Ministry of Defence

Defence Standard

00-25(PART 2)/Issue 2 14 February 1997

HUMAN FACTORS FOR DESIGNERS OF EQUIPMENT

PART 2: BODY SIZE

This Defence Standard supersedes
Def Stan 00-25 (Part 2)/Issue 1
Dated 30 August 1985

AMENDMENTS ISSUED SINCE PUBLICATION

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Revision Note

Since the 00-25 Part 2 Issue 1 appeared in 1985 there have been several important trends which increase the difficulty of the equipment designer's task. The MANPRINT Handbook provides a useful guide to current philosophy in this area. Far greater use is now being made of female military personnel in the front line. This means that the designer has to accommodate a much greater range of sizes eg 50% greater range in some dimensions. Population dimensions are increasing at rates of up to 0.07% per year, eg in terms of standing height, the average soldier and sailor populations are increasing by over a millimetre each year. Since some equipment is likely to remain in service for several decades, the engineer needs to consider designing his equipment to fit populations which have not yet been born, also, with the trend towards multi-national projects and foreign customers, the designer needs to be aware of ethnic anthropometric differences between potential user populations.

Historical Record

This Defence Standard supersedes Defence Standard 00-25 (Part 2)/1 published on 30 August 1985 which had 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

The arrangement of the Parts comprising Def Stan 00-25 is shown below:

PART 1 - Introduction
PART 2 - Body Size
PART 3 - Body Strength and Stamina
PART 4 - Design of the Workplace
PART 5 - The Physical Environment: 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
PART 13 - Human Computer Interaction
PART 14 - Training and Instruction (In Preparation)

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

Collation Page

HUMAN FACTORS FOR DESIGNERS OF EQUIPMENT

PART 2: BODY SIZE

PREFACE

This Defence Standard supersedes Def Stan 00-25 (Part 2) Issue 1 dated 30 August 1985

i This Part of the Defence Standard presents descriptive detail, technical data and diagrams relating to some of the important factors concerned with body size for design application.

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 has been agreed by the authorities concerned with its use and is intended to be used 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.

iv 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.

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 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.

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HUMAN FACTORS FOR DESIGNERS OF EQUIPMENT
PART 13: HUMAN COMPUTER INTERACTION

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0 Introduction

0.1 A knowledge of the sizes and shapes of human beings, both male and female, is essential to the designer who wishes to match equipment and environments to the human user. Adequate clearance must be provided for the tallest, the broadest, and the fattest of individuals. At the same time, the smallest person must be able to reach and operate all of the controls and be able to see all the displays.

0.2 The branch of science which deals with the measurement of the human body is called anthropometry, and anthropometrics is the term used for the application of such data.

1 Scope

1.1 This Part of this Standard discusses both ‘structural’ and ‘functional’ anthropometrics and their relationship to the design of the workspace.

1.2 This Part of this Standard deals with the important concept of body linkages and the use made, by designers, of two-dimensional manikins and computer man-models.

1.3 This document also discusses postural stress and the provision of satisfactory working postures. Many military personnel, such as aircrew, wear restraining harnesses which restrict reach and vision still further. This factor is particularly relevant to Helmet Mounted Sights (HMS) whose potential has not been realised due to anthropometric and harness constraints.

1.4 The anthropometric data in this Part of this Standard refers to both male and female service personnel.

1.5 With much equipment now being produced and procured on a multi-national basis, the designer needs to be aware of national differences in anthropometry. Recent US Army anthropometric data has been included here but up-to-date data from other areas such as Europe, was not available at the time of the compilation of data for this Defence Standard.

2 Related Documents

2.1 The documents and publications referred to in this Part of the Standard are listed at Annex C.

2.2 Related documents can be obtained from:

DOCUMENT	SOURCE
British Standards (BS) and (BS EN) Publications	BSI Sales Department Linford Wood MILTON KEYNES MK14 6LE
Defence Standards	Directorate of Standardization (Stan 1) Kentigern House 65 Brown Street GLASGOW G2 8EX

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.

Section Two. Fundamentals of Anthropometry for Consideration in Workspace Design

3 Human Variations

Because of the truism that 'people come in assorted sizes', it is rarely possible to tailor, or customize, a piece of equipment to an individual operator. The designer is almost always required to create a workspace which is compatible with a range of individuals. Therefore the first step in workspace design should be to define the 'target' population who will use the equipment.

3.1 Human body variation dimensions

The variation which is found in most human body dimensions conforms quite closely to the Gaussian, or 'normal', distribution. For any given dimension, values tend to cluster around an average, and extreme cases are relatively rare. (See figure below)

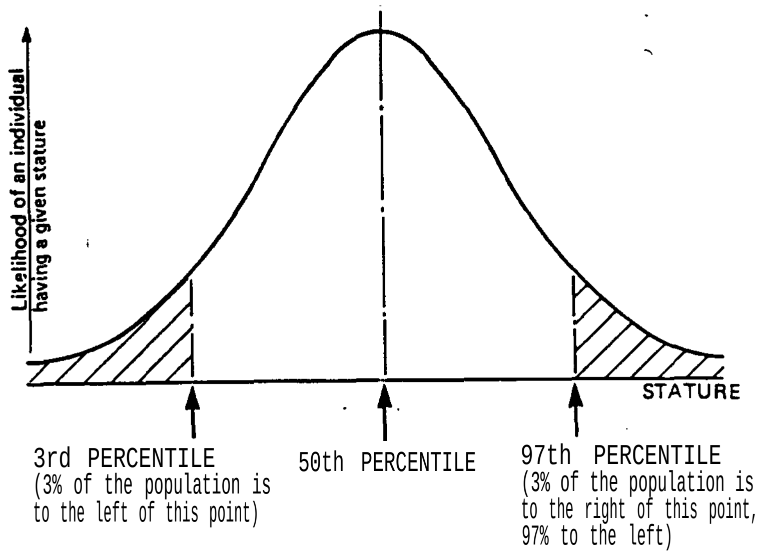


Fig 1: Gaussian (Normal) Distribution Curve

3.2 Human variation presented as percentiles

3.2.1 Variation in anthropometric data is often described in terms of percentiles (%les). For any dimension in any population of individuals, 'n' percent of people are smaller than the 'nth' percentile. Hence, 3% are shorter in stature than the 3rd %le, 97% are shorter than the 97th %le, and so on. For most practical purposes, we may consider the 50th percentile and the 'average' or 'mean' to be one and the same.

3.2.2 Two important points should be reinforced at this stage:

(a) a percentile value refers to one dimension only; hence, a man of average (50th %le) height may well have a larger waist depth (eg 80th %le);

(b) a percentile value refers to a specific population; hence, the 50th %le stature for UK aircrew (1783 mm) is the 63rd %le for UK non aircrew.

3.3 Designing for the 'target' population

3.3.1 From the following extreme example it can be seen that ‘designing for the average man’ will result in equipment which is poorly matched to the range of users.

Consider the case of a doorway or passage designed, both in height and width, to average (50th %le) dimensions. Such a door would greatly inconvenience those of the population who were taller or wider than average. The 50% of people taller than average would have to stoop, however, since there are some people who are not only shorter than average but also wider than average, a certain additional number of individuals would have to squeeze through, or pass throughout sideways. Hence, the door or passage ‘designed for the average person’ would be suitable for less than half the people who used it.

3.3.2 The most difficult problems arise in those workplaces where several dimensions are all critical for various reasons: cockpits and driving seats provide good examples of this. Although the designer should accommodate a population range of 5th to 97th percentile, (3rd to 97th where possible) it must be remembered that a person who is 3rd percentile in stature certainly is not 3rd percentile in all other dimensions.

For example, if all personnel who are 3rd percentile and less or 97th percentile and more are excluded, when 6 critical design dimensions are used, it is not 94% of the population but only 78.6% who are acceptable.

Dimension	Range Limitation	% of Total Population Accommodated
Sitting height	3 to 97% ile	94
Buttock-knee length	3 to 97% ile	89
Buttock-heel length	3 to 97% ile	87
Functional reach	3 to 97% ile	84
Sitting knee height	3 to 97% ile	83
Bideltoid breadth	3 to 97% ile	78.6

3.4 The limitations of anthropometry in design

3.4.1 The dimensional matching of machine to operator is a complex matter. Constraints which are truly critical are not always easy to identify and anthropometric tables should be used only when the designer understands the whole situation.

3.4.2 The use of anthropometrics at the drawing-board stage does not necessarily ensure an ergonomically sound design. Designs should be thoroughly tested firstly by the use of computer based dynamic design tools, and then by conducting fitting trials on a full-scale mock-up of the equipment using a representative sample of users.

3.4.3 The use of anthropometrics is only one stage in the application of ergonomics in the design of equipment.

3.5 Increasing use of the female population. Until recently, the majority of female military personnel were employed in office environments, rather than in the front line. That situation has now changed, with women serving as aircrew and on warships. The engineer must now take account of both male and female sizes when designing equipment.

The twin population distributions shown below, illustrates the increased requirement and consequent difficulty that an equipment designer now has, to accommodate all potential users.

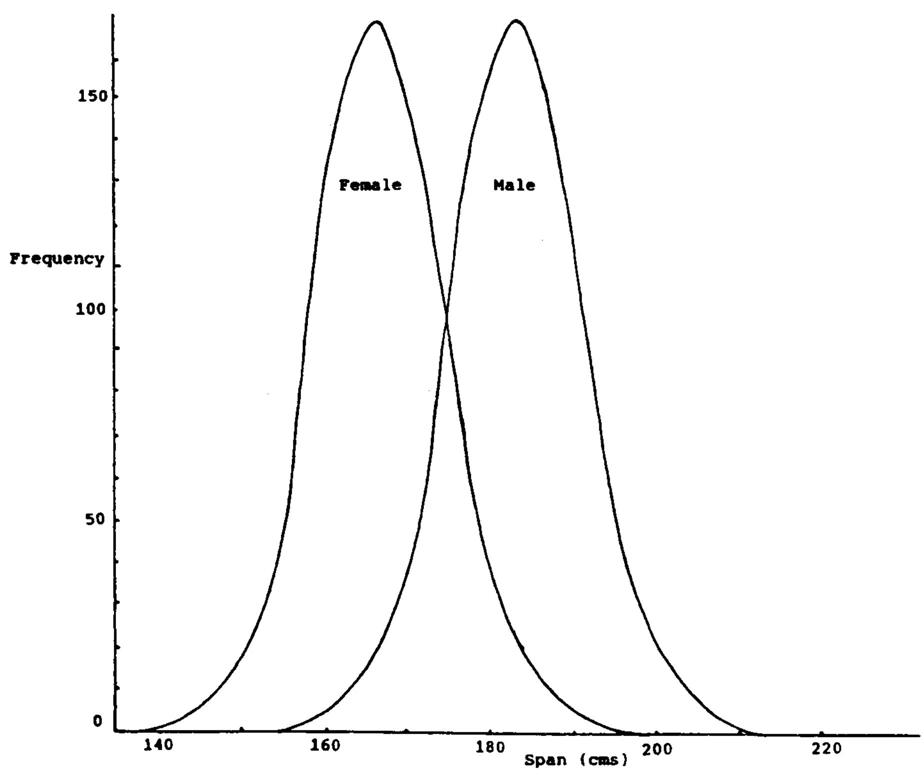


Fig 2: Near 'Normal' Female and Male Population Distribution of Arm Span

Section Three. Structural Anthropometry

4 Definition

Structural (or static) anthropometry concerns those dimensions taken with the body in rigid standardized positions.

4.1 Statistics and Diagrams. It is not possible to include here every dimension a designer may require. Therefore, a list of those dimensions considered to be most representative in the field of equipment design and workspace layout has been compiled.

The tabulated data for the Armed Services are taken from those sources listed at annex B. To date, a major survey of British civilians has not been conducted.

Equipment should be designed around the operators who have to work there, both now and in the future. This has not always happened in the past. It is further complicated by the fact that equipment may remain in service for 40 years, or even longer eg The DC3, which is still flying in considerable numbers, first flew in 1935 and was, itself, based on the earlier DC-2 design. Not only has the equipment in the cockpits changed radically, but the size of the user population is constantly changing due to ethnic, genetic, nutritional and gender reasons.

For example, in the past a design for the RAF might have had to cope only with a 5th to 95th percentile range of dimensions and strengths of male Britons. Now, a multi-national design will have to accommodate not only personnel from 4 or more nations, but also from male and female populations.

If the equipment is likely to be in service for several decades, then the increasing dimensions of each population will have to be forecast for 30 to 40 years in the future. Surveys of Australians over a 50 year period showed an increase in average stature of 1.3 mm a year for males and 0.9 mm for females. This trend is accelerating and repeated elsewhere where general living conditions have improved and where there is a greater genetic mixing in the population.

4.2 Clothing corrections and other assumptions. All data in section 3 diagrams and tables refer to UNCLOTHED AND UNSHOD PERSONS: Before such data can be used, corrections for clothing and footwear must be added wherever applicable - see clause **5.4** and table L.

4.2.1 Tables A - D show the body dimensions for 3rd, 50th and 97th percentile unclothed military males. The data are broken down into dimensions taken from UK (1987) and US (1988) surveys. The designer should where possible try to accommodate the range from 3rd to 97th percentile for all 32 dimensions and these data are given in the first part of each table. However, some MOD requirements call for only 5th to 95th percentiles to be accommodated by equipment. Hence data for 5th and 95th percentile male and female populations are also given in tables A-2 to F-2.

4.2.2 Beside each actual data point is an estimate of how that dimension will have changed by the year 2000, assuming that the population dimensions will continue to increase in size at the current rate. MOD will specify whether the use of extrapolated data is to be demanded.

4.2.3 For the precise operational definitions of each dimension the designer should refer to the original sources from which the data was extracted - see annex B. It should be noted that measurement techniques are not always precisely the same in different surveys.

4.3 Female population data. Until recently, data on military female populations has been limited. It is not, therefore, possible to predict the increase in size of females for the year 2000 as has been attempted for males, here in Tables A to D. However, the data in tables E and F for female military personnel is relatively current and should be used until further data becomes available.

4.4 Age and sample sizes. Table H lists the population ages and sample sizes from which the data in tables A to G have been derived.

4.5 National aircrew comparison.

4.5.1 Table J lists equivalent data for dimensions 1-32, where available, for German, US, Italian and Royal Air Force aircrew.

4.5.2 It indicates that there were differences between the four separate aircrew populations when the data was collected in the 1960/70 decade. However, care is needed in interpreting the data since it is likely that, for some dimensions at least, different anthropometric measuring techniques were employed to obtain the data as the RAF aircrew certainly cannot be 22% greater than that for the other nationalities.

4.5.3 Furthermore, it can be assumed that most if not all, of the measurements will have increased, probably at the rate of at least 0.03% per year since the data was collected.

Index	**Male**	**Female**
	Table	Table
Body Dimensions (Standing	A	E
Body Dimensions (Sitting)	B	F
Breadth and span Dimensions	C	F
Functional Reaches (Sitting)	C	F
Hand and Foot Dimensions	D	F
Head Dimensions	D	F
Body Weight	G	G
Population ages and sample sizes	H	H
National Aircrew Comparisons	I	

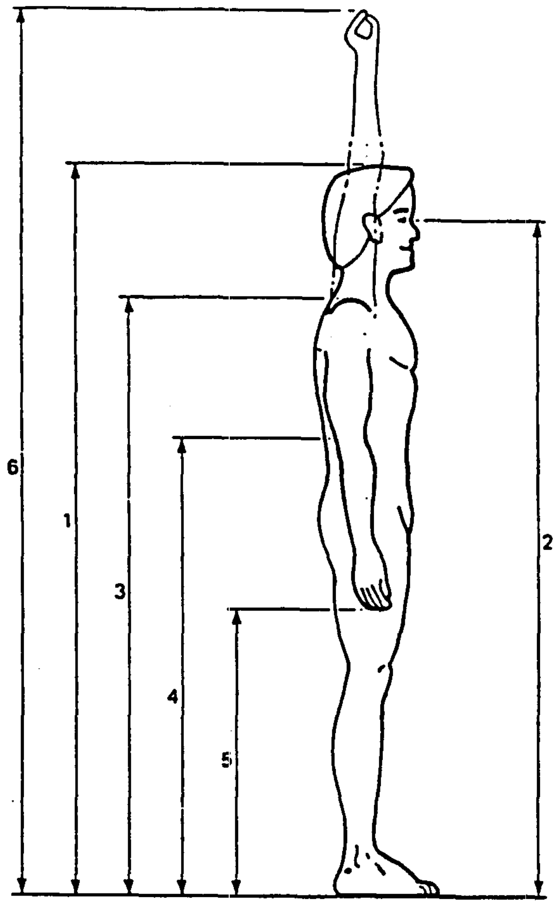


Fig 3: Body Dimensions (Standing)

	DIMENSIONAL DESCRIPTIONS AND APPLICATIONS
1	**STATURE** Minimum floor to roof clearance. Stature is also an important dimension for making rapid comparisons between populations and for selecting subjects for fitting trials.
2	**EYE HEIGHT** Height of optical equipment. Reference point for calculating the line of sight in order to optimize the locations of visual display. (See clause **7** and figure **23)**
3	**ACRIMONIAL HEIGHT** (The Acromion is a body landmark at the tip of the shoulder. Some surveys include 'shoulder heights', which are defined differently). This variable represents the distance from the ground to the centre of rotation of the shoulder point. It is a useful datum for optimizing control locations in standing workspaces.
4	**ELBOW HEIGHT** Reference level for optimizing the height of work surfaces.
5	**FINGERTIP HEIGHT** Defines the lowest limit of the preferred zone for fingertip operated controls. Controls which must be grasped should be at least 140 mm higher.
6	**VERTICAL FUNCTIONAL REACH** Maximum height of controls

Table A
Male Body Dimensions in Millimetres (Standing)

Table A

		3rd Percentile					
		UK Aircrew		UK Non-Aircrew		US Army	
		Actual	Estim.	Actual	Estim.	Actual	Estim.
		1987	2000	1987	2000	1988	2000
1	Stature	1658	1659	1641	1655	1632	1646
2	Eye Height	1564	1565	1550	1564	1513	1526
3	Acromial Ht (Shoulder Ht)	1356	1357	1329	1341	1327	1339
4	Elbow Height	1018	1019	1001	1010	996	1004
5	Fingertip Height	615	616	606	611	582	587
6	Vertical Functional Reach	2089	2090	2068	2085	2056	2074

		50th Percentile					
		UK Aircrew		UK Non-Aircrew		US Army	
		Actual	Estim.	Actual	Estim.	Actual	Estim.
		1987	2000	1987	2000	1988	2000
1	Stature	1783	1792	1763	1778	1755	1770
2	Eye Height	1676	1683	1657	1671	1633	1647
3	Acromial Ht (Shoulder Ht)	1453	1460	1437	1449	1430	1443
4	Elbow Height	1109	1115	1097	1106	1092	1101
5	Fingertip Height	675	678	666	672	652	658
6	Vertical Functional Reach	2247	2258	2221	2240	2211	2230

		97th Percentile					
		UK Aircrew		UK Non-Aircrew		US Army	
		Actual	Estim.	Actual	Estim.	Actual	Estim.
		1987	2000	1987	2000	1988	2000
1	Stature	1901	1909	1887	1906	1882	1901
2	Eye Height	1783	1790	1767	1785	1757	1775
3	Acromial Ht (Shoulder Ht)	1565	1571	1553	1569	1549	1565
4	Elbow Height	1190	1195	1181	1193	1178	1190
5	Fingertip Height	733	736	736	744	725	732
6	Vertical Functional Reach	2395	2405	2378	2402	2371	2395

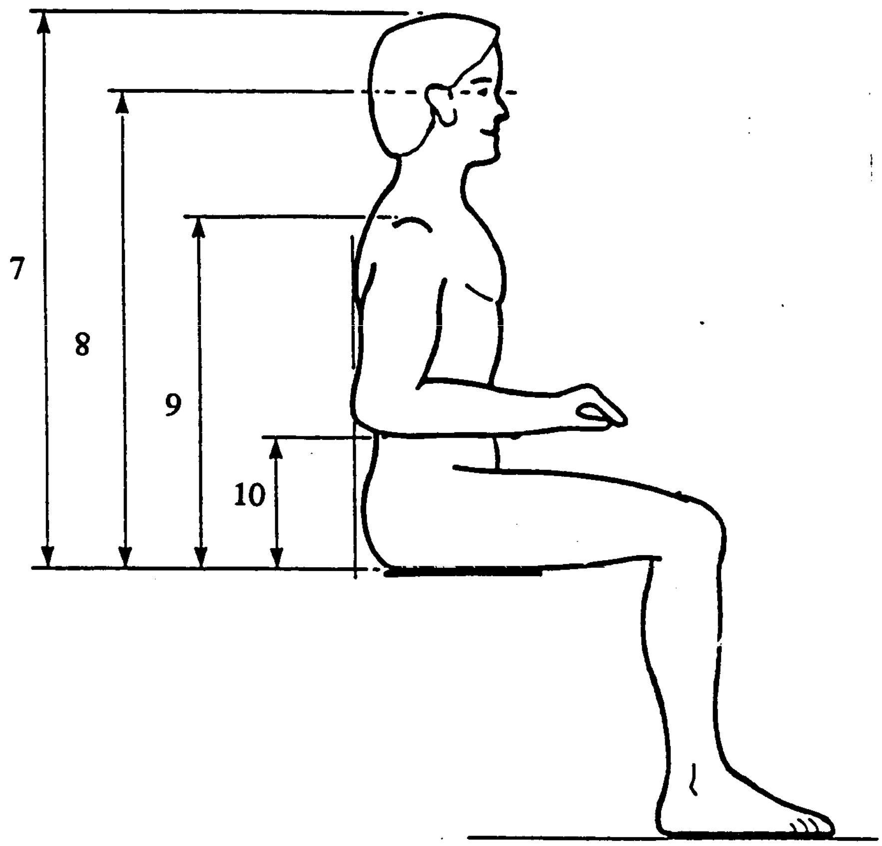


Fig 4: Body Dimensions (Sitting)

	DIMENSIONAL DESCRIPTIONS AND APPLICATIONS
7	**SITTING HEIGHT** Minimum seat to roof clearance. Maximum height of the visual obstruction caused by a sitting person.
8	**EYE HEIGHT** Height of optical equipment above the seat surface, reference level for calculating lines of sight in order to optimize the location of visual displays. Variability in this dimension may determine the range of seat adjustment required.
9	**ACROMIAL HEIGHT** Distance between the seat surface and the centre of rotation of the shoulder; a reference point in optimizing the location of controls (See clause **7).**
10	**ELBOW-REST HEIGHT** Height above the seat surface of arm-rest, desk-tops, keyboards and other important controls. Variability in this dimension may determine the range of vertical adjustment required of the seat.

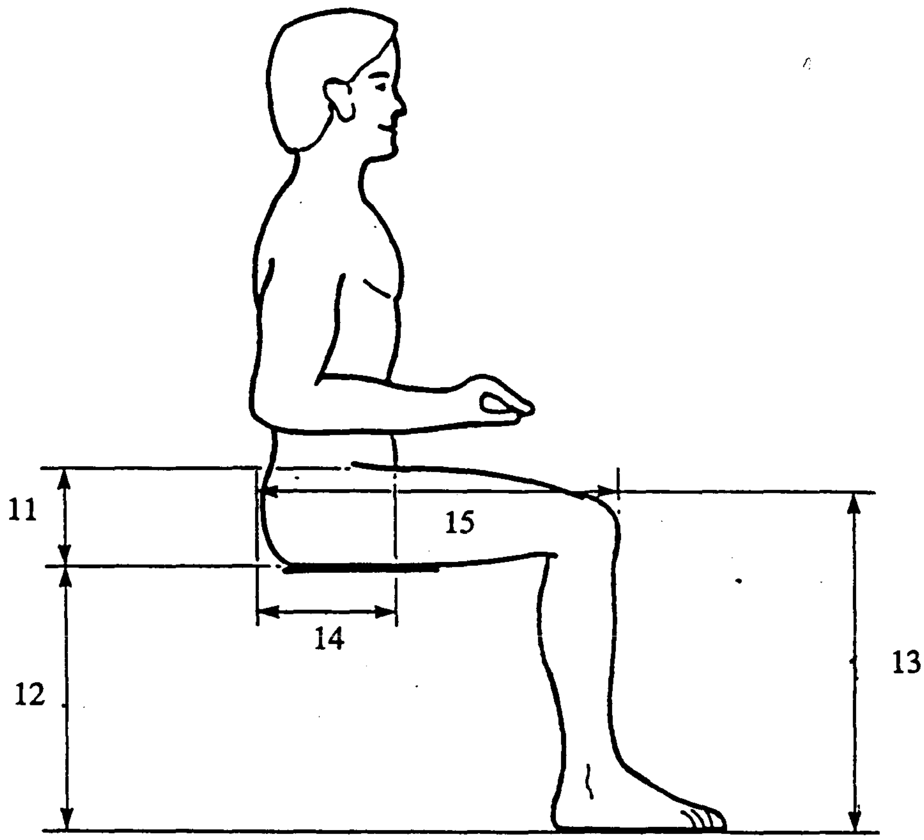


Fig 5: Body Dimensions (Sitting)

	DIMENSIONAL DESCRIPTIONS AND APPLICATIONS
11	**THIGH CLEARANCE** Minimum vertical clearance between seat surface and underside of the table or other obstruction.
12	**STOOL HEIGHT** (Represented with the subject's thighs horizontal, his shanks vertical, and the soles of his feet flat on the ground).
13	**KNEE HEIGHT** Minimum vertical clearance between floor (or footrest) and underside of table or other obstruction.
14	**ABDOMINAL (STOMACH) DEPTH** Minimum forward clearance between seat back and obstructions above thigh level - eg table edges, steering wheels
15	**BUTTOCK TO KNEE LENGTH** Minimum forward clearance between seat back and obstructions at level of the seat surface.

Table B
Male Body Dimensions in Millimetres (Sitting)

Table B

3rd Percentile

		UK Aircrew		UK Non-Aircrew		US Army	
		Actual	Estim.	Actual	Estim.	Actual	Estim.
		1987	2000	1987	2000	1988	2000
7	Sitting Height above seat	869	870	865	873	846	853
8	Eye Height above seat	775	776	775	782	727	733
9	Acromial Height above seat	567	568	565	570	541	546
10	Elbow Rest Height above seat	202	202	203	205	178	180
11	Thigh Clearance	152	152	140	141	146	147
12	Stool Height	354	354	357	360	-	-
13	Knee Height	512	512	507	511	508	512
14	Abdominal Depth	194	194	200	202	194	196
15	Buttock to Knee Length	561	562	554	559	563	568

50th Percentile

		UK Aircrew		UK Non-Aircrew		US Army	
		Actual	Estim.	Actual	Estim.	Actual	Estim.
		1987	2000	1987	2000	1988	2000
7	Sitting Height above seat	935	939	926	934	914	922
8	Eye Height above seat	828	831	828	835	792	799
9	Acromial Height above seat	626	628	618	623	598	603
10	Elbow Rest Height above seat	251	252	250	252	232	234
11	Thigh Clearance	175	176	168	169	168	169
12	Stool Height	398	400	412	416	-	-
13	Knee Height	561	563	557	562	558	563
14	Abdominal Depth	237	238	245	247	236	238
15	Buttock to Knee Length	611	613	608	613	615	620

97th Percentile

		UK Aircrew		UK Non-Aircrew		US Army	
		Actual	Estim.	Actual	Estim.	Actual	Estim.
		1987	2000	1987	2000	1988	2000
7	Sitting Height above seat	1002	1010	988	998	979	989
8	Eye Height above seat	884	888	884	893	856	865
9	Acromial Height above seat	686	689	674	681	653	660
10	Elbow Rest Height above seat	296	297	298	301	280	283
11	Thigh Clearance	202	203	197	199	194	195
12	Stool Height	445	447	465	470	-	-
13	Knee Height	612	615	608	614	612	618
14	Abdominal Depth	297	298	313	316	299	302
15	Buttock to Knee Length	664	667	663	670	675	682

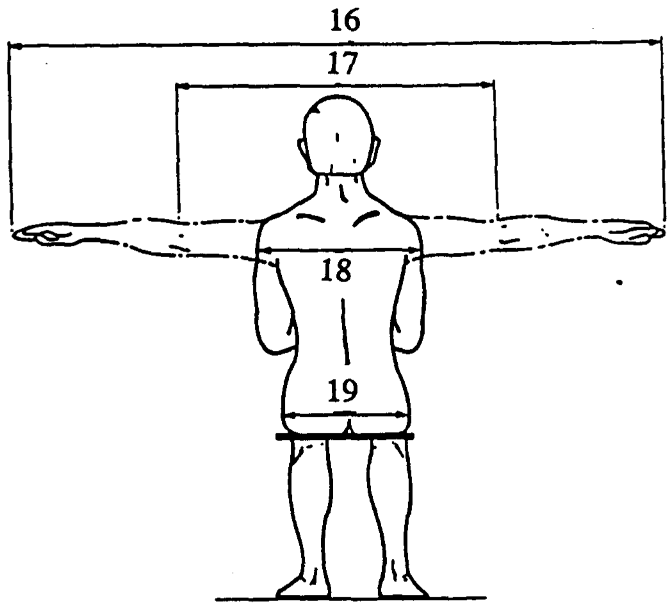


Fig 6: Breadth and Span Dimensions

	DIMENSIONAL DESCRIPTIONS AND APPLICATIONS
16	**SPAN** Overall lateral limits of reach. Appropriate reduction must be made if controls are to be operated other than with the fingertips. (See clause **5)**
17	**INTER-ELBOW SPAN** Lateral clearance for good elbow room during manual activities.
18	**SHOULDER BREADTH (BI-DELTOID BREADTH**) Minimum lateral clearance required in workspace. Note. This dimension is not the same as bi-acromial breadth.
19	**HIP BREADTH** Width of seat. (Minimum lateral clearance for the thighs will be up to 70 mm greater than this dimension.)

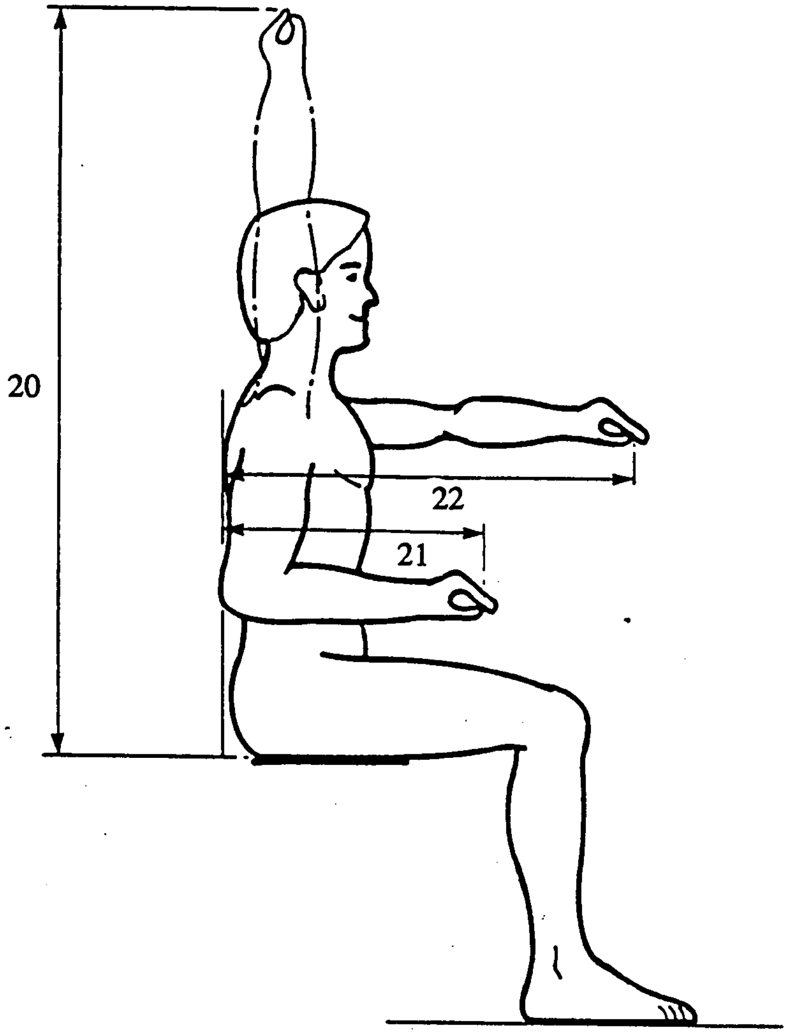


Fig 7: Functional Reaches (Sitting)

	DIMENSIONAL DESCRIPTIONS AND APPLICATIONS
20	**VERTICAL FUNCTIONAL REACH** Maximum height of controls above the seat surface
21	**ELBOW FUNCTIONAL REACH** Maximum forward location of the controls for operation with the upper arm vertical and the forearm horizontal.
22	**FORWARD FUNCTION REACH** (This represents the distance from the back of the shoulders to the thumb-tip of a pinch grip.) Maximum forward location of controls for easy operation.

Note: These reach measurements are made to the tip of the thumb as it makes a pinch grip with the forefinger. Corrections must be made for other types of grip. The subject of reach is discussed at clause **5.**

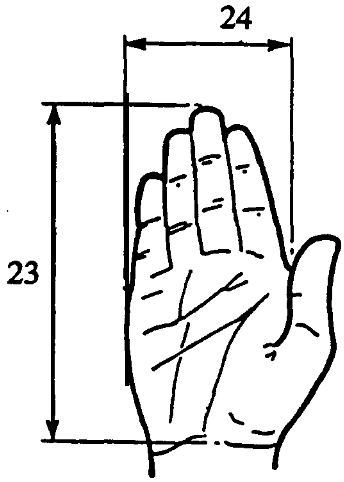
Table C
Male Body Dimensions in Millimetres (Sitting)

Table C

	3rd Percentile					
	UK Aircrew		UK Non-Aircrew		US Army	
	Actual	Estim.	Actual	Estim.	Actual	Estim.
	1987	2000	1987	2000	1988	2000
16 Span between Fingertips	1677	1678	1656	1671	1677	1692
17 Inter Elbow Span	882	883	875	883	889	897
18 Shoulder Breadth	450	450	434	438	444	448
19 Hip Breadth	342	342	333	336	323	326
20 Vertical Functional Reach above seat	1273	1274	1269	1280	1258	1269
21 Horizontal Eblow Functional Reach	390	390	384	387	-	-
22 Forward Functional Reach	717	718	713	719	732	738

	50th Percentile					
	UK Aircrew		UK Non-Aircrew		US Army	
	Actual	Estim.	Actual	Estim.	Actual	Estim.
	1987	2000	1987	2000	1988	2000
16 Span between Fingertips	1818	1825	1797	1812	1820	1836
17 Inter Elbow Span	963	967	953	961	965	973
18 Shoulder Breadth	493	495	483	487	491	495
19 Hip Breadth	383	385	379	382	365	368
20 Vertical Functional Reach above seat	1376	1381	1362	1374	1364	1376
21 Horizontal Eblow Functional Reach	424	426	418	422	-	-
22 Forward Functional Reach	784	787	780	787	800	807

	97th Percentile					
	UK Aircrew		UK Non-Aircrew		US Army	
	Actual	Estim.	Actual	Estim.	Actual	Estim.
	1987	2000	1987	2000	1988	2000
16 Span between Fingertips	1975	1983	1942	1962	1980	2000
17 Inter Elbow Span	1050	1054	1029	1040	1049	1060
18 Shoulder Breadth	543	545	538	543	541	547
19 Hip Breadth	426	428	433	437	418	422
20 Vertical Functional Reach above seat	1490	1496	1465	1480	1472	1487
21 Horizontal Eblow Functional Reach	462	464	454	459	-	-
22 Forward Functional Reach	862	866	849	858	877	886



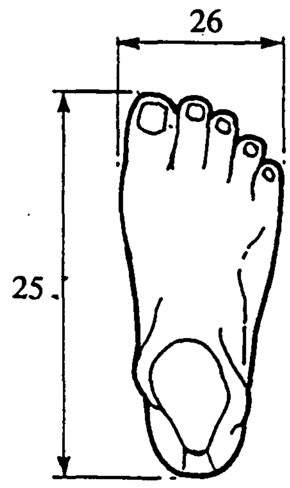


Fig 8: Hand Dimensions

Fig 9: Foot Dimensions

	DIMENSIONAL DESCRIPTIONS AND APPLICATIONS FOR FIG 8
23	**HAND LENGTH** Direct application of this dimension are limited, but it is useful for making comparisons between populations and in selecting subjects for fitting trials.
24	**HAND BREADTH (METACARPAL BREADTH**) Access, of hand, to narrow apertures. Design of handgrips, lifting handles, etc.

	DIMENSIONAL DESCRIPTIONS AND APPLICATIONS FOR FIG 9
25	**FOOT LENGTH** Design of foot-operated controls.
26	**FOOT BREADTH** Design of foot-operated controls.

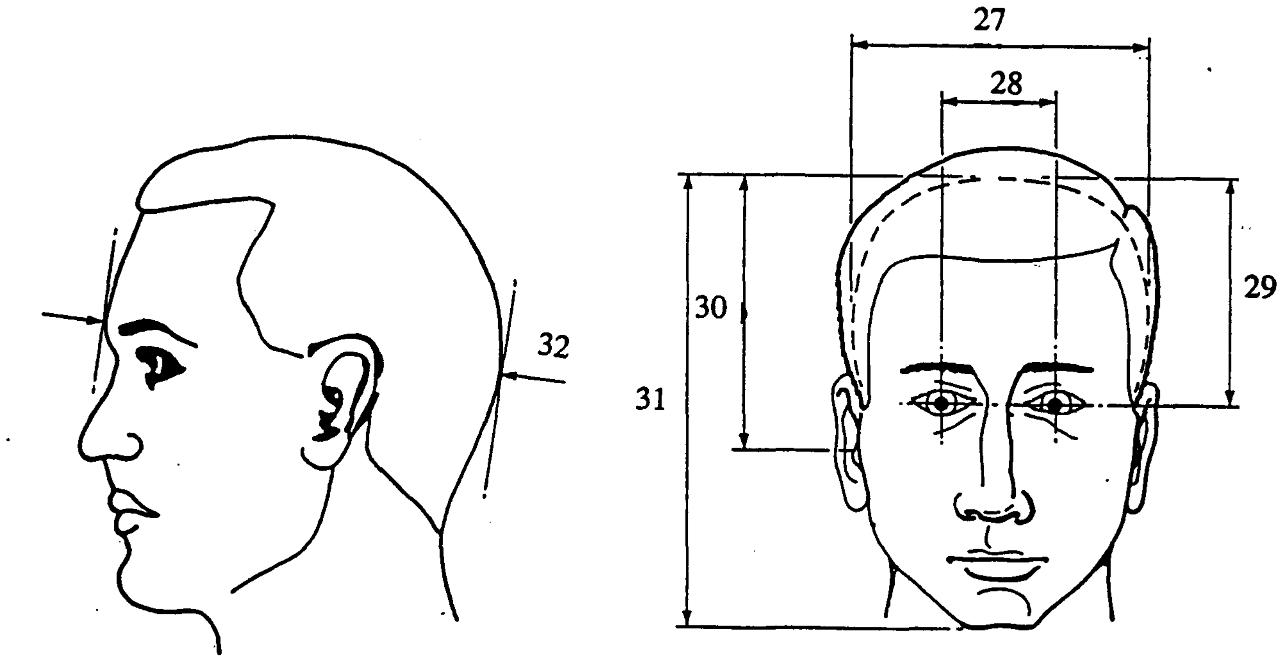


Fig 10: Head Dimensions

	DIMENSIONAL DESCRIPTIONS AND APPLICATIONS
27	**HEAD BREADTH** Minimum lateral clearance for head and the maximum horizontal head breadth above the ears (the location of this dimension is highly variable). Useful for head phone design.
28	**INTERPUPIILARY DISTANCE** The horizontal distance between the centres of the pupils when the subject looks straight ahead. Used in the design of binocular devices for example.
29	**PUPIL TO VERTEX** The vertical distance from the centre of the eye to the vertex (crown)
30	**TRAGION TO VERTEX** The vertical distance between the centre of the ear and the crown. Used in the design of the head phone set for example.
31	**HEAD HEIGHT** This distance between the most inferior point of the menton (chin) and the vertex (crown)
32	**HEAD LENGTH** The dimension between the lowest point on the head (between the crown ridge) and the rear most point, wherever found (usually in the mid-sagittal planes).

Table D
Male Hand, Foot and Head Dimensions in Millimetres

Table D		3rd Percentile						50th Percentile						97th Percentile					
		UK Aircrew		UK Non-Aircrew		US Army		UK Aircrew		UK Non-Aircrew		US Army		UK Aircrew		UK Non-Aircrew		US Army	
		Actual	Estim.	Actual	Estim.	Actual	Estim.	Actual	Estim.	Actual	Estim.	Actual	Estim.	Actual	Estim.	Actual	Estim.	Actual	Estim.
		1987	2000	1987	2000	1988	2000	1987	2000	1987	2000	1988	2000	1987	2000	1987	2000	1988	2000
23	Hand Length	181	181	176	178	177	179	196	197	193	195	193	195	213	214	210	212	213	215
24	Hand Breadth	79	79	78	79	83	84	88	88	86	87	90	91	96	96	94	95	99	100
25	Foot Length	245	245	243	245	246	248	267	268	265	267	269	271	289	290	289	292	296	299
26	Foot Breadth	89	89	87	88	91	92	98	98	97	98	101	102	107	107	106	107	111	112
27	Head Breadth	145	145	144	145	142	143	155	156	154	155	152	153	165	166	165	167	162	164
29	Inter pupillary distance	57	57	57	57	58	59	63	64	63	63	65	66	70	71	70	71	72	73
30	Tragion to Vertex(Ear centre to top of head)	118	118	117	118	120	121	130	131	129	130	131	132	142	143	141	142	142	143
31	Head Height	215	215	205	207	216	218	232	233	227	229	232	234	248	249	246	249	249	252
32	Head Length	187	187	186	188	184	186	201	202	199	201	197	199	214	215	211	213	210	212

Table E
Female Body Dimensions in Millimetres (Standing)

Table E		3rd Percentile			50th Percentile			97th Percentile		
		UK RN	UK Mil	US Army	UK RN	UK Mil	US Army	UK RN	UK Mil	US Army
		1986-90	1994	1988	1986-90	1994	1988	1986-90	1994	1988
1	Stature	1540	1529	1513	1644	1638	1627	1762	1763	1753
2	Eye Height	1454	1414	1401	1543	1531	1515	1645	1652	1637
3	Acromial Height (Shoulder Height)	1237	1244	1227	1340	1347	1332	1455	1454	1446
4	Elbow Height	925	-	909	1004	-	994	1093	-	1087
5	Fintertip Height	572	583	544	635	644	609	692	709	678
6	Vertical Functional Reach	1920	1852	1788	2075	2010	1945	2246	2179	2115

Tables A2 to D2
5th and 95th Percentile Body Measurements in Millimetres for Male Military Personnel

TABLE A-2 Male Body Dimensions (Standing)

		5th Percentile						95th Percentile					
		UK Aircrew		UK Non-Aircrew		US Army		UK Aircrew		UK Non-Aircrew		US Army	
		Actual	Estim.	Actual	Estim.	Actual	Estim.	Actual	Estim.	Actual	Estim.	Actual	Estim.
		1987	2000	1987	2000	1988	2000	1987	2000	1987	2000	1988	2000
1	Stature	1674	1675	1660	1676	1647	1663	1889	1897	1870	1892	1867	1888
2	Eye Height	1577	1578	1567	1582	1528	1543	1772	1779	1752	1772	1743	1763
3	Acromial Height	1369	1370	1358	1371	1342	1355	1545	1551	1529	1547	1546	1564
4	Elbow Height	1027	1028	1018	1028	1010	1020	1182	1187	1170	1183	1168	1181
5	Fingertip Height	621	622	613	619	591	597	726	729	727	735	716	724
6	Vert. Fn Reach	2109	2111	2111	2111	2074	2094	2380	2390	2356	2382	2352	2379

TABLE B-2 Male Body Dimensions (Sitting)

		5th Percentile						95th Percentile					
		UK Aircrew		UK Non-Aircrew		US Army		UK Aircrew		UK Non-Aircrew		US Army	
		Actual	Estim.	Actual	Estim.	Actual	Estim.	Actual	Estim.	Actual	Estim.	Actual	Estim.
		1987	2000	1987	2000	1988	2000	1987	2000	1987	2000	1988	2000
7	Sitting Height above seat	881	882	871	879	855	863	995	999	981	992	972	983
8	Eye Height above seat	784	785	778	785	735	742	878	882	863	873	848	858
9	Acromial Height above seat	571	571	572	578	549	554	674	677	668	676	646	653
10	Elbow Rest Height above seat	206	206	209	211	184	186	290	291	292	295	274	277
11	Thigh clearance	155	155	143	144	149	150	198	199	192	194	190	192
12	Stool Height	359	359	365	369	-	-	441	443	459	464	-	-
13	Knee Height	521	521	515	520	514	519	602	605	600	607	606	613
14	Abdominal Depth	196	196	203	205	199	201	290	291	301	304	291	294
15	Buttock Knee Length	568	568	561	566	569	574	657	660	656	663	667	675

TABLE C-2 Male Body Dimensions (Sitting)

		5th Percentile						95th Percentile					
		UK Aircrew		UK Non-Aircrew		US Army		UK Aircrew		UK Non-Aircrew		US Army	
		Actual	Estim.	Actual	Estim.	Actual	Estim.	Acutal	Estim.	Actual	Estim.	Actual	Estim.
		1987	2000	1987	2000	1988	2000	1987	2000	1987	2000	1988	2000
16	Span between Fingertips	1696	1698	1675	1691	1693	1709	1958	1966	1918	1940	1960	1983
17	Inter Elbow Span	892	893	885	894	895	904	1040	1044	1020	1032	1042	1054
18	Shoulder Breadth	453	453	438	442	450	454	539	541	530	536	535	541
19	Hip Breadth	346	346	337	340	329	332	418	420	423	428	412	417
20	Vertical Functional Reach above seat	1283	1284	1277	1289	1272	1284	1475	1481	1450	1467	1459	1476
21	Horizontal Functional Reach	394	394	388	392	386	390	456	458	449	454	452	457
22	Forward Functional Reach	729	730	722	729	739	746	850	854	840	850	867	877

TABLE D-2 Male Hand, Foot and Head Dimensions

		5th Percentile						95th Percentile					
		UK Aircrew		UK Non-Aircrew		US Army		UK Aircrew		UK Non-Aircrew		US Army	
		Actual	Estim.	Actual	Estim.	Actual	Estim.	Actual	Estim.	Actual	Estim.	Actual	Estim.
		1987	2000	1987	2000	1988	2000	1987	2000	1987	2000	1988	2000
23	Hand Length	181	181	178	180	178	180	211	212	208	210	211	213
24	Hand Breadth	80	80	79	80	84	85	95	95	93	94	98	99
25	Foot Length	248	248	245	247	249	251	287	288	285	288	292	295
26	Foot Breadth	90	90	88	89	92	92	105	105	104	105	110	111
27	Head Breadth	147	147	146	147	143	144	164	165	163	165	161	163
28	Inter Pupillary distance	58	58	57	58	59	60	69	69	69	70	71	72
29	Pupil to top of head	97	97	93	94	101	102	117	117	118	119	123	124
30	Tragion to vertex (ear centre to top of head)	119	119	118	119	122	123	140	141	139	141	140	142
31	Head Height	216	216	208	210	218	220	246	297	244	247	247	250
32	Head Length	189	189	188	190	185	187	211	212	209	211	209	211

Table F
Female Body Dimensions in Millimetres (Sitting), Hands, Feet and Head

		3rd Percentile			50th Percentile			97th Percentile		
		UK RN	UK Mil	US Army	UK RN	UK Mil	US Army	UK RN	UK Mil	US Army
	Table F	1986-90	1994	1988	1986-90	1994	1988	1986-90	1994	1988
7	Sitting Height above seat	821	798	788	870	860	851	934	919	918
8	Eye Height above seat	735	692	677	769	751	738	817	806	802
9	Acromial Height above seat	538	515	503	581	567	555	628	618	611
10	Elbow Rest Height above seat	212	202	169	249	251	221	297	299	271
11	Thigh Clearance	132	132	138	155	155	158	182	182	184
12	Stool Height	330	343	-	384	386	-	433	434	-
13	Knee Height	468	474	468	515	515	514	565	562	567
14	Abdominal Depth	172	192	181	219	232	219	285	300	279
15	Buttock Knee Length	527	542	535	578	592	588	622	648	647
16	Span between fingertips	1506	1496	1524	1639	1637	1670	1755	1785	1828
17	Inter Elbow Span	805	806	815	875	882	892	953	968	993
18	Shoulder Breadth	396	385	392	436	426	431	480	478	479
19	Hip Breadth	342	331	337	376	379	383	448	441	440
20	Vert Fn. Reach	1161	1137	1162	1256	1231	1264	1360	1336	1364
21	Horiz. Elbow Reach	348	-	347	379	-	383	411	-	419
22	Forward Fn. Reach	652	672	670	711	737	734	779	812	806
23	Hand Length	161	167	163	177	185	180	193	205	200
24	Hand Breadth	68	68	73	75	74	79	82	81	87
25	Foot Length	219	220	222	241	241	244	260	262	267
26	Foot Breadth	79	80	81	88	87	90	95	95	99
27	Head Breadth	139	141	136	148	150	144	159	160	154
28	Inter Pupillary Dist	57	53	56	64	58	62	71	63	69
29	Pupil to Top of Head	86	96	93	101	112	105	117	127	118
30	Tragion to Vertex	112	114	113	124	125	124	134	137	134
31	Head Height	194	197	202	212	215	218	230	233	234
32	Head Length	177	177	175	189	190	187	199	203	199

Tables E2 to F2
5th and 95th Percentile Body Measurements in Millimetres for Female Military Personnel

TABLE E2 Female Body Dimensions (Standing)

		5th Percentile			95th Percentile		
		UK RN	UK Mil	US Army	UK RN	UK Mil	US Army
		1986-90	1994	1988	1986-90	1994	1988
1	Stature	1556	1543	1528	1742	1744	1737
2	Eye Height	1466	1543	1415	1627	1637	1621
3	Acromial Height (Shoulder Height)	1250	1257	1241	1438	1444	1432
4	Elbow Height	934	-	917	1080	-	1077
5	Fingertip Height	587	591	551	689	699	670
6	Vertical Functional Reach	1939	1873	-	2220	2158	2115

TABLE F-2 Female Body Dimensions (Sitting)

7	Sitting Height above seat	826	807	795	924	913	911
8	Eye Height above seat	736	699	685	809	799	794
9	Acromial Height above seat	539	520	509	625	612	604
10	Elbow Rest Height above seat	215	210	176	284	293	264
11	Thigh Clearance	136	134	140	178	178	180
12	Stool Height	340	344	-	426	430	-
13	Knee Height	471	480	474	558	556	560
14	Abdominal Depth	179	198	185	278	288	271
15	Buttock-Knee Length	531	546	542	619	641	640
16	Span between fingertips	1522	1520	1542	1750	1755	1809
17	Inter Elbow Span	810	814	795	946	955	943
18	Shoulder Breadth	399	389	397	475	472	472
19	Hip Breadth	345	338	343	441	432	432
20	Vert Fn. Reach	1171	1147	1174	1347	1324	1352
21	Horiz. Elbow Reach	349	-	350	409	-	411
22	Forward Fn. Reach	656	680	677	775	804	797
23	Hand Length	163	170	165	191	202	197
24	Hand Breadth	69	68	73	82	80	85
25	Foot Length	220	222	224	259	259	265
26	Foot Breadth	80	81	82	94	94	98
27	Head Breadth	140	142	137	157	158	153
28	Inter Pupillary Dist	57	54	57	70	63	69
29	Pupil to Top of Head	90	98	94	115	125	116
30	Tragion to Vertex	113	115	114	132	135	133
31	Head Height	196	199	204	228	230	230
32	Head Length	178	179	176	198	201	198

Table G

Male Body Weight in Kilograms

3rd Percentile					
UK Aircrew		UK Non-Aircrew		US Army	
Actual	Estim.	Actual	Estim.	Actual	Estim.
1987	2000	1987	2000	1988	2000
62	65	59	65	59	63

50th Percentile					
UK Aircrew		UK Non-Aircrew		US Army	
Actual	Estim.	Actual	Estim.	Actual	Estim.
1987	2000	1987	2000	1988	2000
78	82	78	82	78	82

97th Percentile					
UK Aircrew		UK Non-Aircrew		US Army	
Actual	Estim.	Actual	Estim.	Actual	Estim.
1987	2000	1987	2000	1988	2000
99	103	101	103	101	105

Female Body Weight in Kilograms

3rd Percentile		
UK RN	UK Mil	US Army
1986-90	1994	1988
49	49	49

50th Percentile		
UK RN	UK Mil	US Army
1986-90	1994	1988
63	61	61

97th Percentile		
UK RN	UK Mil	US Army
1986-90	1994	1988
82	82	80

Applications for fitting trials and seat design. Strength of supporting structures. Body weight is also useful in cross referencing between populations and selecting subjects for fitting trials.

4.6 Survey Age Data. To provide the user with some background of the data in tables A to G, and 3rd, 50th and 97th percentile ages and the overall numbers involved in the surveys are given in table H.

Table H

Population Age at Time of Survey and Number in Survey

	3rd %	50th %	97th %	Number
UK Aircrew Male	22	30	46	367
UK Non-Aircrew Male	18	28	45	1333
US Army Male	19	25	41	1774
UK RN Female	19	25	37	136
UK Military Female	19	24	39	1002
US Army Female	19	25	38	2208

Applications for fitting trials and seat design. Strength of supporting structures. Body weight is also useful in cross referencing between populations and selecting subjects.

Table J
Comparison of Aircrew Data from Different Nations, Dimensions in Millimetres

Percentile		3rd					50th					97th			
Nationality		**GAF**	**USAF**	**RAF**	**IAF**		**GAF**	**USAF**	**RAF**	**IAF**		**GAF**	**USAF**	**RAF**	**IAF**
Survey Date		**1967**	**1967**	**1970**			**1967**	**1967**	**1970**	**1962**		**1967**	**1967**	**1970**	
Stature	1	1657	1659	1655			1767	1773	1770	1717		1886	1892	1890	
Eye Height	2	-	-	1549			-	-	1661	-		-	-	1783	
Shoulder Height	3	1403	1411	1396			1508	1520	1502	1399		1621	1633	1616	
Elbow Height	4	331	-	-			341	-	-	-		372	-	-	
Fingertip Height	5	607	607	606			673	671	670	639		745	741	734	
Vertical Functional Reach	6	-	-	-			-	-	-	-		-	-	-	
Sitting Height	7	846	875	868			909	931	929	903		971	993	988	
Eye Height	8	733	755	765			798	808	824	786		857	869	881	
Shoulder Height above Seat	9	557	-	614			620	-	666	618		675	-	715	
Elbow Rest Height	10	178	203	200			237	251	248	227		294	302	294	
Thigh Clearance	11	106	140	137			151	165	158	165		161	192	180	
Stool Height	12	389	395	376			434	437	424	402		477	480	469	
Knee Height	13	487	512	513			540	557	559	538		591	606	610	
Abdominal Depth	14	181	-	203			220	-	240	-		273	-	287	
Buttock-Knee	15	553	554	559			601	603	606	587		650	657	657	
Span	16	-	-	1692			-	-	1826	-		-	-	1965	
Inter-Elbow Span	17	-	-	909			-	-	990	-		-	-	1070	
Shoulder Breadth	18	409	435	430			457	482	469	-		505	533	508	
Hip Breadth	19	315	319	332			352	352	368	362		390	390	406	
Vertical Reach above Seat	20	-	-	1281			-	-	1385	-		-	-	1478	
Horizontal Elbow Reach	21	-	-	384			-	-	419	-		-	-	458	
Forward Reach	22	721	726	736			800	802	802	745		882	881	871	
Hand Length	23	173	176	173			189	191	191	190		206	207	209	
Hand Breadth	24	78	81	-			86	89	-	-		94	97	-	
Foot Length	25	241	249	244			263	270	266	265		287	293	289	
Foot Breadth	26	86	89	87			100	98	95	101		111	108	104	
Head Breadth	27	131	132	147			141	143	157	156		152	153	168	
Inter Pupillary Distance	28	55	56	-			63	63	-	-		69	69	-	
Pupil to Vertex	29	93	105	97			113	119	112	-		132	134	128	
Tragion to vertex	30	110	123	118			130	135	130	130		147	146	141	
Head Height	31	196	208	210			221	228	230	224		245	247	248	
Head Length	32	173	186	186			190	199	190	194		206	212	210	
Weight (Kg)	-	60.7	61.6	59.5			74.5	78.2	74.5	73.6		90.8	98.3	92.4	

NOTE: Shoulder height above seat (9). Shoulder height - GAF and RAF techniques are different so measurements are not comparable. GAF is taken at mid shoulder and RAF is 90 mm from midline of body.

Section Four. Dynamic Anthropometry

5 Definition

Dynamic anthropometry deals with the dimension of the workspace envelope needed by persons as they perform their work. Unlike static body dimensions, which are measured with the subject in a rigid, standardized position, dynamic measurements are made in working positions and vary accordingly.

5.1 Reach data. In many workspace design problems it is important to know how far an operator is able to reach in a given direction from a specified reference point.

5.2 Formal reach dimensions. All data in section 3 tables and diagrams refer to straightforward anatomical distances (or static body dimensions) although it should be appreciated that an individual is able to reach a good deal further forward than this distance, by thrusting forward or protracting their shoulders, and by flexing and inclining the trunk. However, even this increased reach may be severely limited if the person is constrained by a tight harness, protective clothing or seat geometry. (See Figs 12a and 12b and clause **5.2.5).**

5.2.1 Dynamic reach dimensions. The total volume of space which an individual can reach by adopting whatever postural combination is most advantageous, is defined by a three dimensional system of co-ordinates, centred on, for example the seat reference point, known as a workspace envelope (or kinosphere) (see Figures 12a and 12b). Typical examples of workspace envelopes will be found in Van Cott and Kincade.

5.2.2 Figures 12a and 12b show the 3rd and 97th percentile Dynamic right arm reach envelopes for both male and female current UK military personnel. (It is assumed that the left arm reach envelopes will mirror the right arm's). The reach envelopes shown are intended as a guide and assume that lightly clothed personnel are restrained in a seat with a lap strap.

5.2.3 Distances from the Seat Reference Point (SRP) (See Figure 11) are shown in millimetres. The SRP is at the centre line of the seat pan (which is tilted up at 6°) where it meets the seat back, which is inclined backwards at 13°. Distance from seat reference point, dimensions are measured from SRP vertical axis and not reclined back.

5.2.4 Different seat geometry, use of a tight restraining harness and bulky protective clothing such as helmets, NBC clothing, life saving jackets etc, will change and generally reduce the reach envelope.

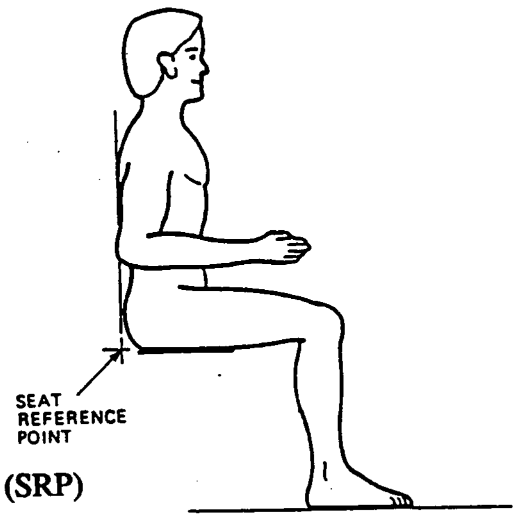


Fig 11: Seat Refence Point (SRP)

5.2.2 The workspace envelope. The seat reference point (SRP) illustrated in figure 11, is commonly used as a standard starting point for reach dimensions of seated operators and is defined as the midpoint of the intersection of the place of the seat surface, with the plane of the backrest surface of the seat and tangents of the mid-line contours of the seated person.

The seat reference line (SRL) and the seat reference vertical (SRV) illustrated in figures 12a and 12b are reference lines plotted from the seat reference point to vertical axsis to highlight reach boundaries when converted to horizontal contours.

The examples are presented as a guide to the designer to introduce the workspace envelope pictorially, and should not be considered as a basis of practicality towards design aspects of functional ergonomics. At present dimensional representations of the horizontal boundaries for British civilian and military personnel are not readily available. However, a fuller description can be found in Van Cott and Kinkade but it should be emphasised that the dimensions tabulated in this work should be treated with caution, they apply only to the populations that are similar in size and proportions to the US Air Force and cannot be used indiscriminately for all populations.

5.2.3 Anthropometry of reach. The anthropometry of reach can be viewed in terms of a relatively large volume which is ‘possible’, within which are successively smaller volumes which are ‘acceptable’, ‘preferred’ or ‘optimal’ for a particular activity (see clause **7.1** Working Posture) and also Defence Standard 00-25 PART 4: Workplace Design and PART 10: Controls.

5.2.4 Reach for workspace layout

(a) Arm reach data is essential for equipment design and workspace layout simply because different controls demand varying degrees of precision of movement and force. Arm length measurements, originally taken from standing subjects as a maximum length to qualify anatomical difference, have now proliferated into numerous dimensions, both standing and sitting, involving various combinations of position of the hand, arm and shoulder.

(b) It is impossible to consider the zone which is defined by the rotation of the upper limb about the shoulder joint anatomically resembling a ball and socket (See section 5 regarding the range of movement of body members, and the guidelines in Defence Standard 00-25, PART 3 concerning the safe limits for force applications).

5.2.5 Head and eye pointing boundaries. When considering Helmet Mounted Sighting Systems for weapon aiming, the designer needs to be aware of possible head and eye movement limitations caused by equipment or protective clothing interference.

Figures 13 and 14 show typical head and eye movement boundaries for fighter pilots, for both the slack and tight restraining harness cases.

5.2.5 (Contd)

Both figures show a side elevation view of a sphere with the pilot looking forwards (to the left). The pilot's eye datum is at the 90°, 0° co-ordinate at the centre of the sphere. From this position, the 3rd percentile male pilot (in terms of head movement - not stature) can only point his head 40° upwards, with a slack harness when looking straight ahead. When looking sideways (90°) he can look only 26° upwards and 10° downwards.

The side of the cockpit prevents the eye from looking downwards more than 40° to the side, even for the 90%le pilot with a slack harness.

This is a general guide to pilots head and eye pointing ability and the following points should be noted:

(a) There is considerable variability in head mobility between subjects. This mobility has little correlation with subject dimensions such as Sitting Eye Height, but appears to be dependent upon the pilot's postural strategy.

(b When wearing a tight harness, head movement upwards and rearwards is severely restricted by interference between the ejection seat head box and the pilot's protective helmet.

(c) Head movement is limited also by interference between the life-saving jacket and the oxygen mask/helmet assembly. Eye pointing is sometimes limited by the bulk of the oxygen mask.

(d) If the harness is worn in the unlocked or slack state, an additional 10° to 20° of head movement can be achieved.

(e) If the eye, rather than the head, can be used for aiming, then an additional 50° becomes available to use.

Little further anthropometric information on head and eye pointing for weapon control has become available since Lovesey's paper in 1987.

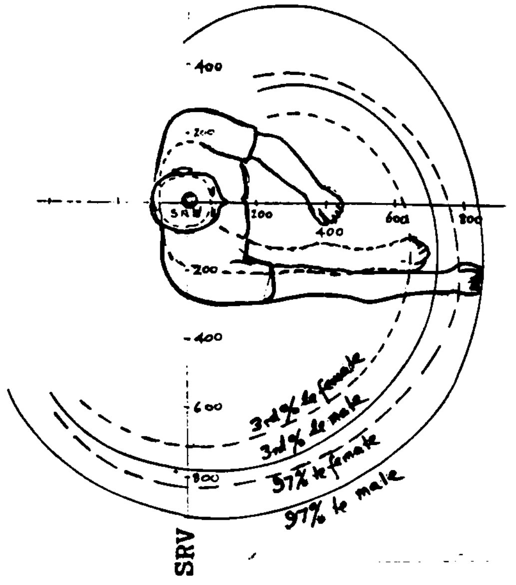


Fig 12a: 3rd and 97th Percentile Male and Female Military Personnel Forward Functional reach Envelopes

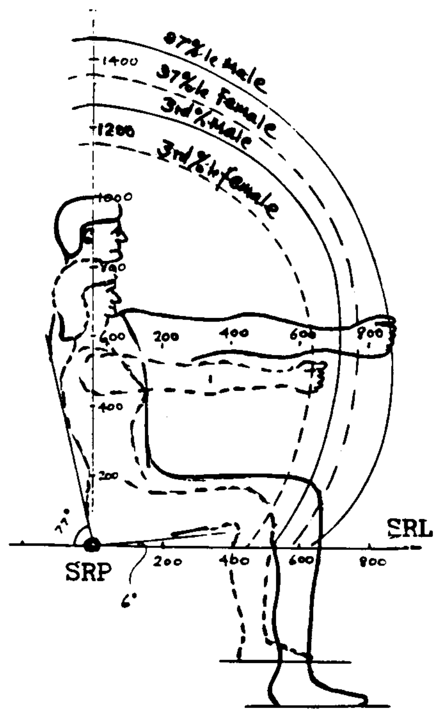


Fig 12b: 3rd and 97th Percentile Male and Female Military Personnel Forward Functional reach Envelopes

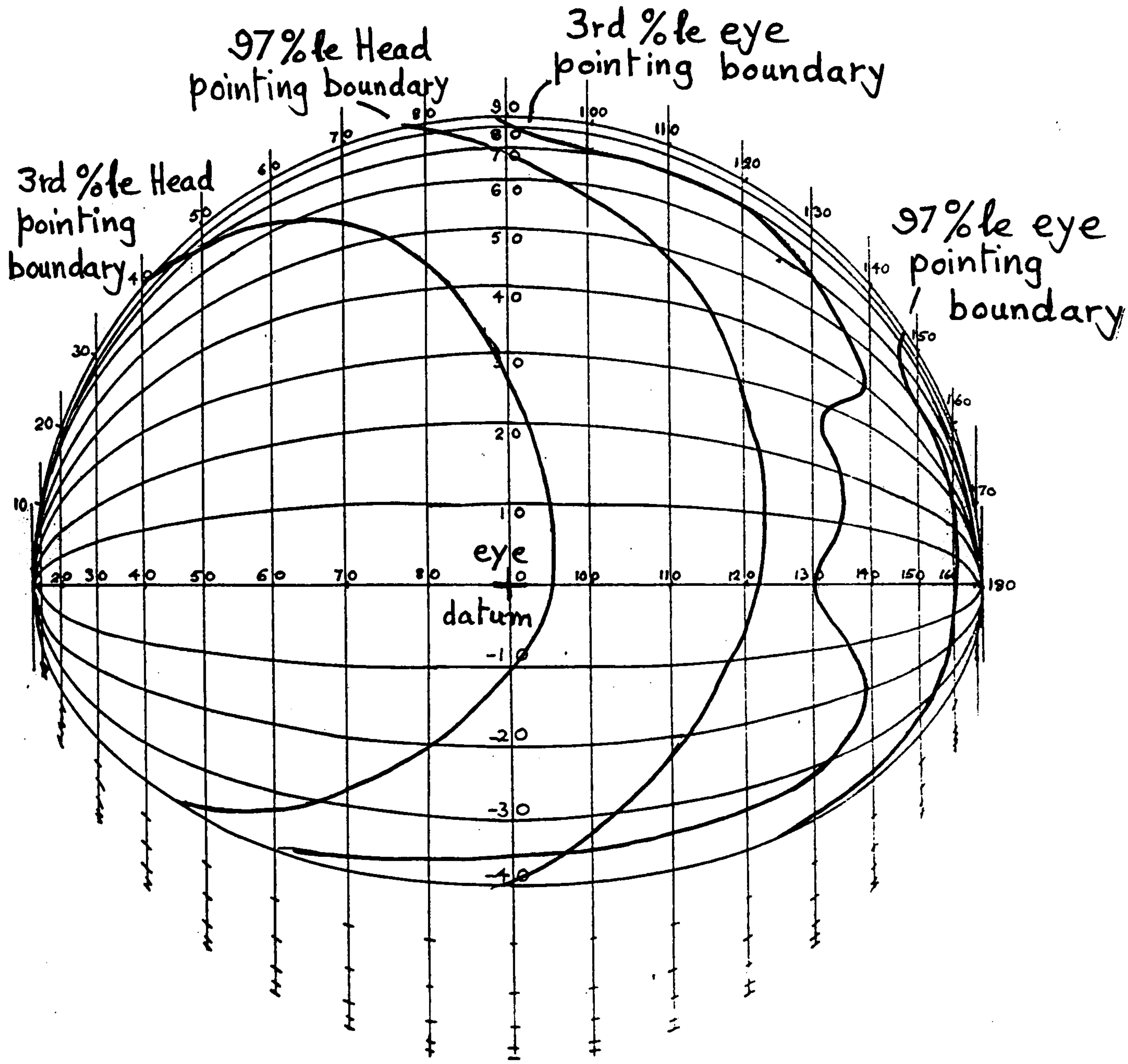


Fig 13: Head and Eye Pointing Boundaries with a Slack Harness (Fast Jet Aircrew in Ejection Seat with Helmet, Oxygen Mask, Life Saving Jacket and Flying Clothes

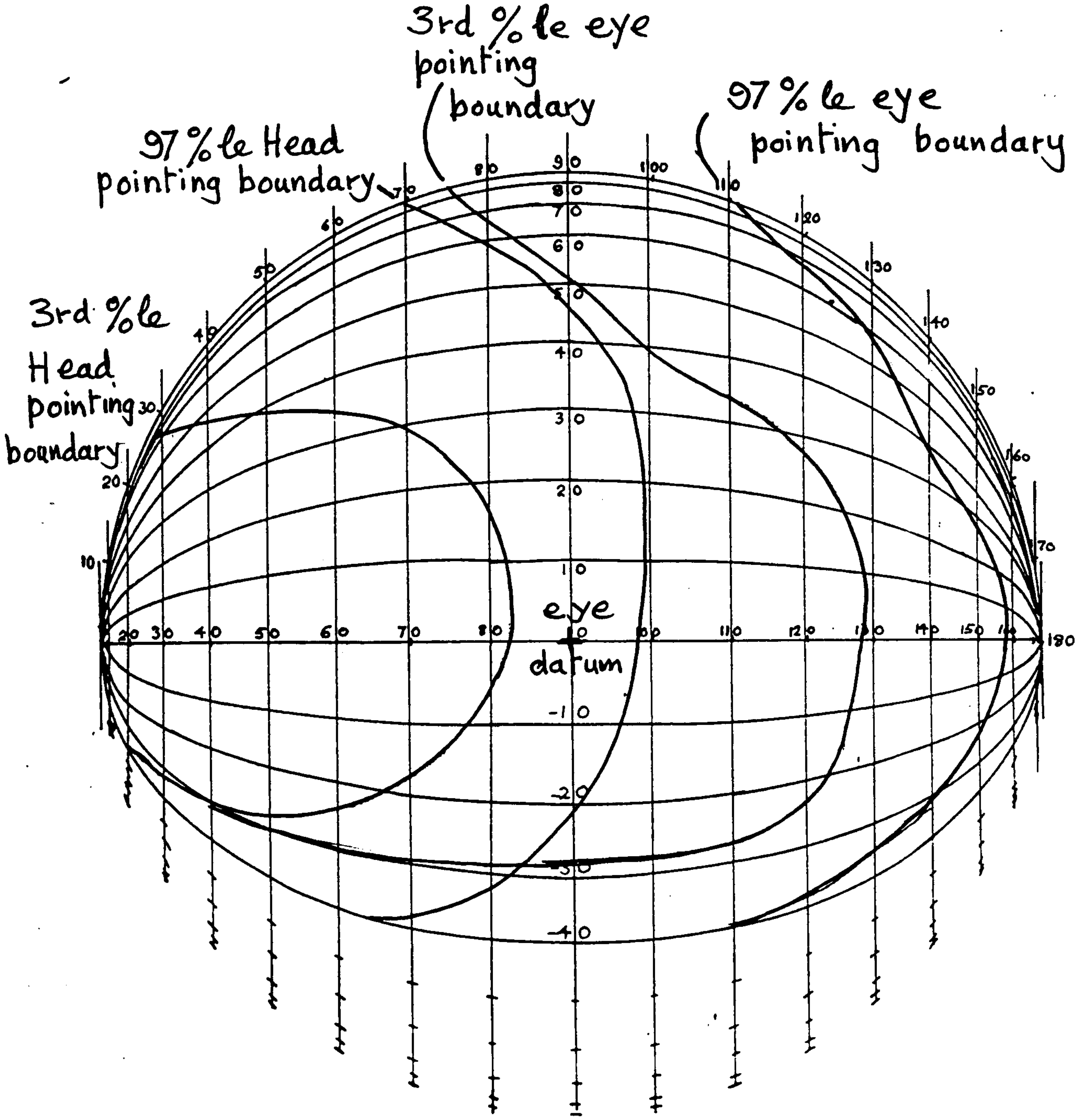


Fig 14: Head and Eye Pointing Boundaries with a Tight Harness (Fast Jet Aircrew in Ejection Seat with Helmet, Oxygen Mask, Life Saving Jacket and Flying Clothes

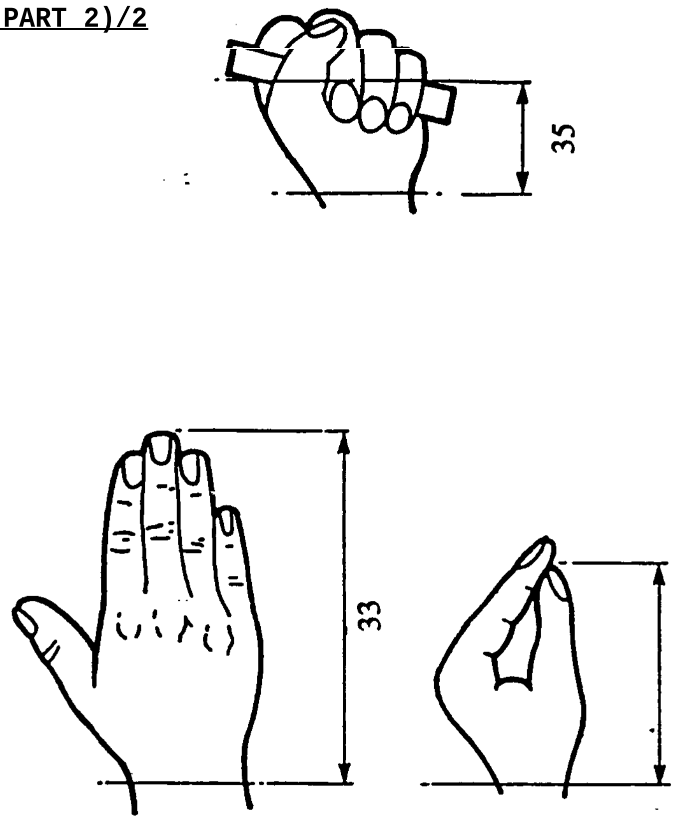


Fig 15: Functional Grip Dimensions

Table K
Grip Correction Factors

	DIMENSIONAL DESCRIPTIONS	% of 33	UK MILITARY (2000 est)					
			3RD %le		50th %le		97 %le	
			M	FM	M	FM	M	FM
33	HAND LENGTH	100	178	161	195	177	212	193
34	WRIST TO THUMB TIP IN A PINCH GRIP	60	107	97	117	106	127	116
35	WRIST TO THE CENTRE OF A FULL GRIP	35	62	56	68	62	74	68

add correction for gloves if necessary. (See 5.4.2)

Note 1: Reach corrections may be calculated using the hand length data tabulated in section 3; figure 8.

Note 2: In typical cases:
For Men - Fingertip reach is 78 millimetres further than thumbtip, and 70 for women.
For Men - Thumbtip reach is 50 millimetres further than full grip and 44 for women.

5.3 Accessibility of confined workspaces

5.3.1 When space is at a premium, it may be necessary to specify minimum dimensions for access by maintenance personnel (plumbers, fitters etc). Figure 16 gives dimensions which will accommodate virtually all civilian, or female Service personnel, however, allowances must be made for footwear, helmets, equipment etc. (Refer to clause **5.4** for clothing corrections.)

5.3.2 When such dimensions are critical, the designers are urged to check using a full scale mock up using subjects representing the largest and bulkiest members of the working population wearing maximum clothing assemblies applicable to climatic/operational conditions.

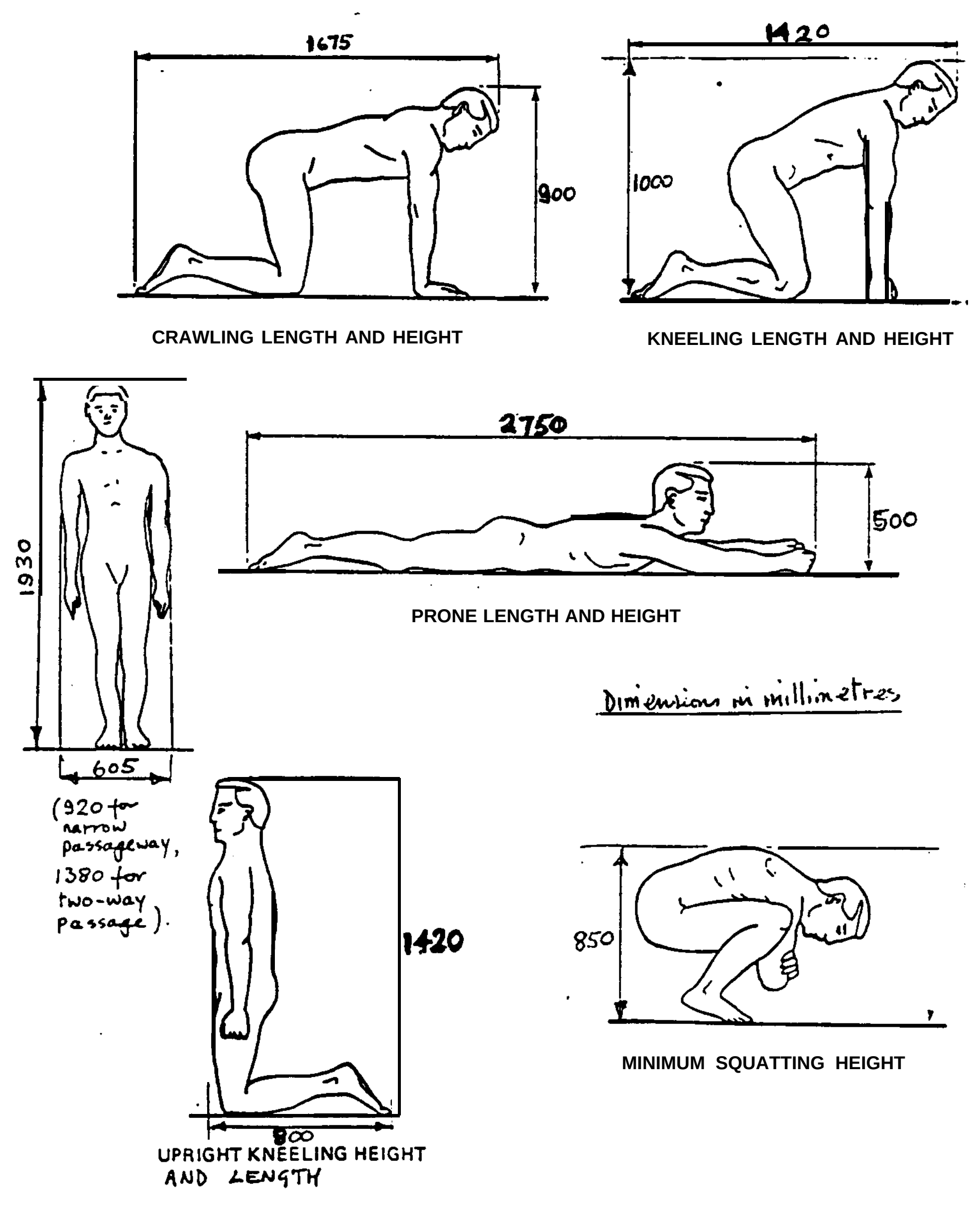


Fig 16: Functional Dimensions for Confined Work Spaces

Note: Add corrections for clothing as given in Table L.

5.3.3 Accessibility for manual tasks

(a) Access openings provided for adjusting and handling interior items should be sized to permit the required operations and where possible provide an adequate view of the item being manipulated. Access covers should be equipped with grasp areas or other means for opening them. Allowance should be made for the clearance of the operators gloved or mittened hand if the access is located externally and may require servicing under cold weather conditions. Some examples of access allowances which may be encountered are shown in figure 17. For access and correct spacing of controls, refer to Defence Standard 00-25. Part 10: Controls, and Part 11: Design for Maintainability.

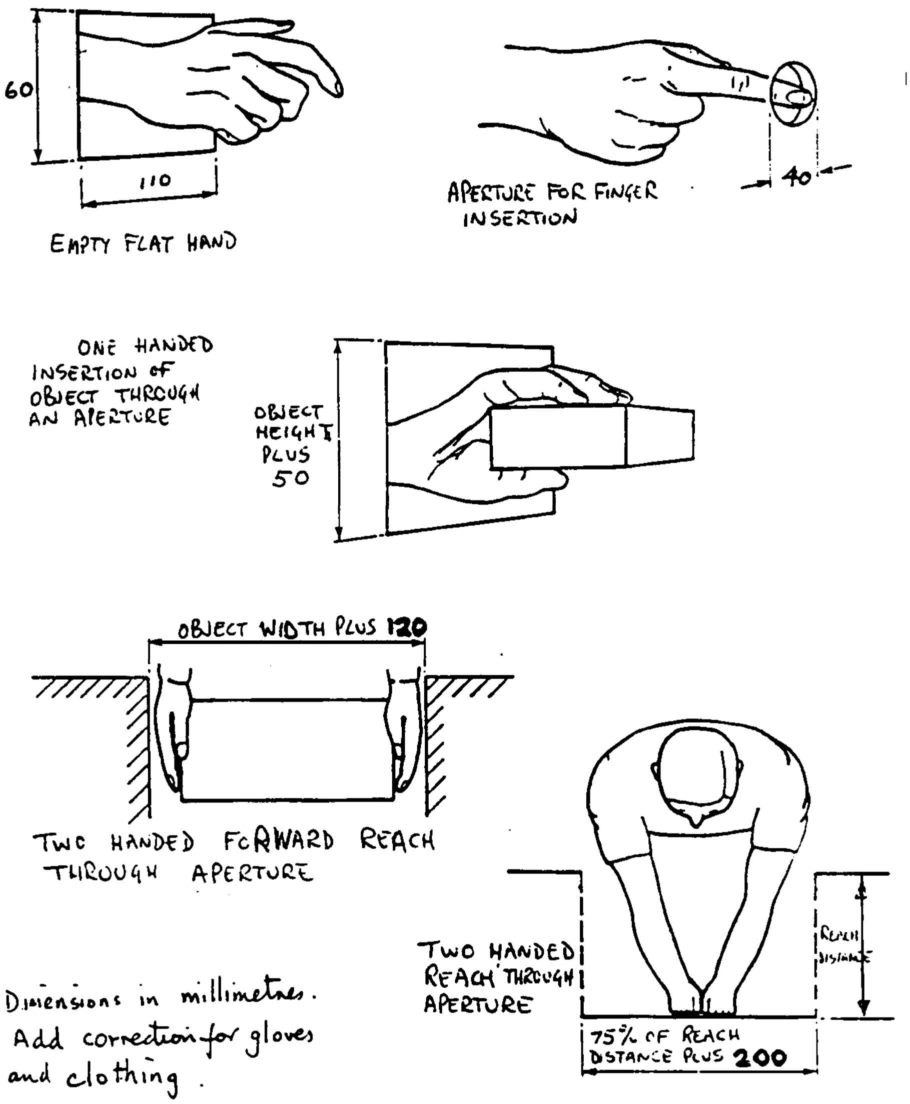


Fig 17: Aperture Dimensions for Manual Tasks

5.3.3 (Contd)

(b) Certain functional dimensions of the workspace can not be adequately derived from simple anthropometric dimensions of the type considered in Section 4. Some dimensions relevant to the design of maintenance access spaces and to the layout of multiple controls on equipment are summarized in figure 17. It should be emphasized that the dimensions indicated in this figure are approximate and that additional allowance may have to be made for special clothing, gloves and footwear.

5.4 Clothing corrections for anthropometric data

5.4.1 Because surveys are generally conducted on semi-nude subjects, clothing corrections must be considered by designers when planning workspace layout and control positioning etc. Substantial differences can occur in anthropometric data with the addition of clothes, tools and equipment see table L for clothing corrections. For overhead reach there is a decrement due to clothing restrictions.

5.4.2 An important factor which determines the clothing correction to be applied, is the NBC operational and/or environmental conditions in which the equipment is to be used, ranging from perhaps, arctic to a tropical environment. For example, in figure 18, a 60 x 110 mm aperture handgrip which will comfortably admit the largest ungloved hands needs to be increased to 100 x 200 mm for a man wearing arctic mittens.

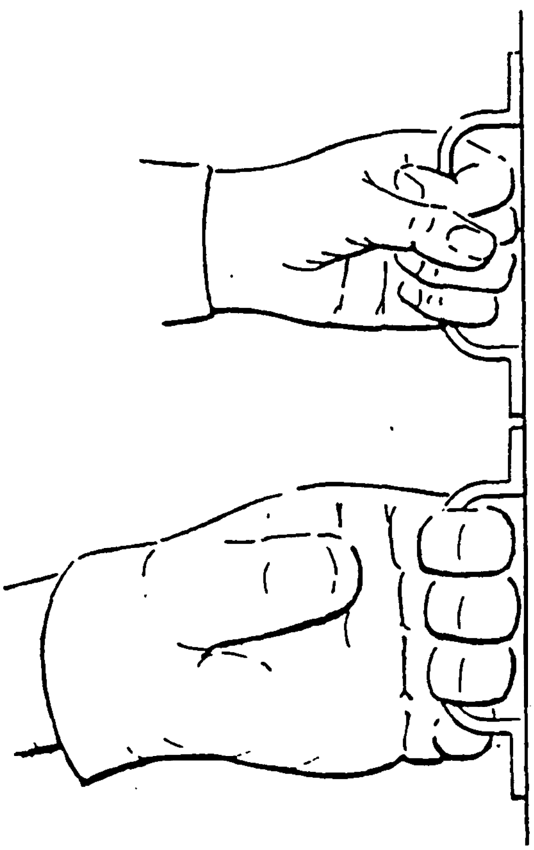


Fig 18: Example Showing Importance of Clothing Correction

Table L

Additions to Anthropometric Dimensions for Clothing

Dimensions in millimetres

Description	COMBAT	COLD WEATHER
Stature	64	76
Eye height standing	27	36
Sitting height	38	51
Eye height sitting	1	10
Thigh clearance	4	23
Knee height	33	56
Buttock to knee length	5	51
Shoulder breadth	6	152
Hip breadth	13	152
Abdominal depth	13	51
Foot Length	41	68
Foot breadth	5	46
Hand breadth	N/A	43
Hand thickness	N/A	84

N/A data not available

Note: Table L (above) is intended as a guide only. With the issue of the combat soldier 95 (CS95) clothing system which includes the MK6 combat helmet and boots it is no longer possible to define a single combat ensemble. Crews for armoured vehicles wear helmets designed for use in those vehicles.

5.4.3 Civilian footwear, the extremes of personal taste, can add substantially to the variability of stature as well as the mean. Clearance dimensions in workspace and passageways may require to take account of a variety of personal equipment and luggage (headset, rescue gear, tool bags etc).

Note: This is absolutely vital for damage control, fire fighting and emergency escape. In these circumstances dimensions must be chosen which will allow 100% of the population to pass without impediment. Military headgear may add over 50 mm stature and boots up to 30 mm.

An example of a subject wearing bulky equipment, such as a parachute is given on page 41, showing dimensions of an escape hatch.

5.4.4 Designers of military equipment cannot consider these factors without data. It is more likely that the operator will need to conform to agreed standards, ie, military environment ie short hair, beard possible states

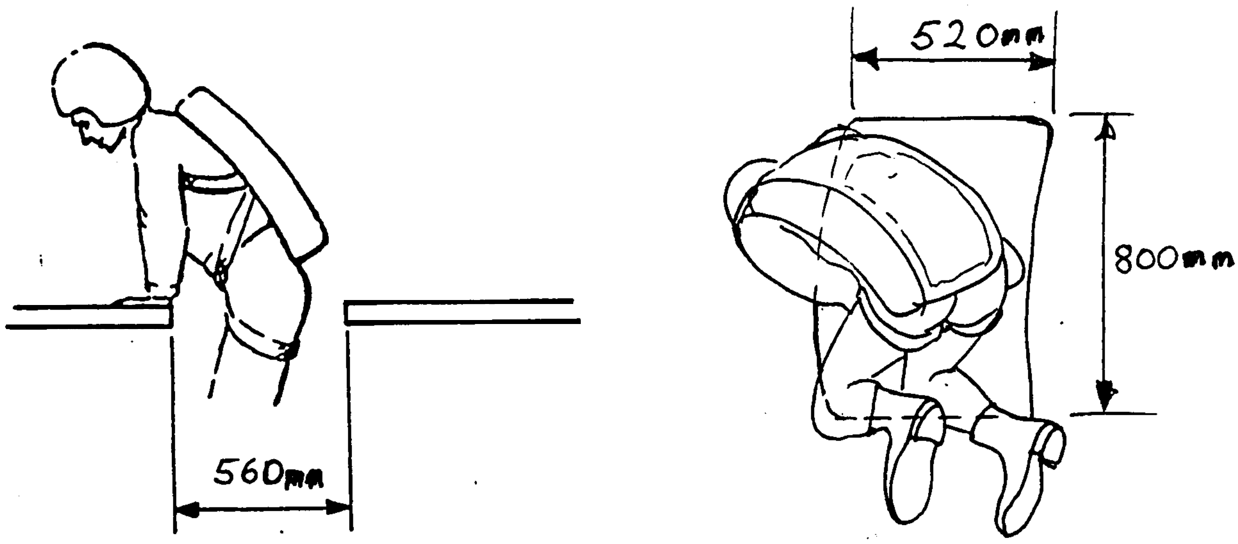


Fig 19: Escape Hatch Dimension

Note: The dimensions in escape hatch design should be chosen which will allow 100% of the population to pass through without impediment.

5.5 Maximal static forces and space requirements

5.5.1 Static (isometric) force as applied to a control means the exertion of muscle force such that the muscles tighten but do not change their length during this tension. The control does not move, or moves negligibly, in relation to the operator's body.

5.5.2 In workspace where manual forces must be exerted it is important to provide sufficient clearance for the operator to use his body to the greatest mechanical advantage. Cramped conditions or obstacles in the workspace lead to a reduction in the person's capacity to exert force and an increased level of strain (see Section 6: Posture and also Defence Standard 00-25 Part 3: Body Strength and Stamina).

5.5.3 The necessity for an operator to exert a force, or support a load, while leaning forward over an obstacle should be avoided. Some approximate guidelines to space requirements are as follows:

Lateral clearance. Inter-elbow span (see figure 6, section 3) provides a reasonable indication of the space required for unrestricted activity. A clearance of 550 mm either side of the mid-line is satisfactory for most purposes. (This figure should be increased if the required force has a sideways component).

5.5.3 (Contd)

Clearance behind the operator. Measuring backwards from the operators hands the following distances should prove adequate for static exertions.

LIFTING FORCES	550 mm
PULLING OR PUSHING FORCES	1250 mm

Note: Pushing forces are increased by the presence of an obstacle behind the operator if he is able to use it for bracing himself. The more complex case of dynamic exertion should be solved by trial and error.

Section Five. Anthropometric Movement of Body Members

6 Definition

The human body may be generally described as a small number of rigid links, connected at specific points about which they are free to rotate.

6.1 Body linkages

6.1.1 To plan positioning and operability of controls, a designer requires data concerning the range of movement of the torso, arms and legs in order to establish the comfortable limits for maximum efficiency.

6.1.2 The moveable joints of the body, articulated by means of ligaments (tough fibrous bands), are of several types, the three most important are: hinge joints (finger), pivot joints (elbow), and ball and socket joints (shoulder and hip). Thus, the human body is basically an open chain system of ‘links’ rotating around joints. The end members of these open-chain links, the hands and feet, can occupy a limitless number of positions in space as a result of the cumulative ranges of these joints (DEMPSTER).

6.2 Dynamic range of movement

6.2.1 The functional (or dynamic) data presented so far has been empirically determined in ad hoc studies to solve specific practical problems. The application of such data is of necessity limited to a narrow range of situations, similar to those in which the data was originally gathered. There are times when a designer needs to reach an approximate solution to a novel problem in functional anthropometrics.

6.2.2 The thigh link extends from the centre of rotation of the hip joint to that of the knee. The shank or lower leg link extends from the knee to the ankle, etc. In table M the average lengths of these links are expressed as a percentage of the stature. Designations 1 to 17 in table M refer to dimensions of the body as seen in side elevation, (known to anatomists as the SAGITTAL PLANE, see figure 20), whereas designation 18 and 19 refer to dimensions of the body as seen in front elevation (known to anatomists as the CORONAL PLANE - see figure 21).

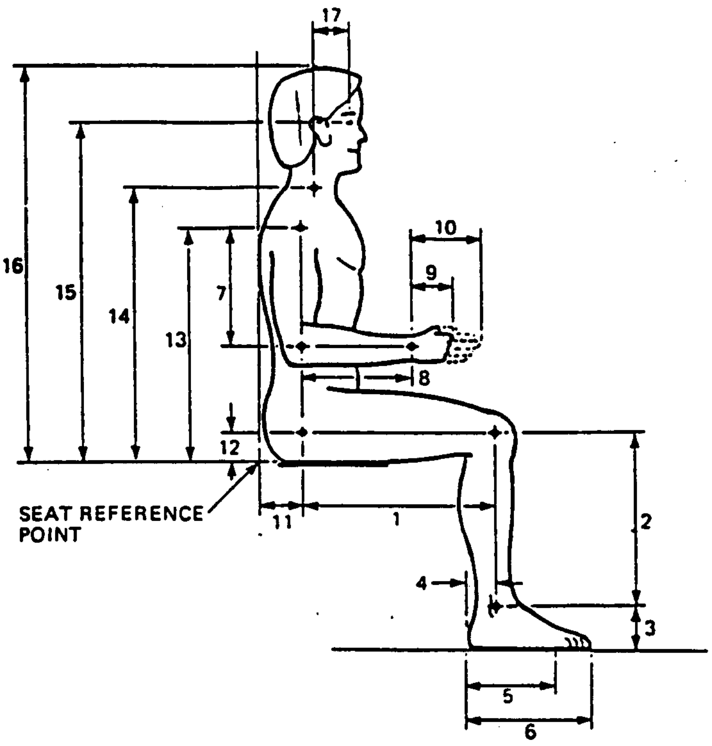


Fig 20: Sagittal Plane Body Linkage

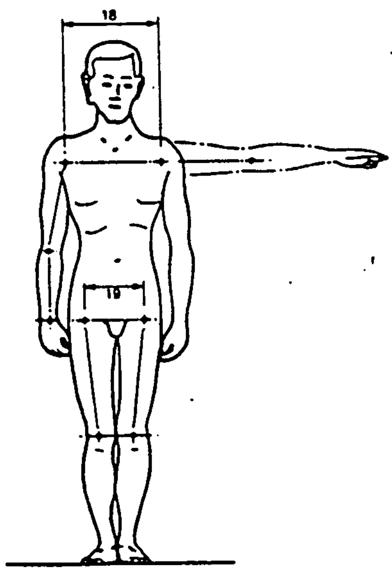


Fig 21: Coronal Plane Body Linkage

Table M
Dimensions of Body Linkages Expressed as a Percentage of Stature from Figs 20 and 21

	DESCRIPTION	PERCENTAGE OF STATURE
1	THIGH	28.4
2	SHANK (LOWER LEG)	23.4
3	ANKLE HEIGHT	4.7
4	HEEL TO ANKLE (HORIZONTAL PROJECTION)	3.3
5	HEEL TO BALL OF FOOT	11.2
6	FOOT LENGTH	15.3
7	ARM (ie SHOULDER TO ELBOW)	17.3
8	FOREARM	15.5
9	WRIST TO CENTRE OF GRIP	3.8
10	HAND LENGTH	10.9
11	HIP TO SRP (HORIZONTAL	6.9*
12	HIP TO SRP (VERTICAL)	5.2*
13	SHOULDER TO SEAT	32.0
14	LOWER NECK (C7 VERTEBRA) TO SEAT	37.8
15	EYE LEVEL TO SEAT	45.9
16	SITTING HEIGHT	52.3
17	EYE TO AXIS OF HEAD (HORIZONTAL)	5.7
18	TRANSVERSE SHOULDERS	22.5
19	TRANSVERSE HIPS	9.8

* The seat reference point (SRP) is the centre point of a line formed by the intersection of the planes of the back and base of a fully compressed seat and tangents of the mid-line contours of the seated man (see figure 11).

6.2.3 It should be emphasised that figure 20 is only an approximation to the truth, the trunk, for example, is by no means a rigid link and the spine is flexible in all three anatomical planes. The centre of rotation of the shoulder joint is by no means static; (see figure 22) the shoulder girdle clavicle and scapula, (or 'collar bone' and 'shoulder blade') are mobile with respect to the rib cage.

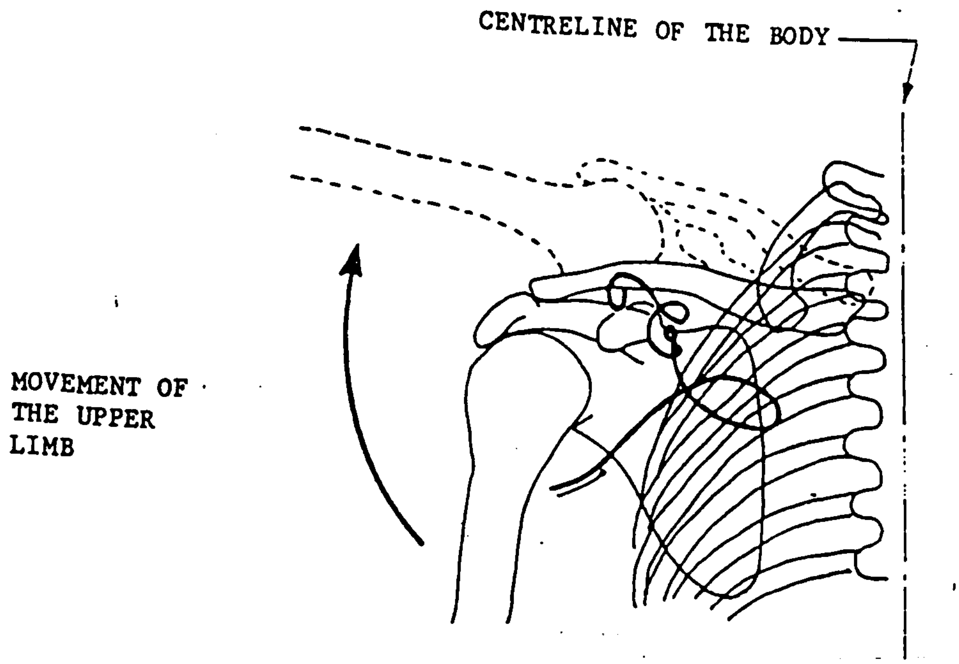


Fig 22: Path of Instantaneous Centre of Shoulder Rotation Showing a very Large and Erratic Pathway for Effective Centres

6.2.4 In using the link system to visualize the reaches possible with the limbs for a given posture, it must be remembered that the actual body joints are not simple centres of rotation, and that some of the body links are by no means rigid (for example, the shoulder joint is not positively located at the upper end of a rigid upper trunk link - see figure 22). Also the possible range of joint movements are dependant on the joint, and that muscular movements of one link about another may vary considerably, not only with the angular disposition of the links, but also with the postural relationships of adjacent links. Thus postures and reach possible with a manikin (see clause **6.3)** may be of little or no practical significance for the man. Computer man models may provide better approximations than manikins (see clause **6.3).**

6.2.5 The designer should bear these limitations in mind. The model would, for example, make a highly conservative estimate of a reach envelope and is of great value when considering the interaction between working posture and workspace (refer to para **7.1** Working Posture and also Defence Standard 00-25 Part 4: Workplace Design.

6.3 Manikins

6.3.1 Two dimensional cut-outs or "manikins", representing the human form and realistically articulated, are used by many designers as an aid to thinking at the drawing board. Detailed drawings from which such manikins may be constructed have been published by Dempster and elsewhere. They may be constructed to represent individuals of average bodily proportions and various statures. (They should not be thought of as representing an 'nth percentile person", since nobody can be nth percentile in all dimensions). Certain manufacturers of drawing instruments market design manikins both flat and three dimensional some of which are very strangely proportioned; it is advisable to check their dimensions against table M. A well made set of drawing board manikins will quickly repay the effort of their construction. They can be usefully supplemented by cut-outs for helmets, boots, gloves, parachutes, etc.

6.3.2 There is now an increasing use of computer based anthropometrics models, by means of which, hypothetical workspace geometries may be evaluated against stored sets of anthropometric data. Reductions in the price of computer hardware (particularly graphics terminals) allows the widespread distribution of standard software packages for such purposes. The use of computer models take much of the drudgery out of anthropometrics and free the ergonomist and designer for the more creative pursuits of their respective crafts. Computerised man-models which are available are:

SAMMIE (UK)	System for Aiding Man-Machine Interaction Evaluation
JACK (USA)	Computer Graphics System for Man-Machine Interaction Evaluation
COMBIMAN (USA)	Computerised Biomechanical Man Model

Many other computerised man-models are available which are already incorporated in CAD systems and others are under development. The designer will have to decide which model offers the best overall solution to his requirements. However, the computer model should be used in conjunction with trials using full-scale mock-ups and subject representing the critical anthropometric dimensions of the target population. (See clause **3.4.2).**

Section Six. Posture and Body Anthropometics

7 Definiton

For the purpose of this Part of this Standard, posture is defined as the orientation of the parts of the body with respect to each other and to the immediate physical environment.

7.1 Working posture. Relationships between the dimensions of the operators and those of their workspace determine the posture in which they ultimately have to perform their task. Thus by applying anthropometric data at an early design stage a satisfactory working posture for operators, of non-standardized dimensions will be achieved.

Note: Poor or inappropriate posture leads to discomfort, fatigue and inefficiency; if prolonged, it may be sufficiently damaging to render the operator unfit for duty. (Although it cannot be proved that poor posture is solely responsible for any specific disease, it is certain that an existing disorder will be severely accelerated by a working posture which stresses the affected part of the body.) (eg, RSI).

Further information on posture and the recommended forces that can be applied are given in Defence Standard 00-25 Part 3: Body Strength and Stamina.

7.2 Body position

7.2.1 Many human dimensions vary with posture or body position. To standardize and compare, the anthropometrist usually requires specific, erect positions rarely assumed by people at work or at rest. Because few people normally stand or sit completely erect, “normal” standing height, sitting height, and eye height involve ‘slump’ and are thus significantly less, than when measured with the body erect. Standing height is shorter than prone or supine length. Hip breadth and waist depth are larger in the seated than in the standing position. Most dynamic dimensions are altered by body movement, thus maximum arm reach with free movement of the shoulder or trunk is much greater than with the shoulder and trunk restrained.

7.2.2 The complexity of the anatomy and mechanics of the human body is such that the prediction of a complete workspace envelope is scarcely possible from a knowledge of the structure and function of the component parts. The empirically determined envelope represents the ultimate limits of a persons’ reaching capacity and requires the adoption of extreme postures. These postures cannot be maintained for any length of time, and therefore are not suitable for the performance of any but the lightest manipulative tasks.

7.3 General recommendations concerning working posture

7.3.1 Wherever possible mobility in the workspace should be encouraged, by giving the operator room to stretch and fidget. Placing continuous mechanical loading on any part of the body should be avoided (see Defence Standard 00-25 Part 4: Workplace Design and Part 5: Stresses and Hazards). These goals, however, may be impossible to achieve due to overriding necessity for restraining harnesses, limited headroom etc, but an individual’s working posture is one of the factors which determine the forces which he maybe expected to exert in the execution of his task (see Defence Standard 00-25 Part 3: Body Strength and Stamina)

7.3.2 The relative advantages of standing and sitting working postures, although elementary, are often ignored. They should be considered at the outset, as should the possibility that a work-station could be devised which would allow the operator to stand or sit as he pleased during his period of duty.

SITTING on a purpose built seat provides a stable base of finely controlled manipulative activities, especially in situations where the working area is itself subject to vibration or acceleration; is restful to the operator and allows the use of a greater number of control devices, eg pedals.

STANDING allows mobility, and the application of large forces by the operator (provided he has adequate working clearance and “footing”.

A variety of mobile seats in a static workplace can be devised which give the seated operator many of the advantages of a standing position.

7.4 Causes of postural stress

7.4.1 Individuals differ greatly in their response to a given postural stress. A stooped position or badly designed seat (eg a seat causing too high a pressure in the invertebral discs) which are scarcely noticed by one person may be cripplingly painful for another. Bad working posture may interact with other stresses, eg sub-optimal environmental conditions, mental workload, operational hazard or poor general health. The nature of these interactions can be very complex.

7.4.2 The following causes of postural stress may be identified.

(a) The need to maintain one or more unsupported parts of the body against the force of gravity. This occurs, for example, when the arms and hands must be held away from the body, either forwards or to be the sides and above the head. Stooped working postures in which either the trunk or the head must be inclined forward are bad for this reason.

(b) Twisted or asymmetric postures. The operation of pedals from a standing position provides a particularly acute example of this problem, as do workspaces which require their users to have “eyes in the backs of their heads”.

(c) Postures in which joints must be maintained near to the limits of their ranges. "Cramped" or “stretched” positions place muscles and ligaments under tension and may restrict blood flow. In general, a posture which uses the middle third of a joint’s range is to be preferred. The ranges of joints, motion are discussed in Defence Standard
00-25 Part 3: Body Strength and Stamina.

(d) Excessive pressure on the surface of soft and fleshy parts of the body or overlying bony prominencies. This occurs frequently to the schialtuberosities of the buttock when sitting in poorly designed seats.

7.5 Areas of posture stress

7.5.1 Eyes, head and neck (standing or sitting work)

(a) Posture. Posture of the head and neck is generally determined by the visual requirements of the task. Forward tilting of the head leads to tension in the neck muscles which is painful (and potentially harmful if prolonged). The head should be as near vertical as possible. Focusing the eyes on close objects for extended periods causes eye strain.

(b) Equipment design features. Frequently used visual displays should be placed within an angle of 30 deg downwards from a horizontal line drawn at eye level, as shown in figure 23 and within 30° either side of the centre line. Minimum comfortable viewing distance is 500 mm; 700 mm is to be preferred. Displays should be bold enough and sufficiently well illuminated to be legible at this latter distance. It is desirable that important sources of visual information should be at similar distances from the eyes, since older operators experience difficulty in making frequent changes in visual focal length. Tilted work surfaces and raised reading stands are often helpful. (See Defence Standard 00-25 Part 6: Vision and Lighting, Part 7: Visual Displays and Part 10: Controls).

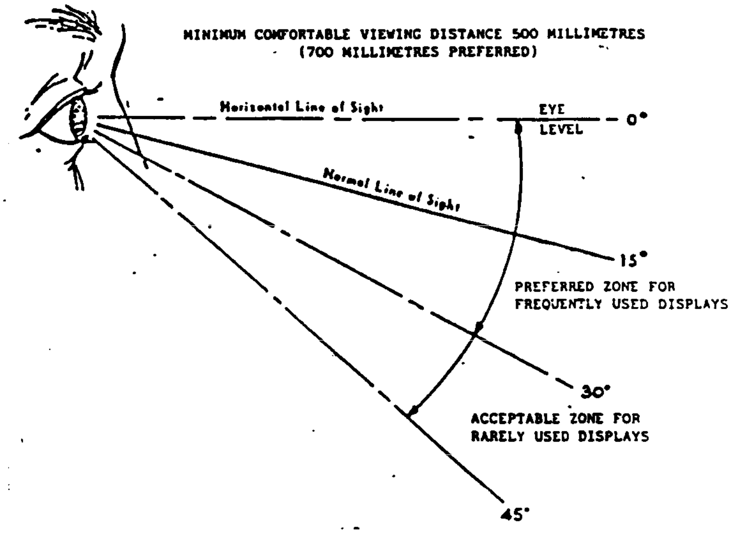


Fig 23: Line of Sight Parameters

7.5.2 Back (standing work)

(a) Posture. The operator should not be required to stoop for prolonged periods during standing work.

(b) Equipment design features. Controls and work surface placed too low or too far away cause stooping. The preferred work surface height for medium or light manipulative tasks is 50 - 150 mm below elbow level. For heavy work, a slightly lower surface is preferred (eg 150 - 250 mm below elbow level). Controls should preferably be at a height between the shoulder and the elbow, and should never be outside the arc described by the upper limb as it rotates about the shoulder. (The radius of the circle is the shoulder to grip distance and is shown in figure 24.

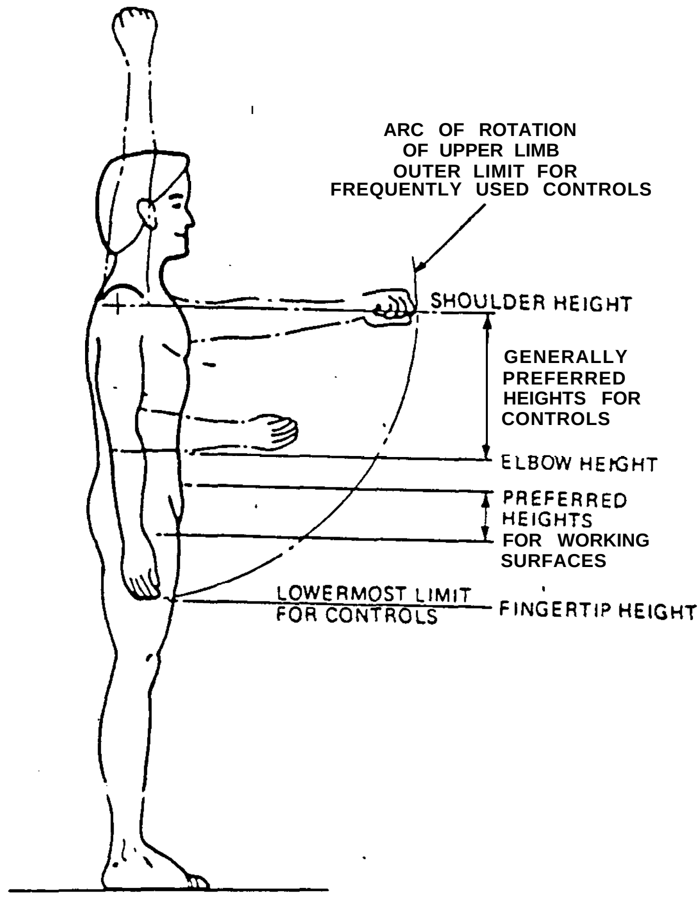


Fig 24 Functional Arc of the Upper Limb

7.5.3 Back (Sitting work)

(a) Posture. A variety of research evidence indicates that it is desirable to maintain a modest spinal curvature such that there is a slight concavity in the lumbar region (ie the “small of the back” approximately at waist level). Slumped sitting postures, in which the spine becomes convex to the rear lead to back strain; especially if the seat itself is subject to vibration (eg in a moving vehicle).

(b) Equipment design features. Working chairs and vehicle seats should provide positive support in the small of the back, or lumbar region (ie between the third and fifth lumbar vertebrae). For office or control working chairs at 8° - 10° backward tilt of the seat squab aids contact with the backrest (see example in figure 25). Inappropriately located vehicle pedals cause the operator’s pelvis to tilt backwards and slide forwards in the seat; this leads to slumped spinal posture (for correct positioning of pedals refer to Defence Standard 00-25 Part 10: Controls). A seat profile which produces only a low pressure in the invertebral discs and requires very little static muscular effort is also the one that causes the fewest aches and pains. When more and less discomfort is experienced it is evidently associated with greater stresses falling upon the discs and fatigue symptoms in the muscles. Opening out the angle between the seat and the backrest to 110° results in less electrical activity in the muscles and greater comfort (Grandjean).

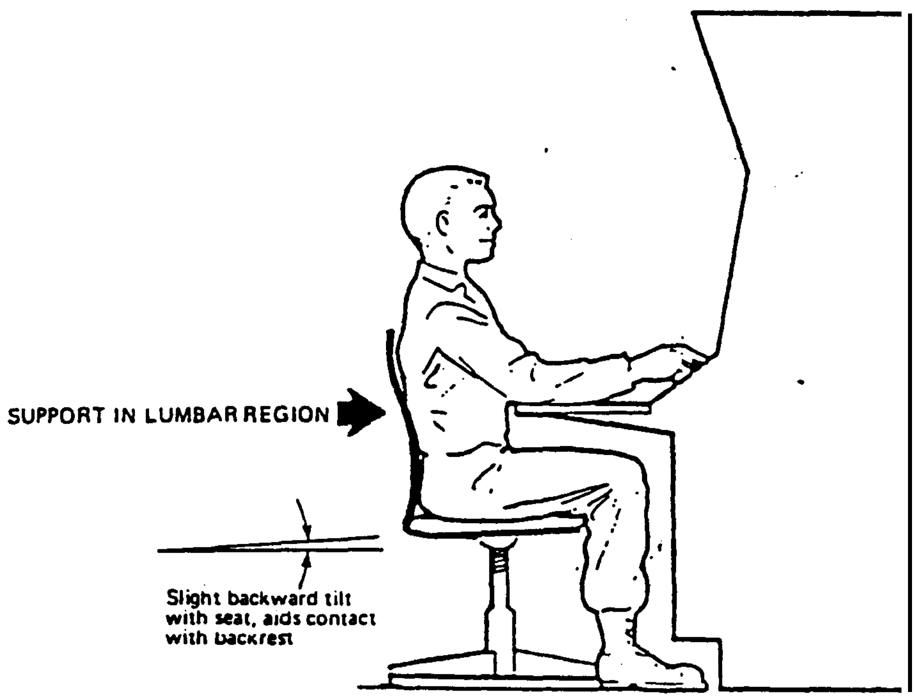


Fig 25: Seated Posture Support

7.5.4 Upper Limb (standing or sitting work)

(a) Posture. Shoulders should be relaxed and the upper arm should be as near vertical as possible. (If the forearm or hand are supported; the above considerations cease to be relevant.) The forearm should be approximately at right angles to the upper arm. Wrist joints should be close to the mid-points of their range of movement.

(b) Equipment design features. The range of adjustability of the heights of seats should allow operators of all sizes to position themselves correctly with respect to hand operated controls. Keyboards should be located close to the elbow height of the operator. Handles of tools etc, should conform to the natural angle of the wrist so that manual tasks are less demanding - see figure 26. In the design of many fine manipulative tasks, desirable posture of the upper limb may conflict with the visual requirements described above. Specially designed supports for the forearms may be required. Tilted work surfaces may also help to resolve this problem.

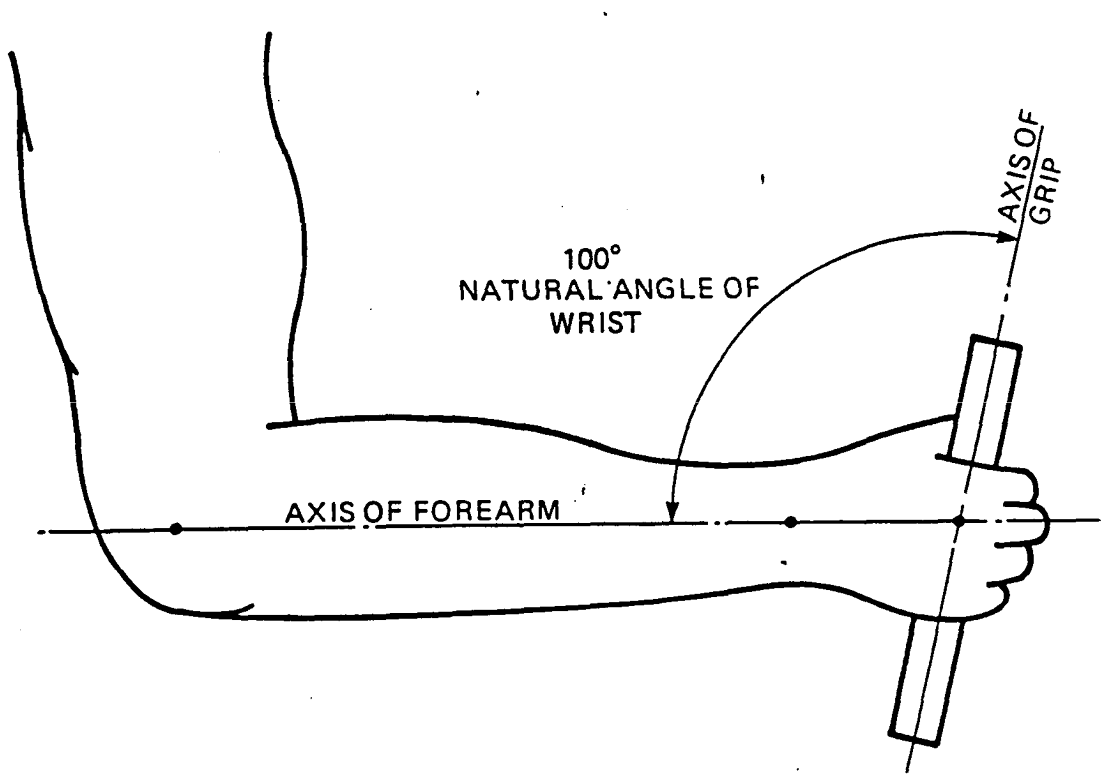


Fig 26: Functional Wrist Angle

7.5.5 Lower Limb (sitting work)

(a) Posture. The thigh should be horizontal or inclined slightly upwards (a maximum of 5° for a static position, and up to 15° for a vehicle/motion situation), with the thighs parallel to each other or slightly spread. The shank should make an angle of between 30° and 90° with the thigh. The trunk should be inclined at an angle of 105° - 110° with the thigh (110° - 130° with the horizontal), The sole of the foot would be at right angles to the shank (see figure 27). Also the buttock height should be higher than heel height.

(b) Equipment design features. Sufficient seat adjustability must be provided to allow all operators to achieve the above posture. A seat which is too high causes pressure on the underside of the thigh which may seriously impair circulation to the lower limb. Short operators may require footrests and a heel stop.) Pedal locations must be chosen with care. For further details of pedal design see Defence Standard Part 10: Controls.

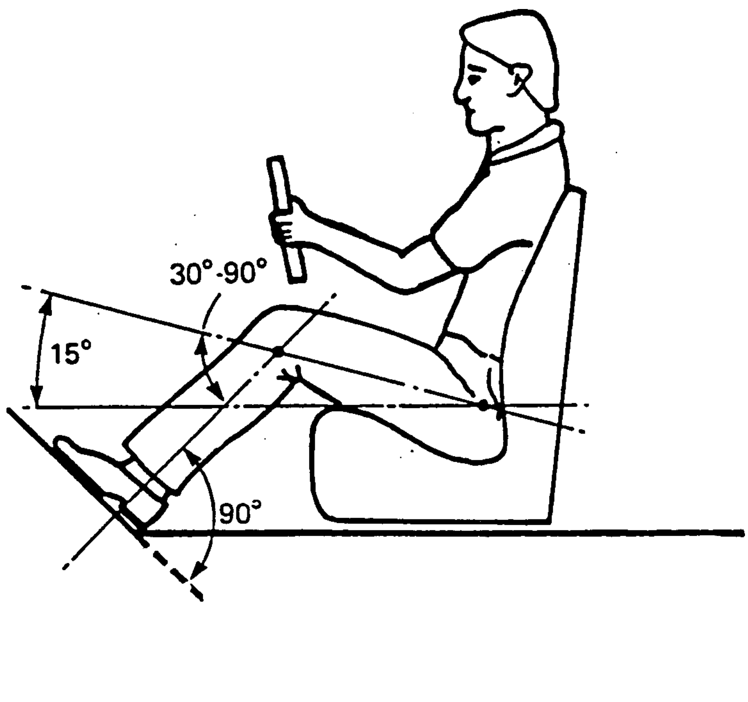


Fig 27: Functional Seated Posture

Section Seven. Design Procedure Check List

8 Definition

This Part of this Standard is a guide for the designer to use the anthropometric data systematically and effectively, in order to accommodate a target population for design application. A suitable procedure check list is as follows:

(a) Define the target population.

(b) Locate sources of data for your target population or for the nearest reasonable equivalent (refer to Annex B).

(c) Establish the critical dimensional constraints, ranking them in order of importance. Consider: Clearance, Reach, Working Posture etc and consult ergonomists at the early stages of the design process to establish what effect the constraints might be on operator performance.

(d) Decide on the percentile range of the target population to be accommodated. If however the User is forced to exclude more, the ergonomist should be consulted to recommend a reduced percentile range to be accommodated in the User’s requirement, and the designer should design accordingly.

(e) Select necessary anthropometric data, adding increments for clothing and equipment.

(f) By interaction of design alternatives determine desirable workspace dimensions with reference to the above.

(g) Check that adjustment in one region does not cause problems in another.

(h) The ergonomist should where possible build a full-sized mock-up or utilise technology such as virtual reality to achieve the same end in operational clothing and simulating their workplace tasks.

Collation Page

Statistical Aspects of Anthropomentry

A.1 The patterns of variations of the majority of bodily dimensions conform quite closely to a statistical model known as the Gaussian, or 'normal' distribution. (Refer to Section 2 for a qualitative introduction to this concept). The Gaussian distribution describing any variable is characterised by two parameters:

The arithmetic mean (m) $\frac{\Sigma x_i}{n}$

The standard deviation (s) $= \frac{\sqrt{\Sigma (x_i - m)^2}}{n}$

Where:

x_i = an individual person's value of the variable
n = number of people upon whom measurements were made

A.2 The mean locates the 'centre' of the distribution and the standard deviation describes the extent to which values might be expected to deviate from the mean. Strictly speaking a distinction should be drawn between the parameters of a sample and those of the population from which the sample was drawn eg between the sample of aircrew measured, and the total number of aircrew in the Air Force. The larger the number of persons in the sample 'n', the more accurate will be the sample parameters as indicators of the population parameters.

A.3 If the mean and standard deviation of any variable is known then any percentile of interest may be calculated. Equations for calculating a selection of percentiles are given in table N. The accuracy of such calculations depends on the accuracy with which the parameters are known and on the extent to which the distribution is truly normal.

Table N
Equations for Calculating Percentile Values from the Mean and Standard Deviation

0.5 %le = m - 2.58s	75th %le = m + 0.67s
1st %le = m - 2.33s	80th %le = m + 0.84s
2.5 %le = m - 1.96s	85th %le = m + 1.04s
3rd %le = m - 1.88s	90th %le = m + 1.28s
5th %le = m - 1.65s	95th %le = m + 1.65s
10th %le = m - 1.28s	97th %le = m + 1.88s
15th %le = m - 1.04s	97.5 %le = m + 1.96s
20th %le = m - 0.84s	99th %le = m + 2.33s
25th %le = m - 0.67s	99.5 %le = m + 2.58s

A.4 Calculations of this kind enable the determination of the percentage of a population who would be accommodated by a particular workspace dimension or range of adjustability. The form of the normal distribution shows that the percentile values are increasingly widely spaced when moved away from the mean in either direction. Expanding design limits to include further percentiles is an increasingly costly endeavour. The percentile at which to stop, poses a question which has no hard and fast answer. Practice and precedent is in favour of designing from the 3rd to the 97th percentile and trusting to human adaptability to cope with residual mis-matches which might arise. Clearly there are cases where such a procedure would be unacceptable, in the case, for example, of an escape hatch (see **5.3.3).**

A.5 Consider now the problem of choosing design limits for several related workspace dimensions. In designing for the 3rd and 97th percentile values for the first dimension the 6% of individuals outside these limits are excluded. For each subsequent dimension <u>more</u> individuals are excluded. Operational constraints have forced the User to accept the smaller 5th to 95th percentile range for Main Battle Tanks (MBTs). However, an infantry vehicle was developed for the 3rd to 97th percentile range, otherwise too many men at the extremes of the user population are excluded particularly at the larger end.

A.6 The statistical calculations which would highlight just how many more individuals are excluded is complicated. It depends on the degree to which the bodily dimensions concerned are correlated with each other. a fuller treatment of these and other statistical matters will be found in Roebuck et al.

Sources of Anthropometric Data

B.1 RAF Aircrew

RAE Technical Report 730803 and 73137
DRA, Farnborough, Hants
An Anthropometric Survey of 2000 Royal Air Force Aircrew 1970/1971

B.2 Army

This data was supplied by the Army Personnel Research Establishment, (now DRA, Centre Human Sciences), Farnborough, Hants. It was generated by combining the results of three surveys of 500 RAC Servicemen, 500 Infantrymen and 100 Guardsmen. These surveys have been published separately as:

(a) 1972 APRE Report 36/73
Anthrompometry of 500 RAC Servicemen

(b) 1973-74 APRE Report 17/76
Anthropometry of 500 Infantrymen

(c) 1977 APRE Report 37/76
A comparison of the Anthropometry of 100 Guardsmen with 500 Infantrymen,
500 RAC Servicemen and 200 RAF Aircrew

B.3 Roval Navy

(a) 1990 INM Report 18/90
An Anthropometric Survey of 1353 RN Personnel 1986-90

(b) 1990 INM Report 7/90
An Anthropometric Survey of 367 RN Airmen 1987-88

(c) 1990 INM Report 15/90
An Anthropometric survey of 136 Personnel of the WRNS 1986-90

(d) 1990 INM Report 17/90
An Anthropometric Survey of 431 RN Submariners 1986-1990

(e) 1990 INM Report 14/90
An Anthropometric Survey of 361 Royal Marines 1989

B.4 US Army

1989 Natick Report TR89/044
1988 Anthropometric Survey of US Army Personnel

B.5 Anthropometric Survey of UK Military Females (J E Aplin) 1995

B.6 Civilians

No extensive anthropometric surveys of British civilians have been conducted. Hence no data is listed in this Standard.

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List of Quoted References

C.1 HMSO

The MANPRINT Handbook

Ministry of Defence, London
MANPRINT draws together the six domains of Manpower, Personnel, Training, Human Factors, Engineering, System Safety and Health Hazard Assessment.

C.2 DEMPSTER W T

Space Requirements of the Human Operator
WADC Technical Report 55/159
Wright-Patteson Airforce Base, Ohio
Although old and difficult to obtain, it remains the definitive discussion of the concepts of body linkages. Contains detailed instruction for the production of drawing board manikins.

C.3 GARRETT J W AND KENNEDY K W

A Collation of Anthropometry (2 Vol)
AMRL-TR-68-1
Wright-Patterson Air Force Base, Ohio
An extensive collection of anthropometric data, both military and civilian, drawn from worldwide sources.

C.4 GRANDJEAN

Fitting the task to the Man
An ergonomic approach

C.5 LOVESEY E J

The Need for Improved Vision in Air Combat
Proceedings: Vision in Vehicles II, Nottingham

C.6 ROEBUCK J A: KROEMER K H AND THOMSON W G

Engineering Anthropometry Methods
John Wiley & Sons: New York
(The nearest thing to a textbook of anthropometrics existing at present.)

C.7 VAN COTT H P; KINKADE R G

Human Engineering Guide to Equipment Design
Joint Army - Navy - Air Force Steering Committee (USA)

C.8 HUMAN FACTORS FOR DESIGNERS OF NAVAL EQUIPMENT

Medical Research Council: Royal Naval Personnel Research Committee: Operational Efficiency Subcommittee.

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The following Defence Standard file reference relates to the work on this Standard - D/D Stan/328/l/2.

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DIRECTORATE OF STANDARDIZATION

MINISTRY OF DEFENCE

D Stan 4b, Room 1138,
Kentigern House, 65 Brown Street,
Glasgow, G2 8EX
Tel: 0141 224 2548
Fax: 0141 224 2503

Your Ref

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AMENDMENT NOTICE

Def Stan 00-25 (Part 2)/Issue 2

Human Factors for Designers of Equipment Part 2: Body Size

Amendment 1 (Revised Text)

This notice has been agreed by the authorities concerned with the use of the above Standard.

1 Page 22. Remove page entirely and insert new page.

2 Make a note of this Amendment in the Amendment Record.

G McBride
for Directorate of Standardization

Table D

Male Hand, Foot and Head Dimensions in Millimetres

Table D

		3rd Percentile						50th Percentile						97th Percentile					
		UK Aircrew		UK Non-Aircrew		US Army		UK Aircrew		UK Non-Aircrew		US Army		UK Aircrew		UK Non-Aircrew		US Army	
		Actual	Estim.	Actual	Estim.	Actual	Estim.	Actual	Estim.	Actual	Estim.	Actual	Estim.	Actual	Estim.	Actual	Estim.	Actual	Estim.
		1987	2000	1987	2000	1988	2000	1987	2000	1987	2000	1988	2000	1987	2000	1987	2000	1988	2000
23	Hand Length	181	181	176	178	177	179	196	197	193	195	193	195	213	214	210	212	213	215
24	Hand Breadth	79	79	78	79	83	84	88	88	86	87	90	91	96	96	94	95	99	100
25	Foot Length	245	245	243	245	246	248	267	268	265	267	269	271	289	290	289	292	296	299
26	Foot Breadth	89	89	87	88	91	92	98	98	97	98	101	102	107	107	106	107	111	112
27	Head Breadth	145	145	144	145	142	143	155	156	154	155	152	153	165	166	165	167	162	164
28	Inter pupillary distance	57	57	57	57	58	59	63	64	63	63	65	66	70	71	70	71	72	73
29	Pupil to Vertex	94	94	91	92	107	108	107	107	106	107	118	119	118	119	120	121	129	130
30	Tragion to Vertex (Ear centre to top of head)	118	118	117	118	120	121	130	131	129	130	131	132	142	143	141	142	142	143
31	Head Height	215	215	205	207	216	218	232	233	227	229	232	234	248	249	246	249	249	252
32	Head Length	187	187	186	188	184	186	201	202	199	201	197	199	214	215	211	213	210	212