normal position.

30.7 Other Requirements. Keys within a keypad should exhibit uniform characteristics. Under conditions of vibration it is desirable for the key to incorporate positive tactile feedback to indicate activation, ie ‘snap’ action. Keys for ‘cancelling’ and ‘enter’ should be provided. For military applications the entire keypad should be designed with NBC decontamination requirements in mind.

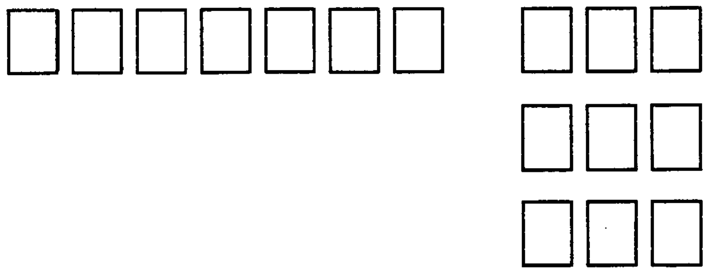
31 Keysets (C5.23)

31.1 Characteristics for Keysets, dedicated functions. Keysets with each key dedicated to a specific switching function or command should be used when the number of functions is relatively small and unchanging. In data entry applications they may be used instead of keyboards to enter system commands.

31.2 Location. Dedicated keysets should be located and configured according to the task of the operator, such as taking into account normal operational sequences (see Part 4 of this Standard).

31.3 Recommended Dimensions. Dedicated keysets should conform to the recommendations for keyboards, except where a label is necessary on the keycap for identification purposes. In this case legend switches (B4.18) dimensions are appropriate.

SIZE: Layout Of Keys



KEY SIZE, For Low Level Vibration Environment		
Bare Handed 10mm Minimum	19mm Maximum	14mm Preferred
Gloved 15mm Mininum		22mm preferred
KEY SIZE, Vehicle Applications		
Bare handed 10mm Minimum	25mm Maximum	
Gloved 19mm Minimum	25mm Maximum	
EDGE SPACING:		
Preferred For Sequential Oper'n Edge-Edge Spacing 6.5mm		
A Spacing Of 13mm Will Reduce Risk Error In Vibration		

Fig 35 Keyset Dimensions

31.4 Shape. Keys may be circular, square or rectangular with a dished top surface. They are not to have any sharp edges.

31.5 Displacement Resistance. Keys should exhibit elastic resistance, but resistance characteristics should be determined by the operational requirements of the equipment.

Displacement for Alphanumeric operation	1.3 mm Min 6.3 mm Max
Numeric and Dual function operation	0.8 mm Min 4.8 mm Max
Membrane 'tactile' keys	0.7 mm Minimum

Resistance for sequential Alphanumeric operation	0.25N Min 1.5N Max
Numeric input, vehicle application	2.8N Min 6.7N Max
Membrane 'tactile' keys	2N Minimum

31.6 Direction of Motion. Touching the key down should activate the key action then the key should return to its normal position.

31.7 Other Requirements. Keys within a keyset should exhibit uniform characteristics. Under conditions of vibration it is desirable for the key to incorporate positive tactile feedback to indicate activation, ie 'snap' action. For military applications the entire keyset should be designed with NBC decontamination requirements in mind.

32 Multi-Function Keysets (C5.24)

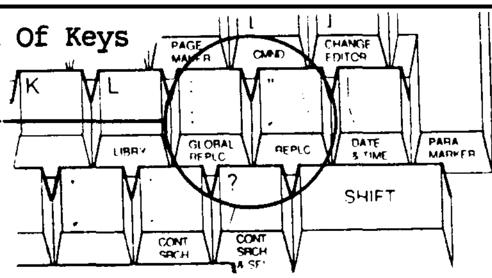
32.1 Characteristics for Multi-Function Keysets. These offer a means of changing the operating functions of individual keys. They can be utilized when switching requirements vary substantially during different phases or modes of operation and when the total number of functions to be switched cannot be conveniently handled by dedicated keys. The risk of error in selection is higher than is the case with dedicated keys, as the same key will have different functions at different times. Consequently, multi-function keys 'ARE NOT to be used for the selection of critical functions'.

32.2 Location. In multi-function keys, the current function of each key is to be clearly visible and the labels are not to be close to their relevant keys. Labels which are not applicable to the selected mode should not be visible. Those switches which may not be selected in the current mode may be indicated, ie by extinguishing an integral light.

32.3 Recommended Dimensions. Multi-function keys are to conform to the recommendations for keyboards, except where a label is necessary for identification purposes.

SIZE: **Layout Of Keys**

Example of computer Multi-function keys



KEY SIZE, For Low Level Vibration Environment		
Bare Handed 10mm Minimum	19mm Maximum	14mm Preferred
Gloved 15mm Minimum		22mm preferred
KEY SIZE, Vehicle Applications		
Bare Handed 10mm Minimum	25mm Maximum	
Gloved 19mm Minimum	25mm Maximum	

EDGE SPACING:

Preferred For Sequential Oper'n Edge-Edge Spacing 6.5mm

A Spacing,Of 13mm Will Reduce Risk Error In Vibration

Fig 36 Multi-Function Keyset Dimensions

32.4 Shape. Keys may be circular, square or rectangular with a dished top surface. They are not to have any sharp edges.

32.5 Displacement Resistance. Keys should exhibit elastic resistance, but resistance characteristics can be determined by the operational requirements of the equipment.

Displacement for Alphanumeric operation	1.3 mm Min 6.3 mm Max
Numeric and Dual function operation	0.8 mm Min 4.8 mm Max
Membrane'tactile' keys	0.7 mm Minimum

Resistance for sequential Alphanumeric operation	0.25N Min 1.5N Max
Numeric input, vehicle application	2.8N Min 6.7N Max
Membrane'tactile' keys	2N Minimum

32.6 Direction of Motion. Touching the key down should activate the key action then the key should return to its normal position.

32.7 Other Requirements. Keys within a keyset should exhibit uniform characteristics. Under conditions of vibration it is desirable for the key to incorporate positive tactile feedback to indicate activation, ie 'snap' action. For military applications the entire keyset is to be designed with NBC decontamination requirements in mind.

33 Voice Recognition System (C6.25)

33.1 Characteristics for Voice Recognition System. Speech is the most natural communication medium, voice control decreases response time and reduces the incidence of operator errors. They are omnidirectional in use, and operable under low ambient light conditions. Data entry by direct voice input (DVI) typically consists of a single utterance, however a critical task during high workload must not rely on DVI. Voice control systems are a potential alternative to keyboard and other manually operated input devices when hands are busy elsewhere.

33.2 Location. Assess if proposed location is suitable.

33.3 Recommended Dimensions. Panel space requirements are small and the equipment required would be designed to suit, ancillary equipment can be stored elsewhere (see Parts 8 and 9 of this Standard).

33.4 Shape. As appropriate (see Parts 8 and 9 of this Standard).

33.5 Displacement Resistance. Not appropriate.

33.6 Direction of Motion. Omnidirectional in use.

33.7 Other Requirements. The systems are to function under the effects of interfering factors which may be imposed under the most severe conditions of use. The operator's voice characteristics will be altered by a variety of factors associated with the operational environment. The system should therefore maintain an acceptable command recognition rate in spite of these vocal and environmental changes. Specialist advice is to be obtained on the viability of voice control for specific applications and the system is preferably to be tested for reliability under a full range of operational conditions, with decontamination requirements in mind.

34 Touch Displays (C7.26)

34.1 Characteristics for Touch Displays. Pointing with the finger or a pointer is a very natural and rapid means of designation on a display. An advantage of the touch display is that there are no loose sensors or probes which may become damaged. A button or similar control needs to be operated with the other hand to command storage of the designated co-ordinates. A disadvantage is that the display is obscured during use and the surface can become soiled. Touch displays may be used for the designation of points on a Cathode-Ray Tube (CRT) or similar display when the display is within reach of the operator and line of sight is approximately normal to the display surface.

34.2 Location. The screen surface should be within reach envelope of the fifth percentile operator (see Part 2 of this Standard).

34.3 Recommended Dimensions. The size of the display must be adequate to meet the visual requirements of the task and to meet the required accuracy of spatial designation performance (see Part 7 of this Standard).

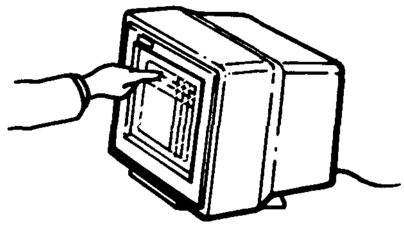


Fig 37 Touch Display

34.4 Shape. Standard CRT, similar display.

34.5 Displacement Resistance. Not appropriate.

34.6 Direction of Motion. The direction of motion of the cursor should be the same as that of the finger or pointer. It is preferable that movement of the finger or pointer across the screen surface should result in the cursor moving at the same rate and with a smooth motion.

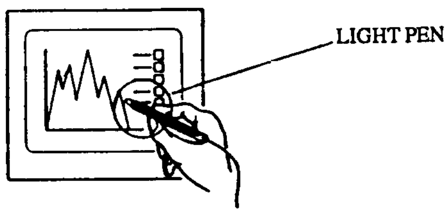
34.7 Other Requirements. Consideration should be given to whether operation will be activated by first or last point of contact. The systems should function under the effects of interfering factors which may be imposed under the most severe conditions of use and should be tested for reliability under a full range of operational conditions.

35 Light Pen (C7.27)

35.1 Characteristics for Light Pen. System capable of sensing the beam from a light pen touching or very close to the surface of a visual display. The disadvantages and advantages are the same as for touch displays, but the light pen is attached to the system by means of a wire, and there is a need to store the probe when not in use. However, the storage of the designated co-ordinates may be commanded, ie by means of a 'push tip' which may conveniently be pressed against the screen surface. Light pens may be used for the generation of freely drawn graphs.

35.2 Location. The screen surface should be within reach envelope of the fifth percentile operator (see Part 2 of this Standard).

35.3 Recommended Dimensions. The size of the display must be adequate to meet the visual requirements of the task and to meet the required accuracy of spatial designation performance (see Part 7 of this Standard).



Length = 'L'	120mm Minimum	180mm Maximum
Diameter = 'D'	7mm Minimum	20mm Maximum

Fig 38 Light Pen Dimensions

35.4 Shape. Standard CRT, similar display. The light pen should take the approximate form of a conventional pen, with surface texture to permit a firm grip.

35.5 Displacement Resistance. Not appropriate.

35.6 Direction of Motion. The direction of motion of the cursor should be the same as that of the light pen. It is preferable that movement of the light pen across the screen surface should result in the cursor moving at the same rate and with a smooth motion. When used as a two axes controller, contact with the screen surface should cause the cursor to appear at the designated co-ordinates on the display and to remain there until the pen is removed.

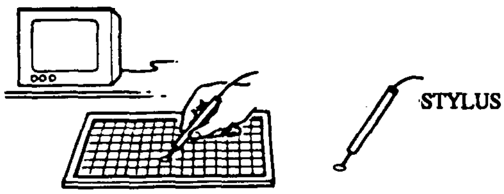
35.7 Other Requirements. Touch displays should not be used when long sessions of spatial application are expected which could result in the operator's arm becoming fatigued. The systems should function under the effects of interfering factors which may be imposed under the most severe conditions of use and should be tested for reliability under a full range of operational conditions. Replacement of the light pen should be designed to be a simple matter of plugging in a replacement, the lead should be long enough to remain slack in use (see Part 11 of this Standard).

36 Digitizing Tablet (C8.28)

36.1 Characteristics for Digitizing Tablet, graphics tablet, grid and stylus. Similar characteristics to the light pen/visual display screen, except the operator is not required to be in contact with the screen. The tablet will require space in front of the seated operator. The stylus is attached to the system by means of a wire and there is a need to store the stylus when not in use. Digitizing tablet may be used for the generation of free-drawn graphics.

36.2 Location. The tablet should be located such as to maintain spatial correspondence with the display, ie the left and right sides of the tablet should correspond to the left and right sides of the screen and the furthermost side of the tablet to the top of the screen. The working height should be at elbow level of the seated operator.

36.3 Recommended Dimensions. The size of the tablet and the display must be adequate to meet the visual requirements of the task and to meet the required accuracy of spatial designation performance (see Part 7 of this Standard).



Length ='L'	120mm Minimum	180mm Maximum
Diameter ='D'	7mm Minimum	20mm Maximum

Fig 39 Stylus Dimensions

36.4 Shape. Standard CRT, similar display. The stylus should take the approximate form of a conventional pen, with surface texture to permit a firm grip.

36.5 Displacement Resistance. Not appropriate.

36.6 Direction of Motion. The direction of motion of the cursor should be the same as that of the stylus. It is preferable that movement of the stylus across the surface grid should result in the cursor moving at the same rate and with a smooth motion. When used as a two axes controller, contact with the tablet surface should cause the cursor to appear at the designated co-ordinates on the display and to remain there until the pen is removed.

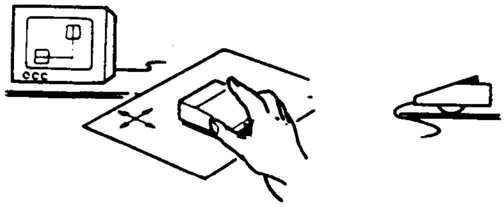
36.7 Other Requirements. Replacement of the stylus should be designed to be a simple matter of plugging in a replacement, the lead should be long enough to remain slack in use (see Part 11 of this Standard). The systems should function under the effects of interfering factors which may be imposed under the most severe conditions of use and should be tested for reliability under a full range of operational conditions.

37 Mouse (C8.29)

37.1 Characteristics for Mouse, free moving 'X-Y' controller. The mouse may be operated by moving it in contact with any flat surface. There is also provision for the incorporation of one or more command keys on the mouse itself, thus permitting one hand operation. The operator is not required to be in contact with the screen. The mouse will require space in front of the seated operator. The mouse is attached to the system by means of a wire and there is a need to store the mouse when not in use. This system requires less space than the graphics tablet.

37.2 Location. A clear flat horizontal surface should be available upon which the mouse may be used. The working height should be at elbow level of the seated operator.

37.3 Recommended Dimensions. The size of the display must be adequate to meet the visual requirements of the task and to meet the required accuracy of spatial designation performance (see Part 7 of this Standard). The mouse controller should fall within the following:



Width(Thumb/Finger Grasp)	Length	Depth	
40mm	70mm	25mm	Minimum
70mm	120mm	40mm	Maximum

Fig 40 Mouse Dimensions

37.4 Shape. Standard CRT, similar display. The mouse to fit the operation grip requirements, with surface texture to permit a grip.

37.5 Displacement Resistance. Not appropriate.

37.6 Direction of Motion. A movement of the mouse across the operating surface should result in a smooth corresponding movement of the display cursor. The system should be designed such that when held in its normal operating position the direction of motion of the mouse is reflected in the motion of the cursor. The cursor should remain at the last designed co-ordinates on the display and to remain there, when the mouse is lifted and removed.

37.7 Other Requirements. The control buttons mounted on the mouse should be located to permit operation of the mouse with either hand. Replacement of the mouse should be designed to be a simple matter of plugging in a replacement, the lead should be long enough to remain slack in use (see Part 11 of this Standard). The systems should function under the effects of interfering factors which may be imposed under the most severe conditions of use and should be tested for reliability under a full range of operational conditions.

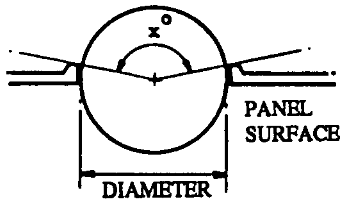
38 Rolling Ball (C8.30)

38.1 Characteristics for Rolling Ball, track ball, ball tracker, joyball controller. These are different names for the same thing, it has particular advantages when the cursor must be moved across large distances on the display, followed by fine adjustment, rapid movement can be achieved by spinning the ball. It is well suited to application where there may be accumulative travel in a given direction. The rolling ball is unsuitable for the tracking of rapidly moving targets, a joystick is more appropriate in this application. It is less prone to accidental damage than spatial designation devices incorporating stylus, light pen or mouse.

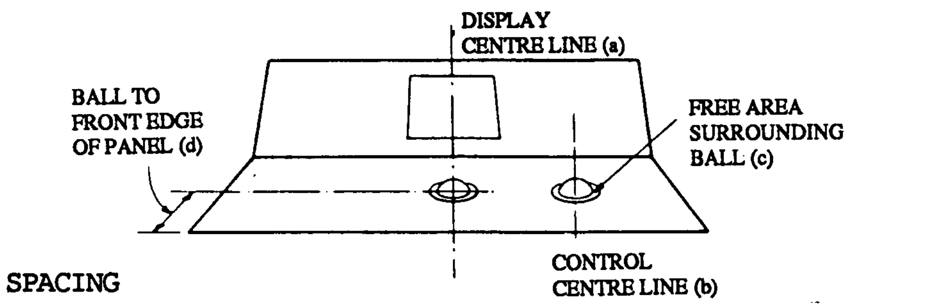
38.2 Location. The ball should be set into a horizontal panel or desk top at around elbow level of the seated operator. It should be possible to rest the third and fourth fingers against the horizontal surface to steady the hand for fine adjustments. The distance from the ball to the front edge of the panel must be adequate to support the wrist and forearm if the ball is to be used for long periods. This is especially important if the chair provided has no armrests.

38.3 Recommended Dimensions. Smaller diameters within the range shown should only be used for low precision control when panel space is limited.

BALL CONTROL



	Minimum	Maximum	Preferred
Diameter	50mm	150mm	100mm
Surface exposure 'X°'	100°	140°	120°



Laterial Displacement Of Control From Display 'a'-'b'	Free Area Round Ball 'c'	Ball To Front Panel 'd'	
nil	50mm	120mm	Minimum
320mm	-	250mm	Maximum

Fig 41 Rolling Ball Dimensions

38.4 Shape. Standard CRT, similar display. Ball sphere shaped. The work surface to fit the operational requirements (see Part 4 of this Standard).

38.5 Displacement Resistance. The ball should exhibit low friction and relatively high inertia to permit it to be spun for rapid and large cursor movements.

Resistance for precision ball adjustments 1.ON Min 0.3N preferred.
Environments subject to vibration/acceleration 1.7N Min

38.6 Direction of Motion. The ball should be rotatable in any direction. A movement of the ball should result in a smooth corresponding movement of the display cursor.

38.7 Other Requirements. The ball should be rotatable in any direction without backlash or cross coupling. Use of a roughened surface will improve grip. If the control is to be used by operators wearing gloves the ‘lip’ of the panel surface should be in close correspondence with the ball surface to prevent the glove material being caught in the gap during operation.

Definitions of Terms.

A.1 The definition of control terms used in this Part of the Defence Standard are listed below.

A.2 Alphanumeric characters. Numerals and letters, eg appearing on a keyboard or display.

A.3 Acquisition. The first phase of a continuous control or tracking task during which the initial error is reduced.

A.4 Break-out force. The threshold force that must be applied to the controller of a continuous variable, eg an isotonic joystick, before it is displaced from its central position.

A.5 Contrast. (As applied to the visibility or lighting requirements of controls difference in luminance between features of the control and the surrounding area. (Contrast has important implications for visual performance see Parts 6 and 7 of this Defence Standard).

A.6 Control coding. A system of principles by means of which controls may be rendered easily identifiable and distinguishable, eg by locating related controls together, by labelling, by colouring related controls similarly, by the use of distinctive control shapes, or by the use of distinctive control sizes.

A.7 Control law. A mathematical function describing the relationship between the input demand to, for example, a joystick and the output from it.

A.8 Cue. An indication of a change in the state of a system which will affect operator's subsequent actions.

A.9 Deadspace. A portion of the movement of the controller of a continuous variable, eg an isotonic joystick, which does not result in a change in the output of the controller.

A.10 Designation. An action on the part of an operator indicating that acquisition is complete, or that a cursor has been moved to the desired point on a display.

A.11 Elastic resistance. A resistance to movement which is proportional to control displacement.

A.12 Feedback. (In the context of man-machine interaction) Information from equipment indicating the consequences of the operator's actions. Thus the 'click' of a control as it snaps into a discrete position indicates to the operator that a setting has been reached.

A.13 Inertial resistance. A resistance to movement which is caused by the mass of the controls.

A.14 Isometric. A type of control operating such that its output signal is proportional to the force applied to it, eg force sensitive joystick controls.

A.15 Isotonic. A control type operating such that its output signal is proportional to the displacement applied to it.

A.16 Kinaesthesia. The sense of body orientation and limb position.

A.17 Percentile. (As applied to the description of human characteristics such as size and weight). The value of a measured characteristic below which lies a given percentage of a population. Thus the fiftieth percentile for height is that height below which lies 50 per cent of the population and the ninety fifth percentile for weight is that weight below which lies 95 per cent of the population.

A.18 Population stereotype. An expectation exhibited by a population of users of the manner of operation of a control, which normally develops as a result of learning and experience (see annex C).

A.19 Static friction. The force opposing the initial movement of a controller which reduces once the movement has started, ('inertia' in control movement).

A.20 Tactile/tactual. Sensations arising as a result of touch. Tactile information can be disrupted by the wearing of protective gloves.

A.21 Tracking. The continuous control of a system by an operator in response to the behaviour of a target motion of which is outside his control. An example of a tracking task is the following of a moving target by the use of a weapon sighting system.

A.22 Viscous resistance. A resistance to movement which is proportional to the velocity of the control movement.

Control Coding

B.1 Specifies the characteristic method of rendering controls identifiable thereby reducing the time taken by the operator to find the correct control. Effective control coding improves operator performance and reduces training time.

B.2 Location Coding

B.2.1 If a control or group of controls is located at a specific place with respect to the operator's body to other controls in the workspace, it is possible for the operator to use this knowledge for control identification purposes.

B.2.2 Location coding is the most effective coding method under conditions in which the control cannot be seen because of low illumination levels or because the control is not positioned in the field of view. Even when the control is visible, location can supplement visual coding and coding of controls in this way is to some extent the natural result of good workplace design (see Part 4 of this Defence Standard).

B.2.3 The grouping of 'families' of functionally related controls helps the operator to find individual controls by limiting search to a small subset of the devices on his control panel. Sequentially used controls will benefit from an arrangement such that they are placed adjacent to one another.

B.2.4 The extent to which location may be used as the sole means of identifying controls will depend upon the mobility of the operator. If his position is constrained then location coding can be extremely effective, eg vehicle pedals are readily identifiable by their location. The method becomes less effective as the number of controls to be discriminated increases especially if they must be placed close together. It is also less effective if the operator is changing his position with respect to the controls.

B.2.5 When location coding is used for controls which cannot be seen they should be positioned in front of rather than behind the operator. Controls in the forward area should be 150 mm - 200 mm apart, while those to the sides and to the back of the operator should be 300 mm - 400 mm apart.

B.3 Labelling

B.3.1 Labels may be placed on or near controls to indicate their function and may bear a written legend or a pictorial symbol illustrating the purpose of the control.

B.3.2 Labelling is the simplest method of coding having the advantage of requiring little or no training for use by the operator. However, labels must meet the visual requirements of the operator in terms of size, illumination and contrast if they are to be adequate (see Part 6 of this Defence Standard). It must be possible for the operator to read the legend while performing his task and the labels should be appropriate brief, clear and unambiguous, containing the basic information needed.

B.3.3 Abstract symbols should only be used when their meaning is understood by the population of users. Technical terms should also be avoided unless they are absolutely necessary and familiar to all operators. Care should be taken to ensure that visually similar labels are not used on different controls

B.3.4 Letters and numerals should be permanent and clearly legible under the most extreme conditions of use likely to be encountered. Latin block letters and Arabic numerals are recommended. Roman numerals should not be used. Colours may be used to enhance contrast with the background, see clause **B.5.**

B.3.5 In the positioning of labels they should not be placed such that they are obscured by the operator's hand when adjusting the control and they should remain legible when the control has been adjusted, eg in the case of a rotary knob the label should not be inverted when the control is turned.

B.3.6 Labels should be located either on the controls or adjacent to them, normally above, except with controls placed above the operator's head in which case location below is more appropriate. They should be sufficiently close to the control for there to be no confusion as to which label goes with which control. Location must be systematic, as uniform as possible and consistent between panels.

B.4 Colour Coding

B.4.1 Different colours may be used to discriminate between controls and the use of the same colour can indicate related controls.

B.4.2 As with labels colour coding can only be used when the operator is able to view the controls whilst performing his task and the colours must remain distinctive under the most extreme conditions of use.

B.4.3 Colour coding is most useful when the operator must search through a large number of controls on a panel as this can reduce the task to one of searching through a smaller subset of controls.

NOTE : Colour coding should only be used as a supplement to other coding methods, as colour blind operators may otherwise be unable to distinguish controls.

Population Stereotypes

C.1 Specifies the characteristics of people raised in a technological culture developing expectations of the method of operation of controls and displays. Some of these expectations will develop as a result of knowledge of the operation of the equipment but others arise as a result of learning and by being exposed to control devices. Examples of this are the expectations that pushing a toggle switch down in the United Kingdom will result in equipment being activated, that turning a potentiometer clockwise will increase the value of the varied parameter but that turning the tap associated with a valve clockwise will decrease the rate of flow of a fluid. These expectations are called population stereotypes, as variations exist between the one population and another.

C.2 Design Guidelines. The designer must consider the population of users for which the equipment is designed when configuring the controls. If the users are not United Kingdom citizens the most appropriate mode of operation of controls may differ from that which the designer may expect. For example, United States of America operators would expect to move a toggle switch upwards to activate equipment in contrast to the typical United Kingdom configuration.

As a general rule unless direction of operation is logically natural or intrinsic to the operation of equipment, eg turning a steering wheel to the right to change direction to the right, the designer should be sensitive to variations in population stereotypes. Where possible United Kingdom stereotypes have been included under the relevant control Standards. However, there will be occasions in which the stereotype is unclear, eg when, due to a change in technology, potentiometer controlled systems are utilized to vary flow rate in a situation in which manually operated valves were used previously. On these occasions advice should be sought from human factors specialists and it may be necessary to determine the appropriate method of operation by experimental methods. Specialist advice should also be sought if design is aimed at a foreign population of users.

C.3 Control/Display Relationships. Conventions exist in the particular relationship between controls and the displays associated with them. These conventions apply with respect to the direction of motion of displays in response to control demands and with respect to the positioning of the display and its associated control in an array of such devices. Detailed advice is given in McCormick and Sanders (1982) Chapter 8.

Published by and obtainable from:
Ministry of Defence
Directorate of Standardization
Kentigern House
65 Brown Street
GLASGOW G2 8EX

Tel No: 041-224 2531/2

The following Defence Standard file reference relates to the work on this Standard - D/D Stan/328/Ol/10.

Contract Requirements

When Defence Standards are incorporated into contracts users are responsible for their correct application and for complying with contract requirements.

Revision of Defence Standards

Defence Standards are revised when necessary by the issue either of amendments or of revised editions. It is important that users of Defence Standards should ascertain that they are in possession of the latest amendments or editions. Information on all Defence Standards is contained in Def Stan 00-00 (Part 3) Section 4, Index of Standards for Defence Procurement - Defence Standards Index published annually and supplemented periodically by Standards in Defence News. Any person who, when making use of a Defence Standard encounters an inaccuracy or ambiguity is requested to notify the Directorate of Standardization without delay in order that the matter may be investigated and appropriate action taken.

90/60044

DIRECTORATE OF STANDARD1ZATION
MINISTRY OF DEFENCE
Room 5138
Kentigern House 65 Brown Street Glasgow G2 8EX
Telephone 041 248 7890Ext
Direct Dlalling 041-224-Ext
Telex:

Your reference

Our Reference
D/D Stan/ 328/01/10

Date
November 1992

INTERIM DEFENCE STANDARD IMPROVEMENT PROPOSAL

Defence Standard No: 00-25 (Part 10)/Issue 1

Title: Human Factors for Designers of Equipment Part 10 Controls

The above Defence Standard has been published as an INTERIM Standard and is provisional because it has not been agreed by all authorities concerned with its use. It shall be applied to obtain information and experience on its application which will then permit the submission of observations and comments from users.

The purpose of this form therefore is to solicit any beneficial and constructive comment that will assist the author and/or committee to review the INTERIM Standard prior to it being converted to a normal Standard.

Comments are to be entered below and any additional pertinent data which may also be of use in improving the Standard should be attached to this form and returned to the Directorate of Standardization at the above address. No acknowledgement will normally be sent.

NAME: A MULLEN SIGNATURE A. Mullen BRANCH: STAN6b

1. Has any part of the Standard created problems or required interpretation during use:

☐ **YES** ☐ **No** if 'yes' state,

a. clause number/s and wording:

b. recommendation for correcting the deficiencies:

2. Comments on any requirement considered too rigid:

Continued over

DGDQA Form 0825

3. Is the Defence Standard restrictive:

☐ YES ☐ NO (if ‘yes’ in what way)

4. General comment:

5. We agree that this INTERIM Standard (subject to amendments to take account of our comments) when published in final form will cover our requirements. Should you find our comments at variance with the majority, we shall be glad of the opportunity to enlarge upon them before final publication.

Signature . . . . Representing . . . .

Submitted by (print or type name and address):	Telephone number:
	Date:
	Our Ref: