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Civil Aircraft Airworthiness Data Recording Programme

A Study of Normal Operational Landing Performance On Subsonic Civil Jet Aircraft

by

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THE CIVIL AIRCRAFT AIRWORTHINESS DATA RECORDING PROGRAMME

A STUDY OF NORMAL OPERATIONAL LANDING PERFORMANCE ON SUBSONIC CIVIL JET AIRCRAFT

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SUMMARY

The object of the Civil Aircraft Airworthiness Data Recording Programme (CAADRP) is a systematic study of operational flight of civil transport aircraft. From 1964 to 1969 a small number of jet aircraft of various types were fitted with analogue trace recorders for the purpose.

A statistical study was conducted of a number of performance and flying control parameters on two aircraft types during final approach and landing. Approximately 200 landings from each of two periods with a gap of one year were studied on both aircraft types and the results show the probability of meeting or exceeding various values of each parameter together with mean values and standard deviations.

* Replaces RAF, Technical Report 72097 - ARC 34303
CAADRP Technical Report 26

CONTENTS

1 INTRODUCTION

The Civil Aircraft Airworthiness Data Recording Programme (CAADRP) is a project administered by the Royal Aircraft Establishment in collaboration with the Civil Aviation Authority and involves a small number of airlines and C.I.Data Centre Ltd. The object of CAADRP is a systematic study of the operational flight of civil transport aircraft. From 1964 to 1969 a small number of jet aircraft in regular airline service were fitted with analogue paper trace recorders to monitor various control surface and flight parameters. A sample of flight recording is shown in Fig.1 but clarity is slightly degraded from the original by photographic and printing processes employed in its production. The programme is fully described elsewhere[1,2].

The two aircraft types (designated Types D_1 and El) monitored during Stage 2 of the programme (1966 to 1969) were selected for a statistical study of a number of performance and flying control parameters with respect to the final approach and landing phases of flight.

The results give mean values and exceedance probability distributions. Values which occur in the average landing, shown by the 50% probability levels, may be compared with measurements from unusual occurrences or 'special events'. Special events involving hard landings are dealt with in an earlier report[3].

2 BRIEF DESCRIPTION OF AIRCRAFT

Both aircraft types had rear-fuselage mounted engines and high subsonic speed capability. Aircraft Type D_1 was the larger and had a longer flight range.

3 SCOPE OF STUDY

Approximately 200 flights from each aircraft type were selected from each of two periods of one year. The flights were selected such that they were evenly distributed throughout each period. (None was rejected for possessing abnormalities.) The first period ranged from August 1966 to July 1967 and the second period August 1968 to July 1969. A break of one year was introduced to highlight any trends due possibly to changes in operating procedures. The parameters measured are listed in Table 1.

4 RESULTS

Table 1 gives the approximate reading accuracies for each parameter and a summary of results for the two periods combined; the values of maximum, minimum, mean and standard deviation of each parameter for each aircraft type are

The distribution of probabilities exceeding given values of each parameter are plotted for aircraft Type D_1 in Figs.2 to 22 and for aircraft Type El in Figs.23 to 43 as listed in Table 1; in each case the vertical scale that is used is such that a Gaussian (or normal) distribution is represented by a straight line, Plotted on each graph for comparison are the results for each of the two individual periods sampled and for the two periods combined. A best fit line by eye is drawn through the 'combined' points. Cn each figure a panel is included which contains values of the maximum, minimum, mean, standard deviation and the sample size of each individual set of results in addition to the values for the combined period. Where the sample size for any parameter, except those involving multiple-impact landings, was smaller than the total for the period, omissions were entirely due to difficulties in analysis unlikely to be correlated with the phenomena being studied.

Matters of particular importance relating to certain items measured and points of interest revealed by the results are discussed in section 6 below.

5 ACCURACY OF EXTREME PROBABILITY ESTIMATES

Whereas the probability distributions are correct for the samples analysed, the accuracy could be expected to degrade at low probability levels in relation to more accurate assessments obtained from larger samples, the practical limit being the total number of landings recorded during the three years of Stage 2 CAADRP (i.e. approximately 1400 landings per year on aircraft Type D_1 and 2400 on Type E_1). Therefore the CG normal acceleration data from all hard landings gathered[3] by CAADRP on both aircraft types were included on the graphs of Figs.9, 10, 30 and 31. These show the peak CG accelerations at initial touchdown for levels of 0.8 Ag and above and provide a better estimate of the extreme conditions met in service.

6 OBSERVATIONS AND COMMENTS

In general little difference between the two periods sampled was evident on either aircraft type; the most significant being the CG normal accelerations at touchdown and during the landing run on aircraft Type D_1 (see 6.5 and 6.8 below).

6.1 Height and height rate

Height measurements on aircraft Type D_1 were obtained from the barometric instrument, the reading being relative to the level recorded during the landing run but static vent position error corrections were not made. The measurements on aircraft Type El were obtained from the radio altimeter. Therefore the quoted height of 150 feet refers to the height above the runway in the case of aircraft Type D_1 and to height above the ground level beneath the aeroplane in the case of aircraft Type E_1.

6.2 Glide slope, localiser and localiser rate

Below a height of about 200 feet the ILS (instrument landing system) zero signal lines often wander from the ideal glide path at many installations due to beam reflections from local terrain and man-made structures. Therefore the probability curves result from errors in both aircraft flight path and ILS zero signal positions in space. The proportion due to each is not known and the statistical analysis can only be regarded as of displacements of the pilot's indicator from the zero DDM (mid) position.

6.3 Flare initiation

The flare is the change in the aircraft's pitch attitude effecting a reduction in the descent rate during the final 50 feet (approx) of the approach aimed at producing an acceptably gentle touchdown.

The time of flare initiation was identified on the records by a sustained or progressive displacement of elevator producing a rise in pitch angle and CG vertical acceleration accompanied by a reduction in descent rate. Nevertheless the initiation of flare was not always clearly defined, particularly where this was applied gradually.

6.4 CG normal accelerations at initial touchdown

There was a notable improvement in the level of total peak accelerations at initial touchdown on aircraft Type D_1 in the second year period (see Fig.9). At levels exceeding 0.34 Ag (increment above 1.0g datum) with a probability of of 50% the improvement was 0.1 g rising to over 0.2 g at 2% probability.

The peak ground-forced accelerations at touchdown (i.e. the acceleration peak levels relative to the accelerations due to aerodynamic lift, see section 6.5 below) in the second year sample were improved similarly (see Fig.10), suggesting that the improvement was due to a decrease in descent velocity at the moment of impact. This may well be correlated with the 2 seconds (approx.) longer spent in the flare, shown by Fig.5 (which may indicate touchdown further from the threshold) and with a larger normal acceleration during the early part of the flare.

Aircraft Type El exhibited little or no change between the sampling periods (Figs.30 and 31).

6.5 Ground-forced CG normal accelerations

These are acceleration peaks generated by direct interaction between the ground and aeroplanes via the undercarriages at touchdown and at subsequent multiple-impact landings. On touchdown the peak ground-forced acceleration was obtained by subtracting the acceleration due to aerodynamic lift from the total peak level. The measured peak accelerations, however, included contributions (often significant) at higher frequencies, probably produced by excitation of airframe resonance modes which affect the accelerometer records up to the accelerometer system frequency response limit[3] (80% response occurred at 20 Hz on Type D_1 and 15 Hz on Type El). It was impracticable to separate these higher frequency components from the fundamental frequency in the large samples studied owing largely to the insufficient resolution of the records, but an attempt was made for hard landings in Ref.3.

The probability distribution of ground-forced accelerations (Figs.10 and 31) was very similar to the total acceleration distribution (Figs.9 and 30) for both aircraft types at initial touchdown (considering the two periods combined) confirming the high probability of landing initially with an aerodynamic lift of 1.0g (absolute) shown by Figs.8 and 29; whereas Ref.3 shows that hard landings occur with an average of about 1.1g (absolute) aerodynamic lift.

The acceleration due to aerodynamic lift at the second landing impact (see section 6.6) was generally 0.1 g less than at the initial impact (and would usually be even less at any subsequent impacts). This made the level of peak acceleration at the second impact at least as significant for undercarriage and fuselage structures as that at the first impact (compare Figs.10 and 16, and 31 and 37). Aerodynamic lift at the second impact was studied only for the second period sampled.

6.6 Multiple-impact landings

A multiple-impact landing is defined, for the purpose of this study, as one producing two or more CG normal acceleration peaks caused by the wheels of one or both main undercarriage units meeting the ground surface at different instants. Thus, during the periods separating each impact the aircraft may be either totally airborne or partly supported by one main undercarriage. Of the landings whose impacts are separated by periods of less than $1\frac{1}{4}$ seconds many will be of the latter type and others (particularly those with low accelerations) may not be displaying multiple impacts but heaving motions of the partially airborne aircraft upon its oleos. Any such cases in the data unavoidably contaminated the results as, at the current state of the art, these were not positively identifiable from the recordings.

Although some landings display a third impact and on rare occasions a fourth, for economy of analysis only the first and second impacts were studied.

The results are presented as a percentage of the number of landings which contained an identifiable second landing, except in Figs.17 and 18 where the smaller sample sizes quoted were as a result of some traces being unresolvable. The proportion of landings containing more than one impact were 52% and 28% in the two periods respectively on aircraft Type D_1; and 36% in each period on aircraft Type E_1.

6.7 Pitch rate just prior to nosewheel ground contact

The mean pitch rate during the two seconds prior to the nosewheel contacting the ground during each landing was measured (Figs.21 and 42). This mean value was measured instead of the rate at the instant of nosewheel impact, which would have been preferred, owing to the difficulty of measuring the slope of a curved line, often of poor clarity, at the discontinuity in slope produced by the nosewheel impact.

It was observed that some pitch rates were at constant rate over the last two seconds while others were decelerated to a low rate by the pilot pulling back on the elevator prior to nosewheel impact.

Therefore some measurements, and almost certainly most of the highest values, represented the rate at nosewheel impact and can be used for assessing nose undercarriage strength requirements.

6.8 Peak normal accelerations during landing run

The 'landing run' was the aircraft travel from the cessation of landing impact(s) to completion of deceleration to a taxi speed of about 40 knots, or to the termination of the flight record, whichever was the earlier. The flight record seldom terminated above an airspeed of about 60 knots.

Distributions are shown for aircraft Types D_1 and E_1 in Figs.22 and 43, respectively, for the probability of a landing run experiencing a single positive peak normal acceleration equal to or exceeding each of various levels and the probability of experiencing a single negative peak at various levels*. Since a measurement threshold at $\pm 0.20\ \Delta g$ was chosen only the distribution

In the case of aircraft Type D_1 (see Fig.22) there was a considerable improvement in the second year period over the results of the first. In the case of Type El (Fig.43) there was an insignificant change in the probabilities of meeting positive values and a small improvement of about 2 to 1 on the negative side.

The fatigue and ultimate load implications of extreme positive accelerations recorded during take-off on aircraft Type E_1 are dealt with in Ref.4.

7 CONCLUSIONS

A number of performance and flying control parameters on two aircraft types during the final approach and landing phases of flight were studied. The results show the values of the parameters that occur in the average case on each aircraft type, together with exceedance probability estimates with a fair degree of confidence down to about 5% probability. Below this level estimates are of doubtful accuracy and other data[3] should be used as appropriate. The analysis of larger samples should become feasible with the introduction of the projected computer processing of digital data from operational aircraft.

There was generally little difference in the results of the two periods sampled (above 5% probability) on either aircraft type, the most significant being the CG normal acceleration at touchdown on one aircraft type aircraft.

Acknowledgment

The author thanks Mr. L. Pocock and his staff of C.I. Data Centre Ltd. for their work in extracting the measurements from the flight recordings.

Param	›rox. reading; accuracy		Aircraft Type E₁			
	'an 'ror	Max error	Max	Min	Mean	Std. dev.
Glide slope de 150 ft (above	5	7	172	I	47	35
Glide slope de 150 ft (below	5	7	190	0	36	34
Rate of descer	2	3	28	6	13.2	3.1
Localiser devi	5	7	23	0	4	4
Localiser devi	l	2	3.7	0	0.5	0.6
Time from flar	l	5	14.3	2.7	6.8	2.0
Airspeed loss	2	4	26	0	12.6	5.0
CG normal acce first impact	.05	0.07	0.2C	-0.0ʕ	0.01	0.05
Peak CG normal at first impac	.05	0.07	I.18	0.0:	0.38	0.151
Ground-forced impact	.05	0.07	1.06	0.0;	0.36	0.15
Roll angle at	3	5	7	0	0.7	1.0
Pitch angle at	.5	1.0	9.8	1.8	4.5	1.2
Time from firs	l	I	3.0	1.0	1.5	0.4
CG normal acce second impact	.05	0.07	1.0	0.76	0.92	0.04
Peak CG norm. at second impa	.05	0.07	0.64	0.07	0.30	0.09
Ground-forced second impact	.05	0.07	0.75	0.12	0.41	0.12
Roll angle at	3	5	4	0	0.6	0.9
Pitch angle at	.05	1.0	8.4	0.9	3.6	1.3
Time from firs	l	I	1.9	1.3	4.3	1.7
Distance trave impact	50	500	:310	300	920	350
Mean pitch rat nosewheel impa	.5	1.0	4.5	0.3	1.4	0.6
Extreme positi increment abov	.05	0.07			-	-

* Second peri

REFERENCES

No.	Author	Title, etc.
1	The CAADRP Technical Panel	The Civil Aircraft Airworthiness Data Recording Programme. RAE Technical Report 64004 (ARC 26490) (1964)
2	E. Marjorie Owen	Achievements in recording and analysis of civil aircraft operations 1962-1969. ARC CP 1181 (1971)
3	The CAADRP Special Events Working Party Co-ordinated by G.B. Hutton	Hard landings encountered by subsonic civil jet aircraft. ARC CP 1182 (3970)
4	C B. Hutton	Uneven runways encountered by subsonic jet transport aircraft during scheduled airline operation. RAE Technical Report 72095 (ARC 34499) (1972)

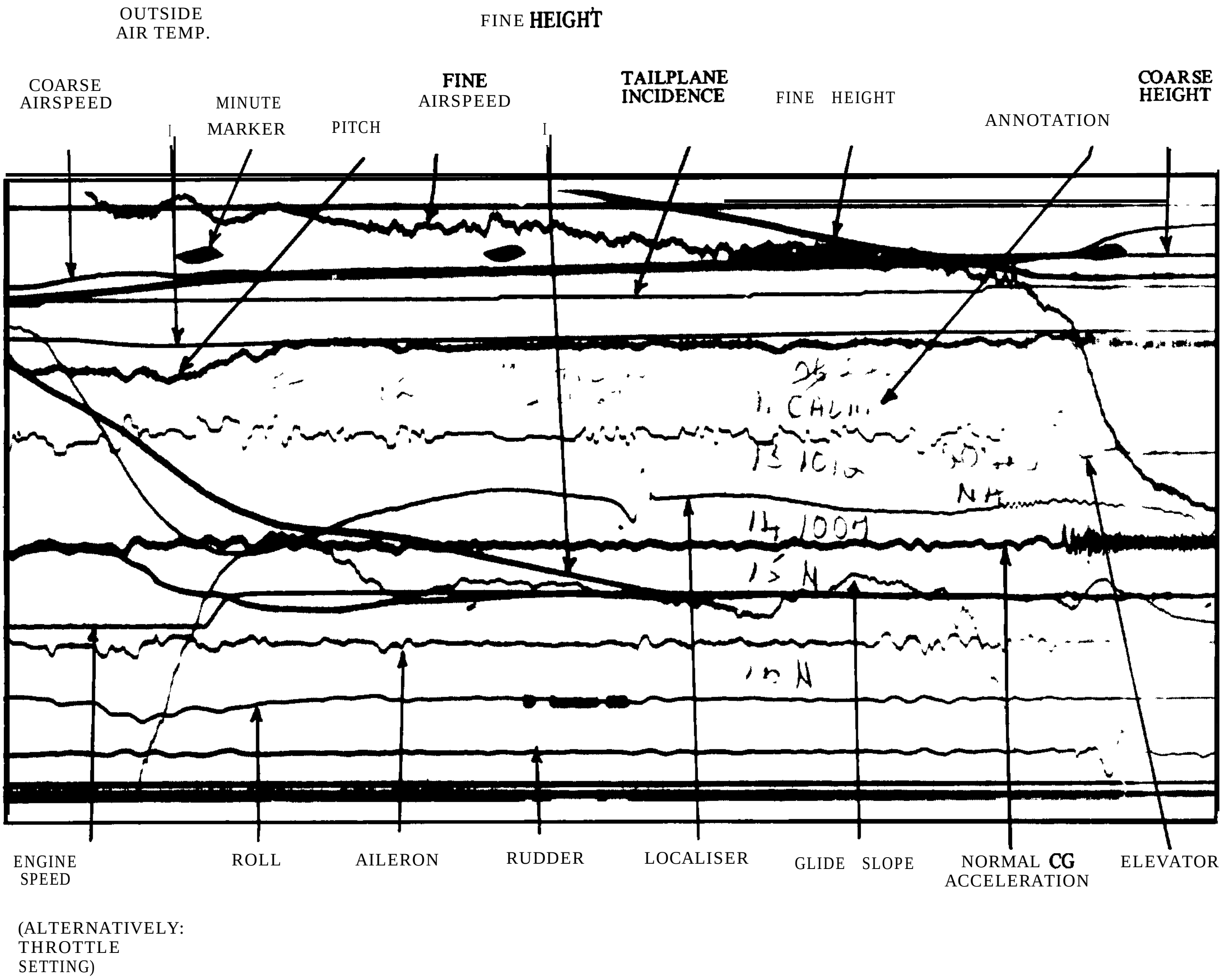
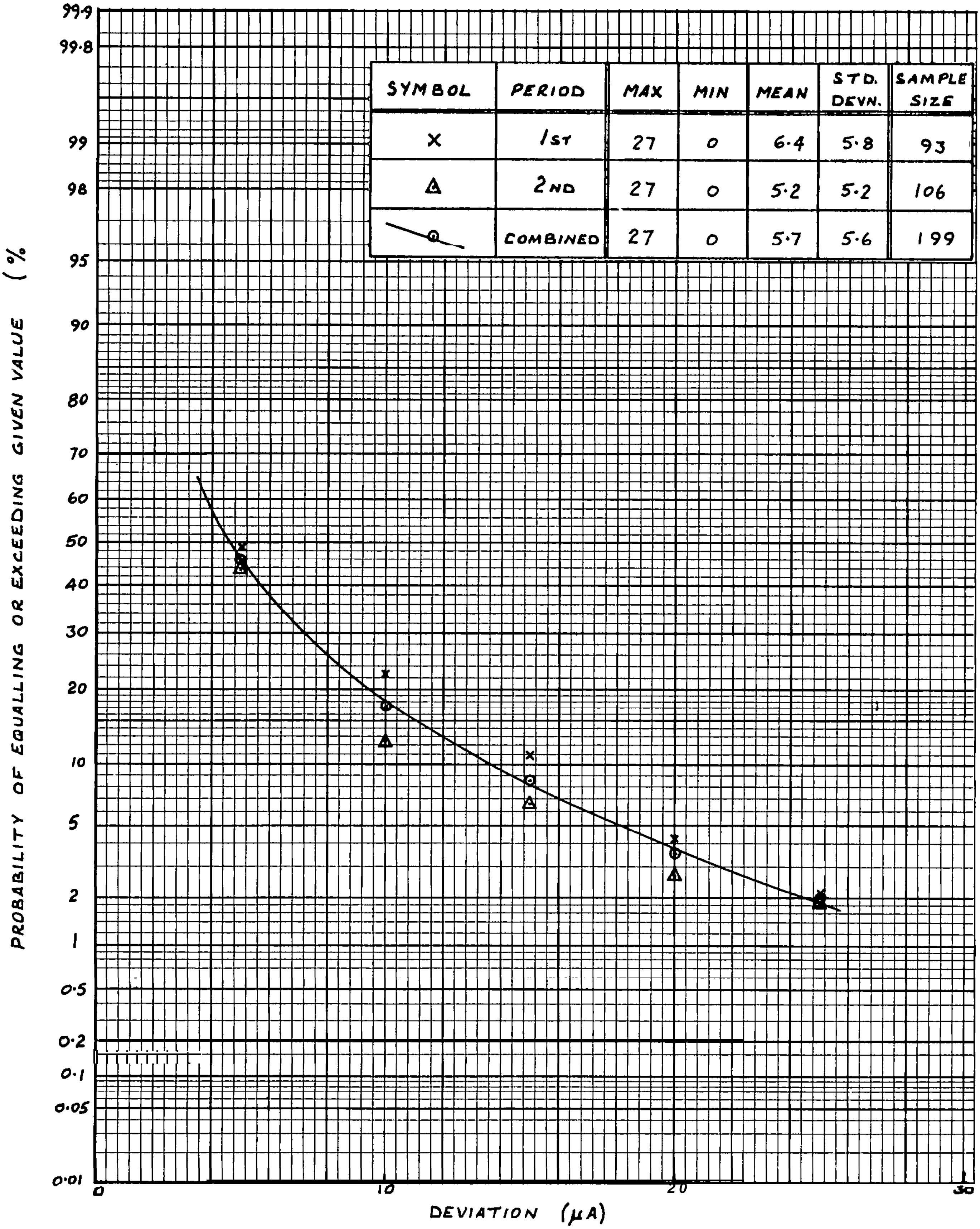


Fig.1. Sample record



SYMBOL	PERIOD	MAX	MIN	MEAN	STD. DEVN.	SAMPLE SIZE
×	1ST	27	0	6·4	5·8	93
Δ	2ND	27	0	5·2	5·2	106
—⊙—	COMBINED	27	0	5·7	5·6	199

Fig.4 **Localiser deviation from zero at a height of 150 ft**
Aircraft Type D_1

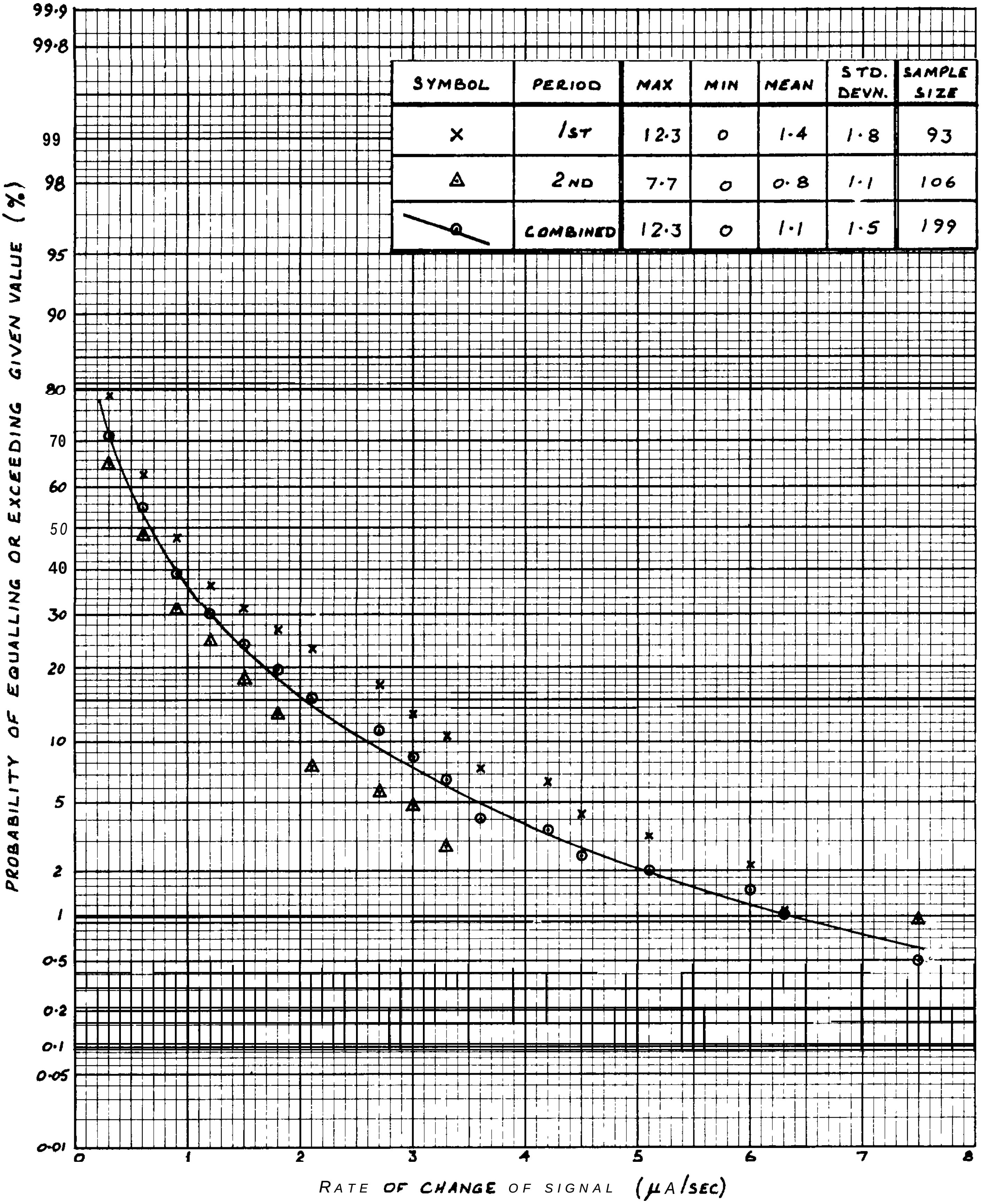
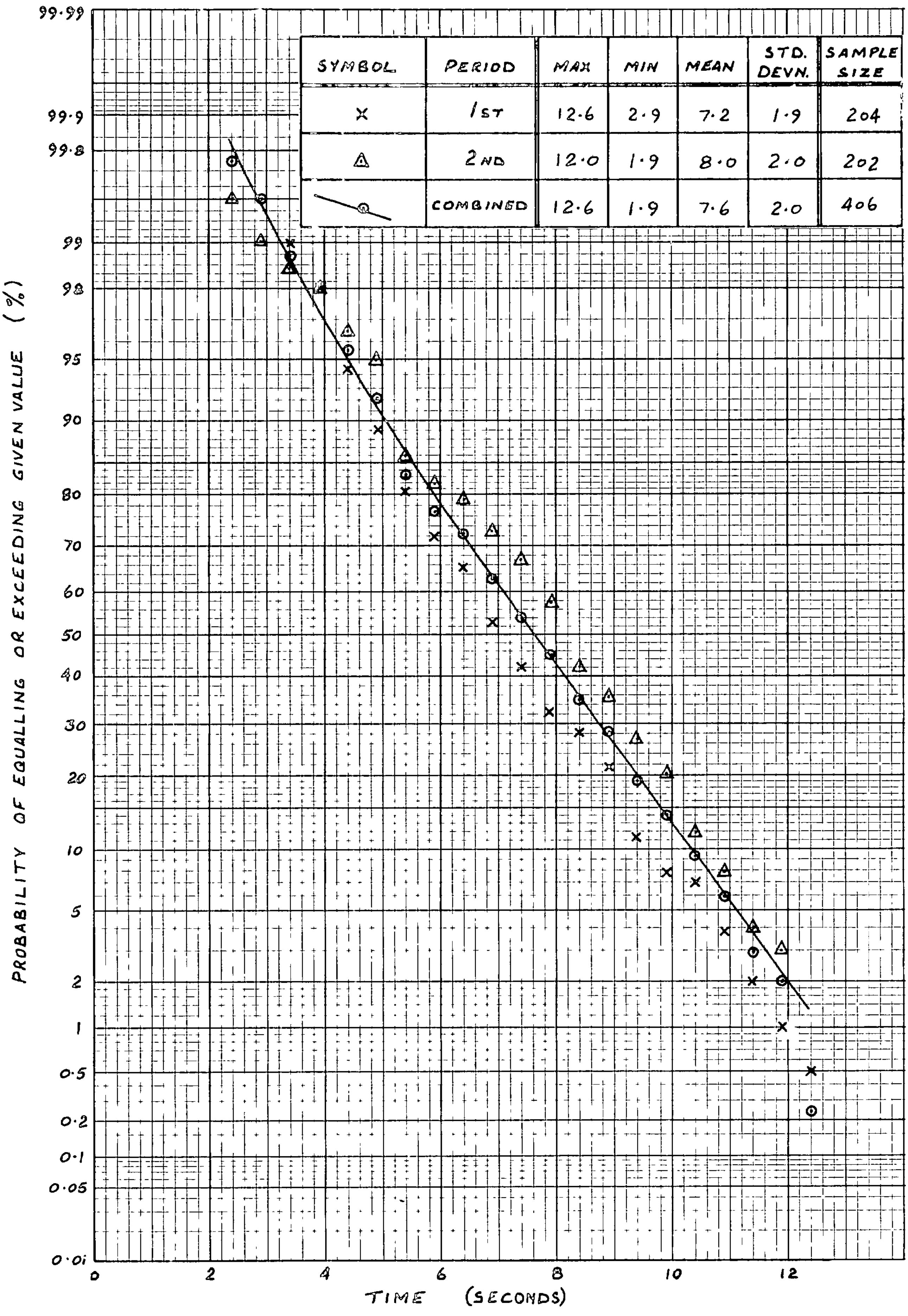


Fig.5 Localiser deviation rate at a height of 150 ft
Aircraft Type D_1



SYMBOL	PERIOD	MAX	MIN	MEAN	STD. DEVN.	SAMPLE SIZE
×	1ST	12·6	2·9	7·2	1·9	204
△	2ND	12·0	1·9	8·0	2·0	202
—⊙—	COMBINED	12·6	1·9	7·6	2·0	406

Fig.6 Time from flare initiation to touchdown
Aircraft Type D_1

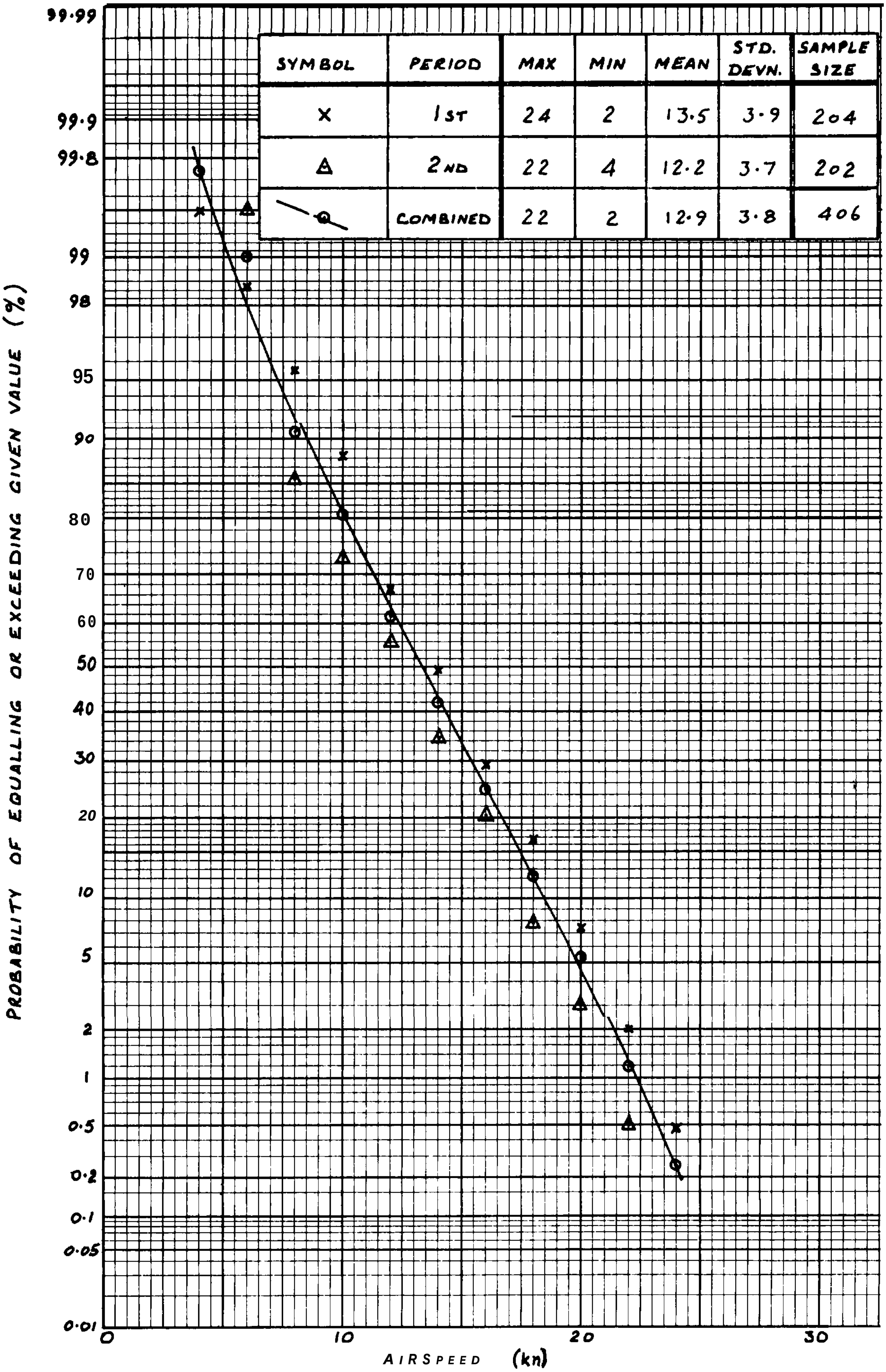


Fig 7 Airspeed loss from height of 150 ft to touchdown

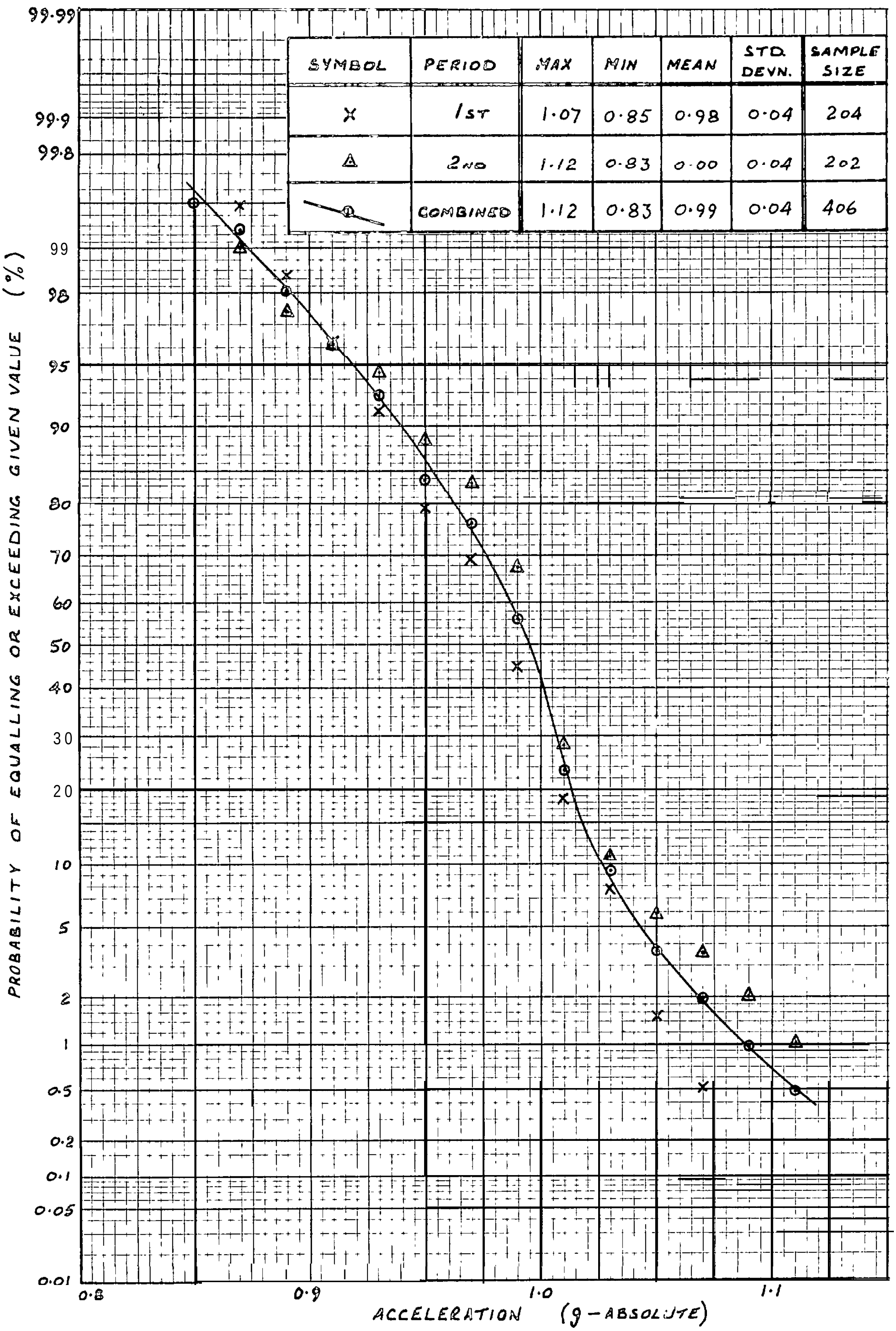


Fig.8 CG normal acceleration due to aerodynamic lift at first impact
Aircraft Type D_1

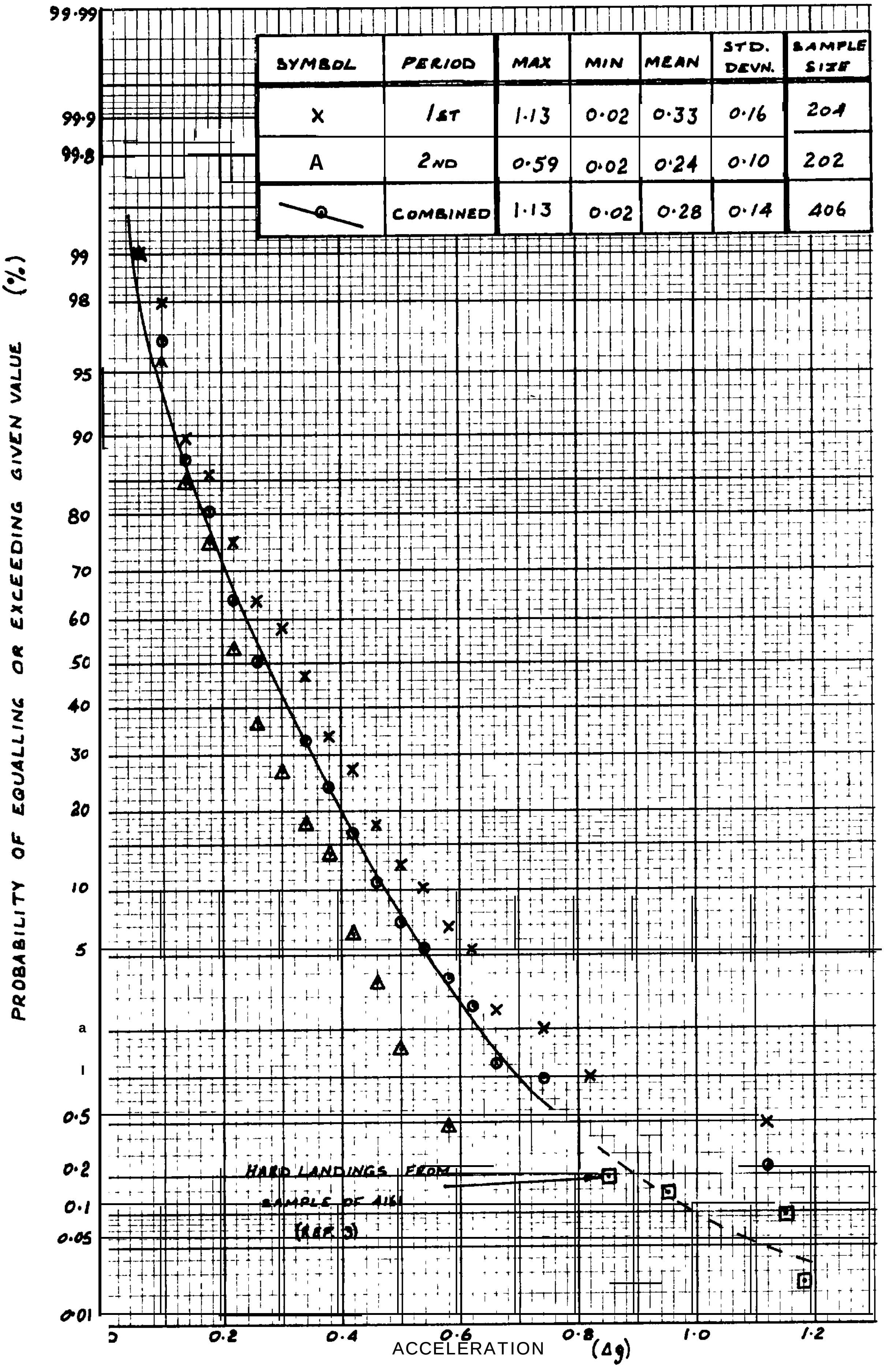


Fig.9 Peak CG normal acceleration increment above 1g datum at first impact Aircraft Type D_1

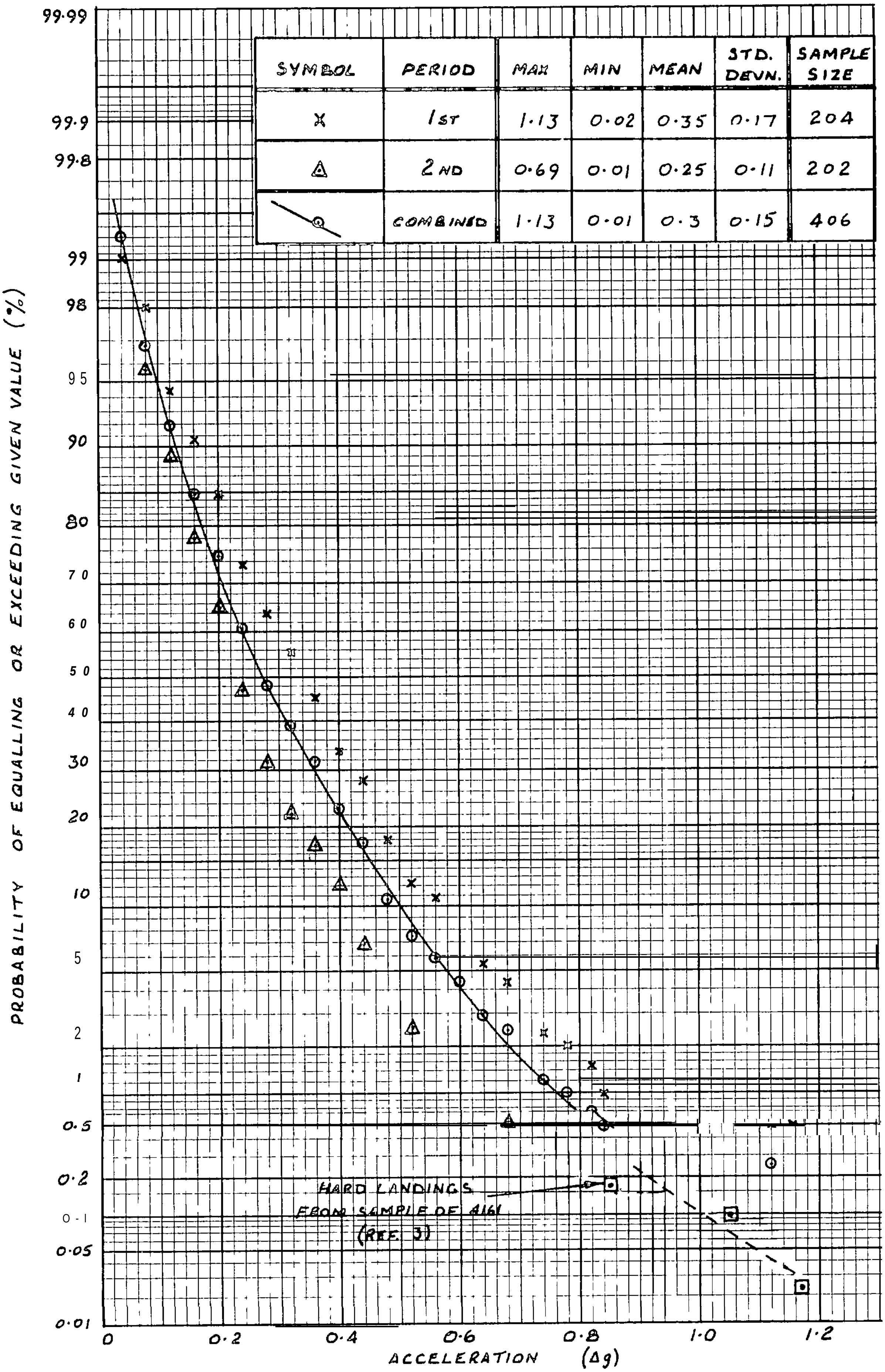
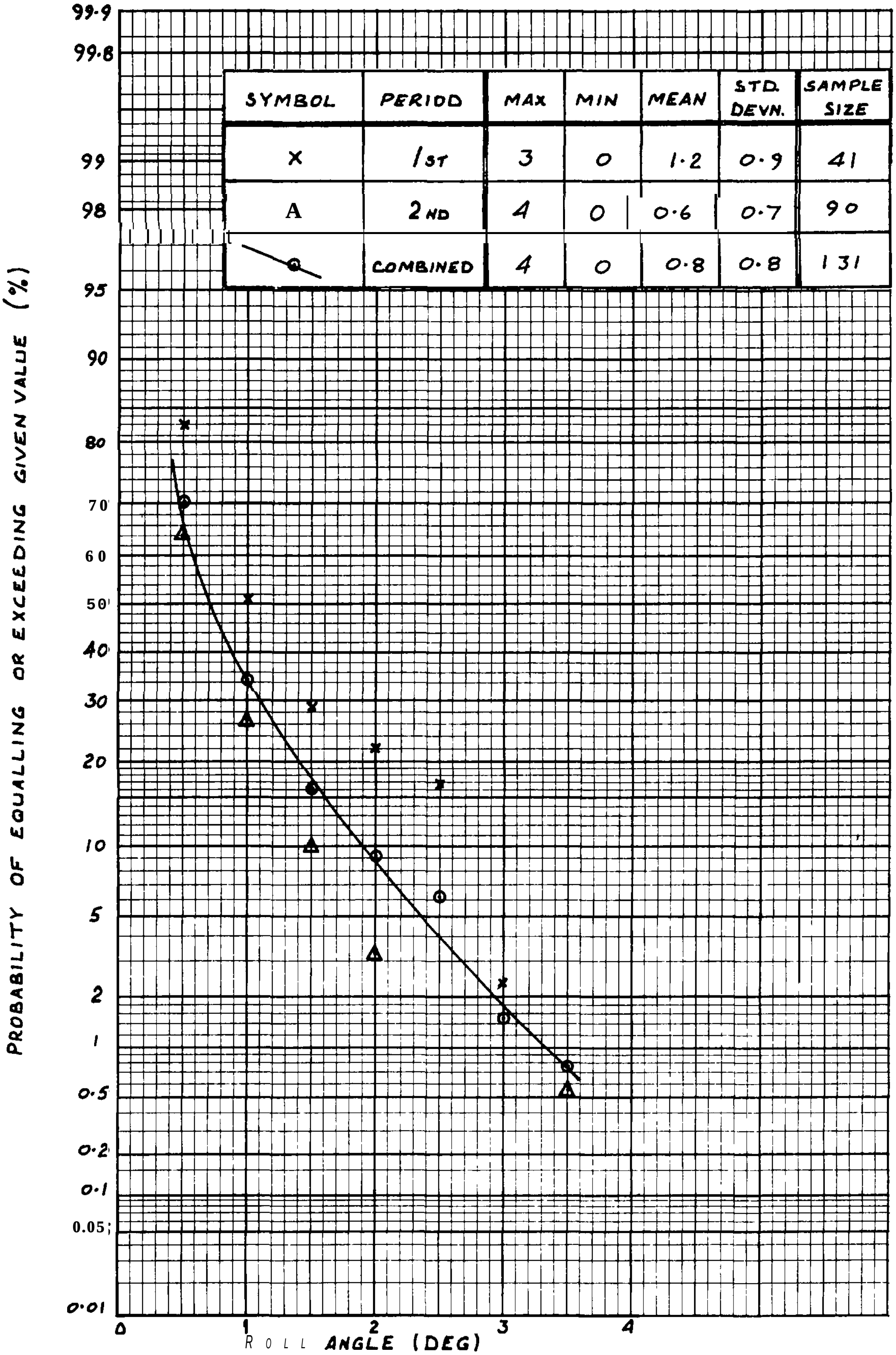
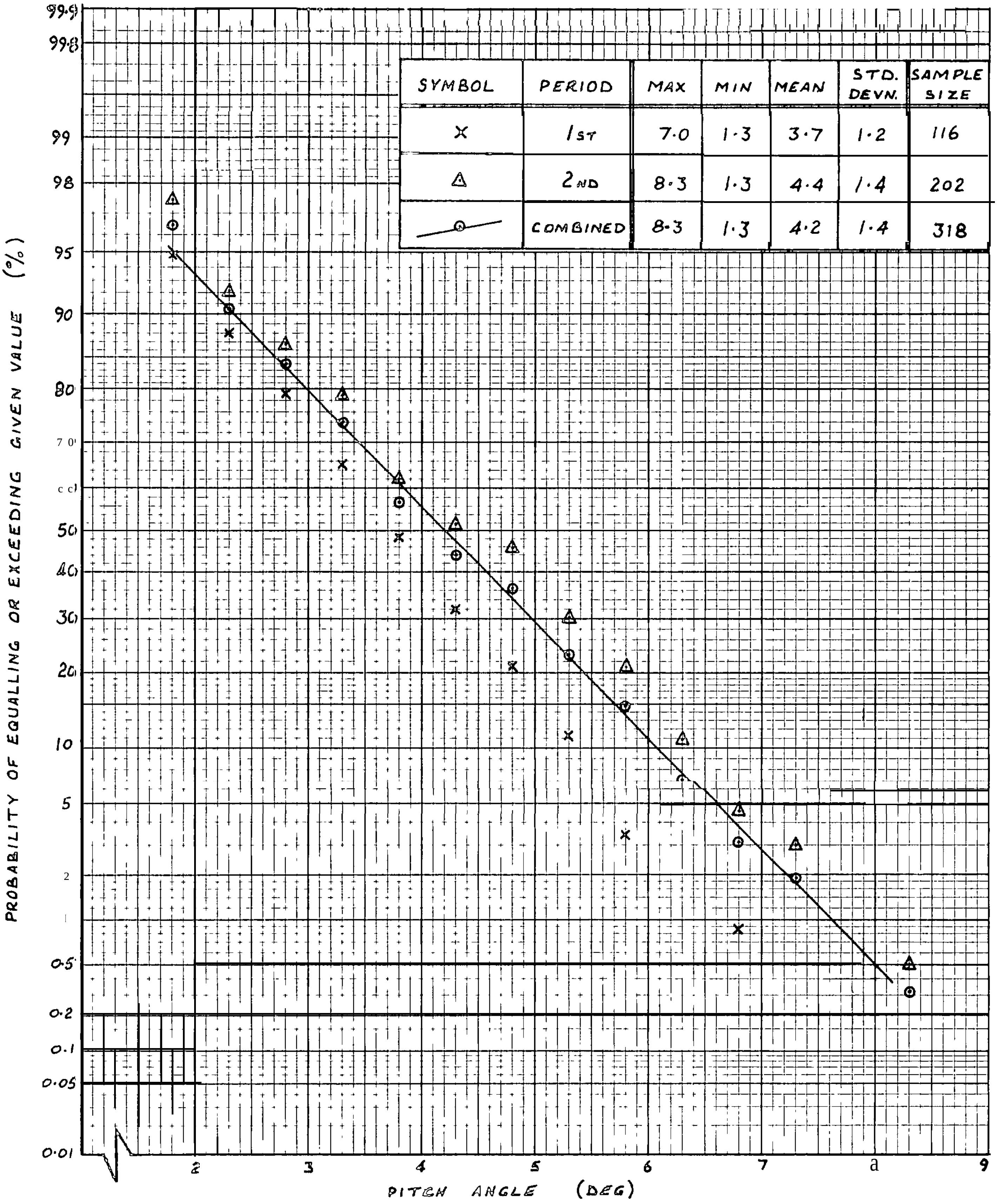


Fig.10 Ground-forced peak CG normal acceleration at first impact Aircraft Type D_1

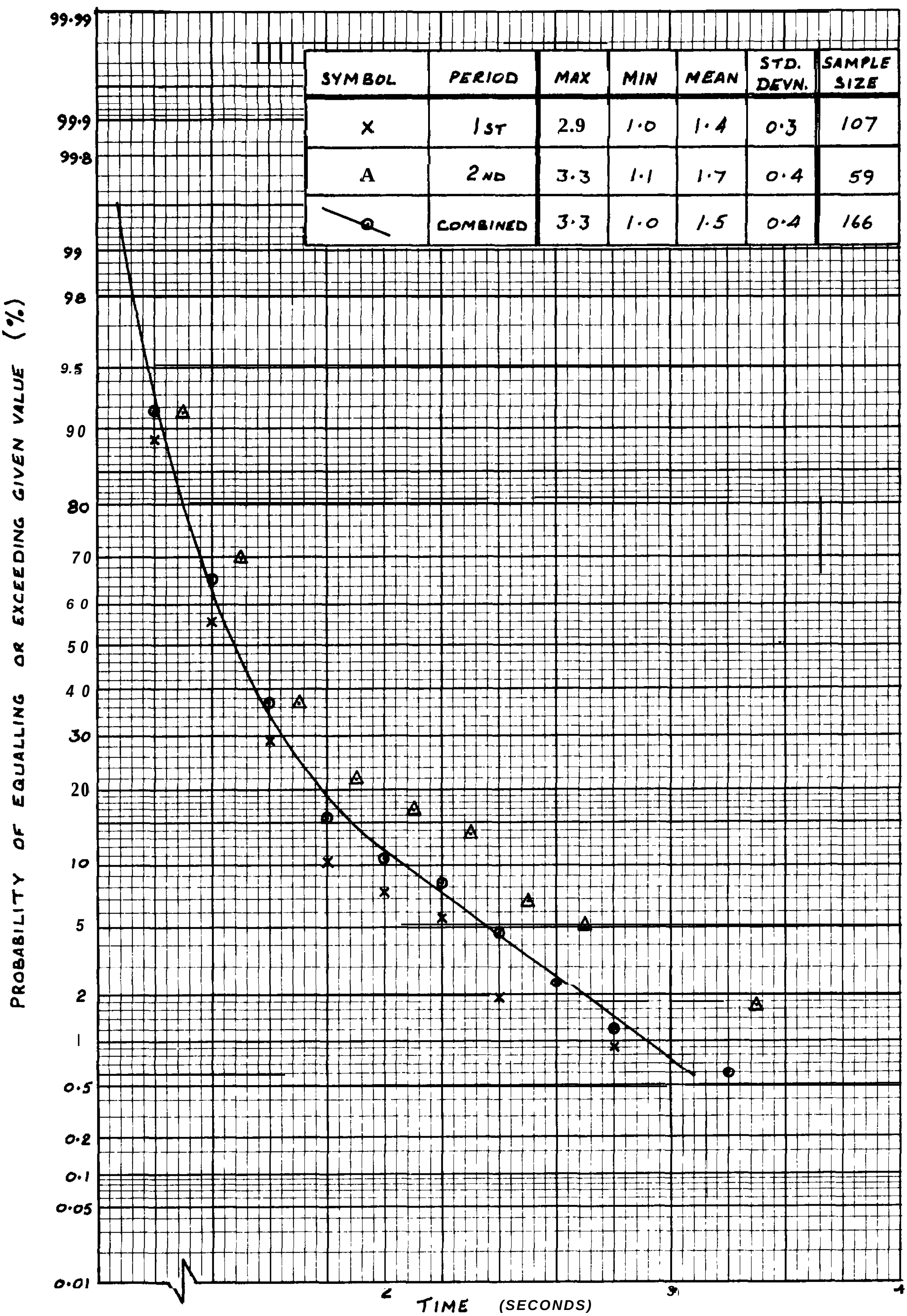


SYMBOL	PERIOD	MAX	MIN	MEAN	STD. DEVN.	SAMPLE SIZE
×	1ST	3	0	1·2	0·9	41
A	2ND	4	0	0·6	0·7	90
—⊙—	COMBINED	4	0	0·8	0·8	131



SYMBOL	PERIOD	MAX	MIN	MEAN	STD. DEVN.	SAMPLE SIZE
×	1ST	7.0	1.3	3.7	1.2	116
△	2ND	8.3	1.3	4.4	1.4	202
⊙ (line)	COMBINED	8.3	1.3	4.2	1.4	318

Fig.12 Pitch angle at first impact
Aircraft Type D_1



SYMBOL	PERIOD	MAX	MIN	MEAN	STD. DEVN.	SAMPLE SIZE
X	1ST	2.9	1·0	1·4	0·3	107
A	2ND	3·3	1·1	1·7	0·4	59
(line with circle)	COMBINED	3·3	1·0	1·5	0·4	166

Fig.13 Time from first to second impact
Aircraft Type D_1

PERIOD	MAX	MIN	MEAN	STD. DEVN.	SAMPLE SIZE
2ND	1·00	0·75	0·88	0·05	59

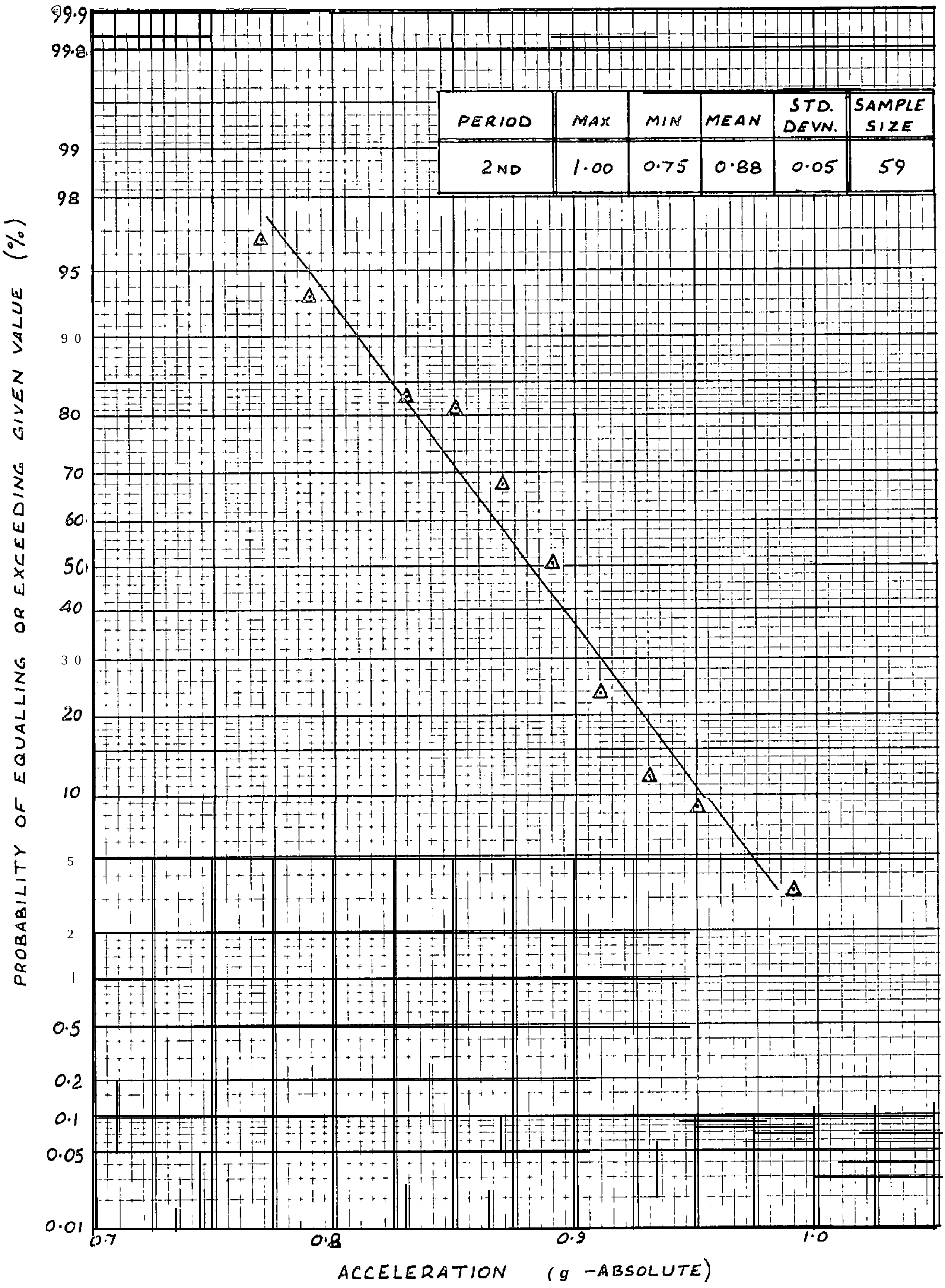
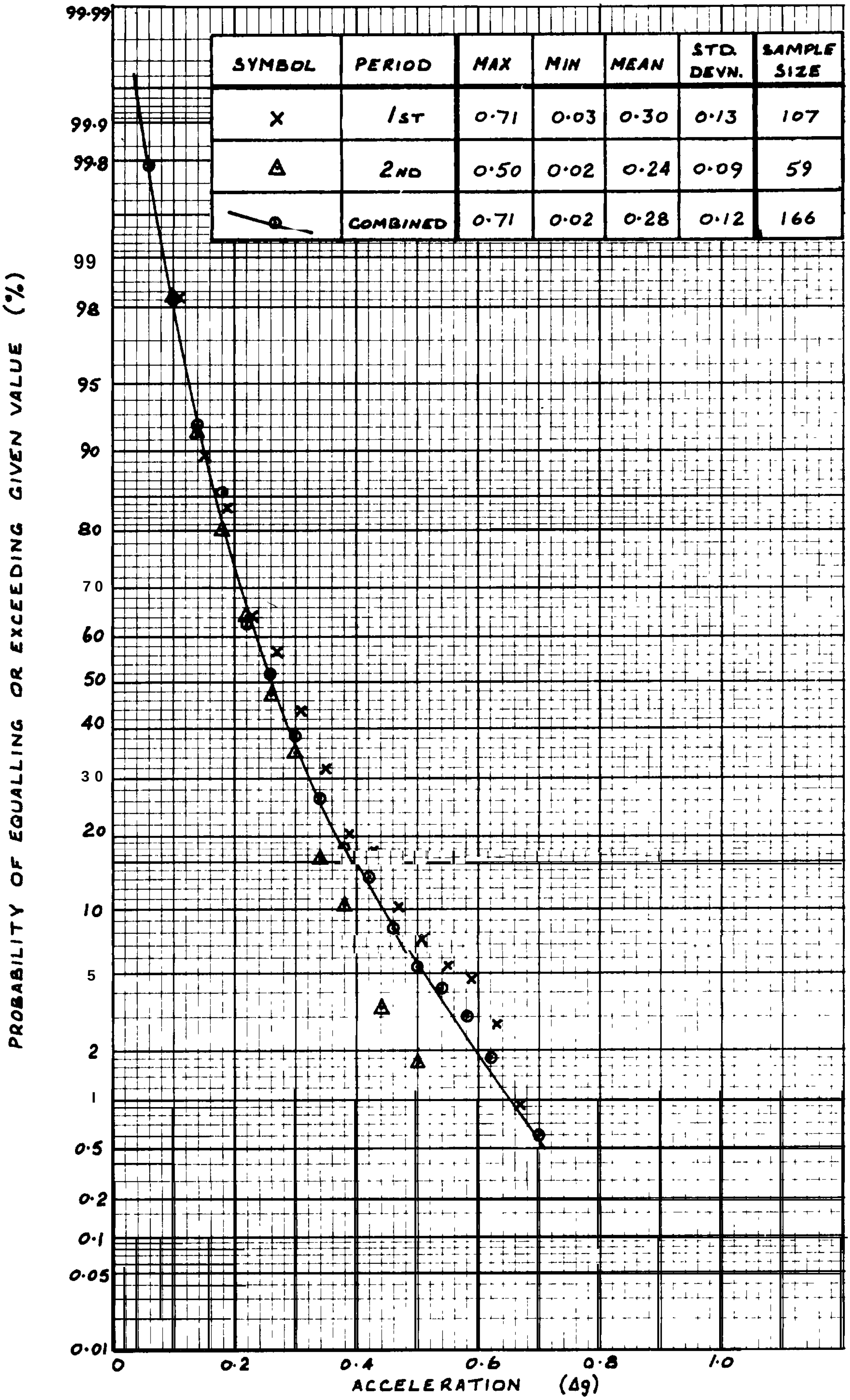


Fig.14 CG normal acceleration due to aerodynamic lift at second impact
Aircraft Type D_1



SYMBOL	PERIOD	MAX	MIN	MEAN	STD. DEVN.	SAMPLE SIZE
×	1st	0·71	0·03	0·30	0·13	107
Δ	2nd	0·50	0·02	0·24	0·09	59
—⊙—	COMBINED	0·71	0·02	0·28	0·12	166

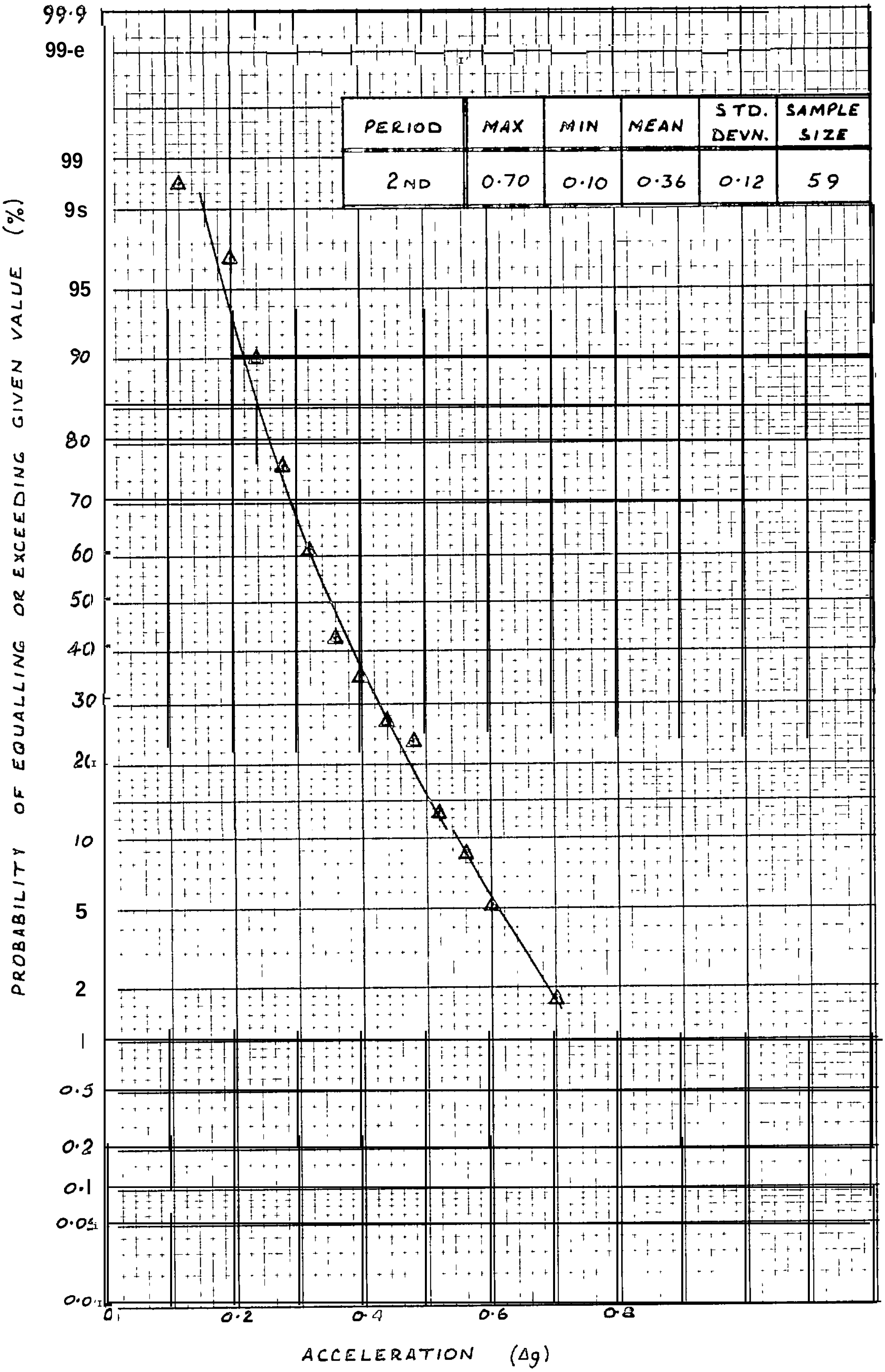
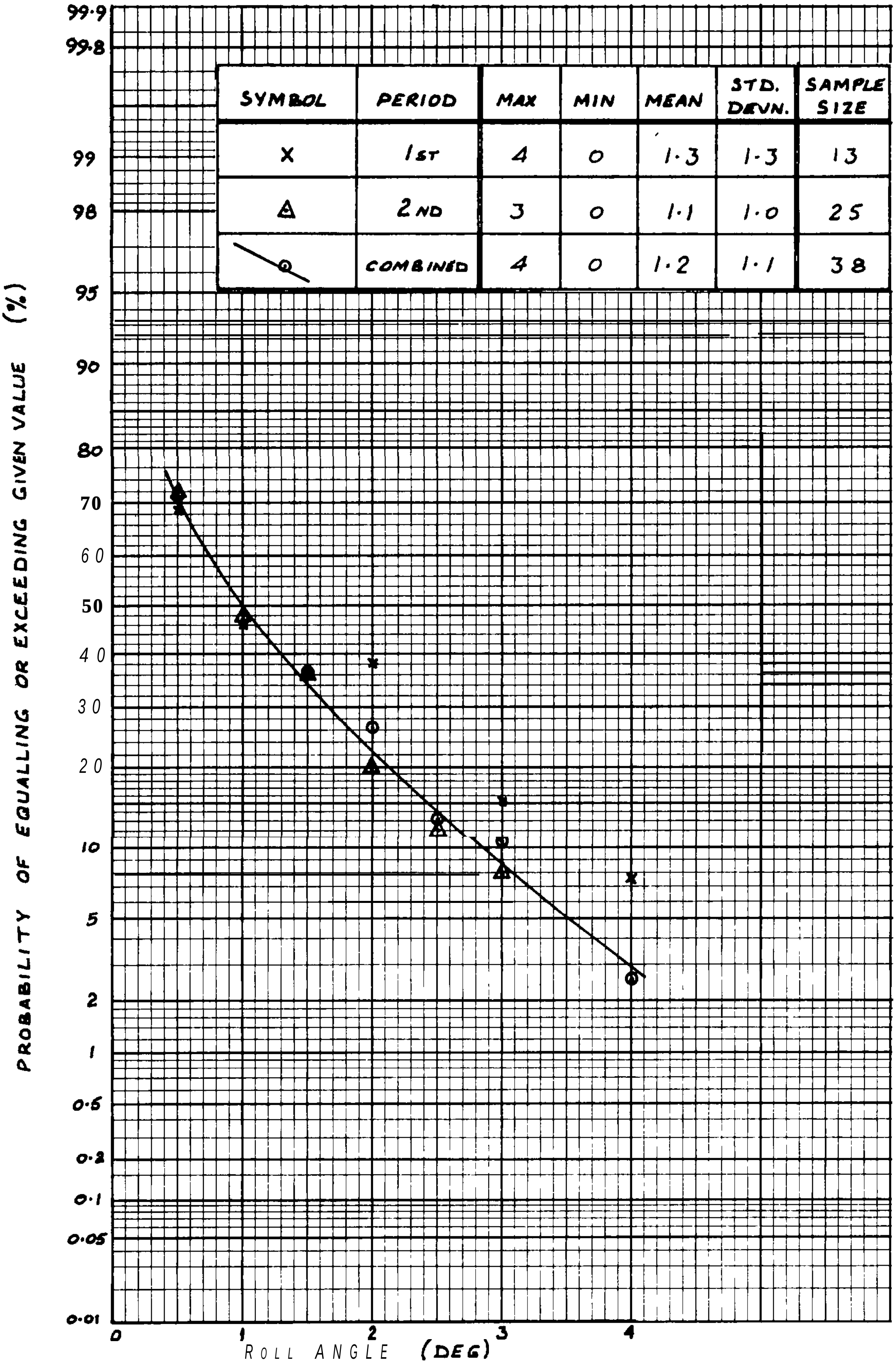


Fig.06 Ground-forced peak normal CG acceleration at second impact
Aircraft Type D_1



SYMBOL	PERIOD	MAX	MIN	MEAN	STD. DEVN.	SAMPLE SIZE
X	1ST	4	0	1·3	1·3	13
△	2ND	3	0	1·1	1·0	25
—⊙—	COMBINED	4	0	1·2	1·1	38

Fig.17 Roll angle at second impact
Aircraft Type D_1

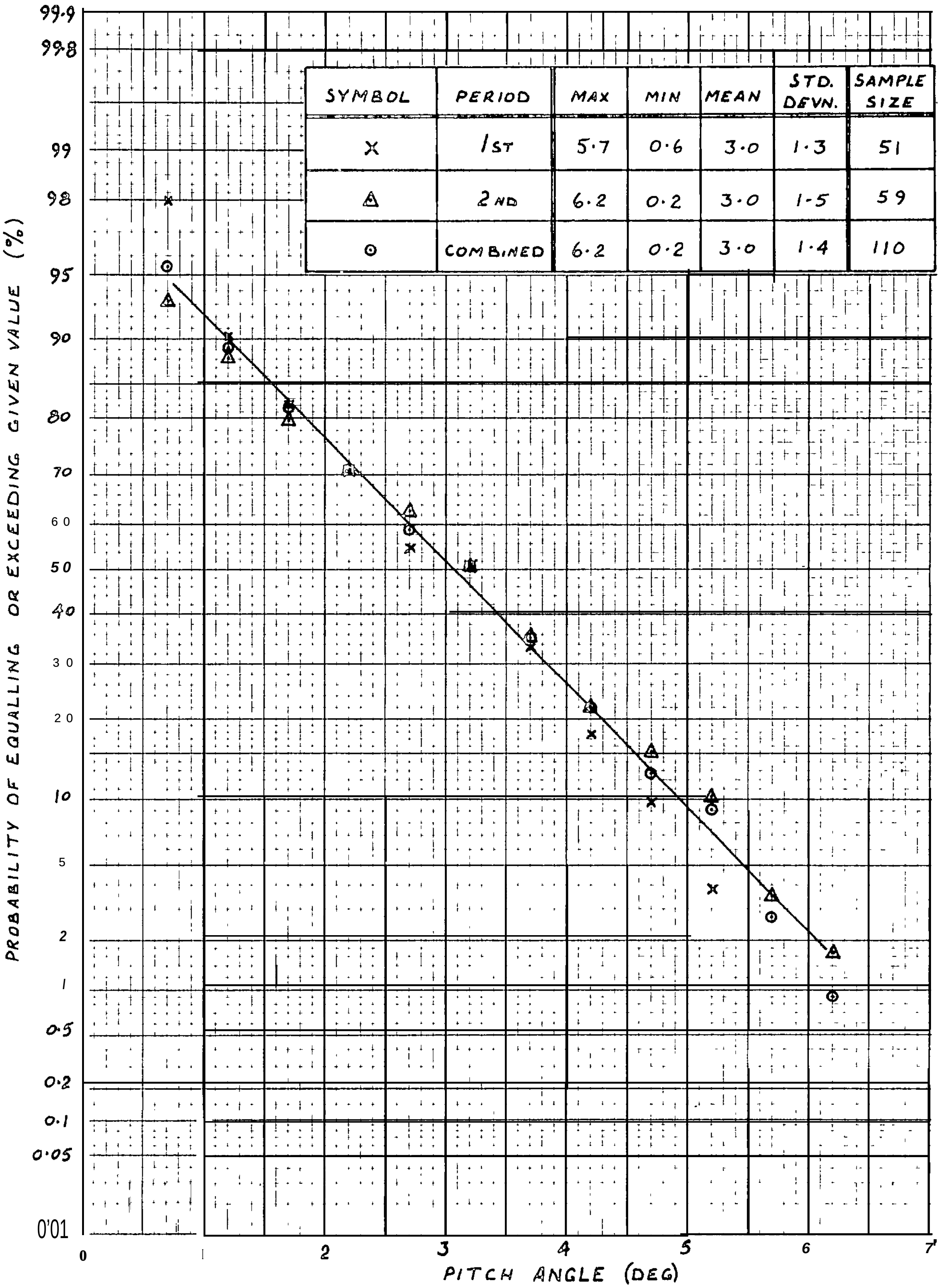
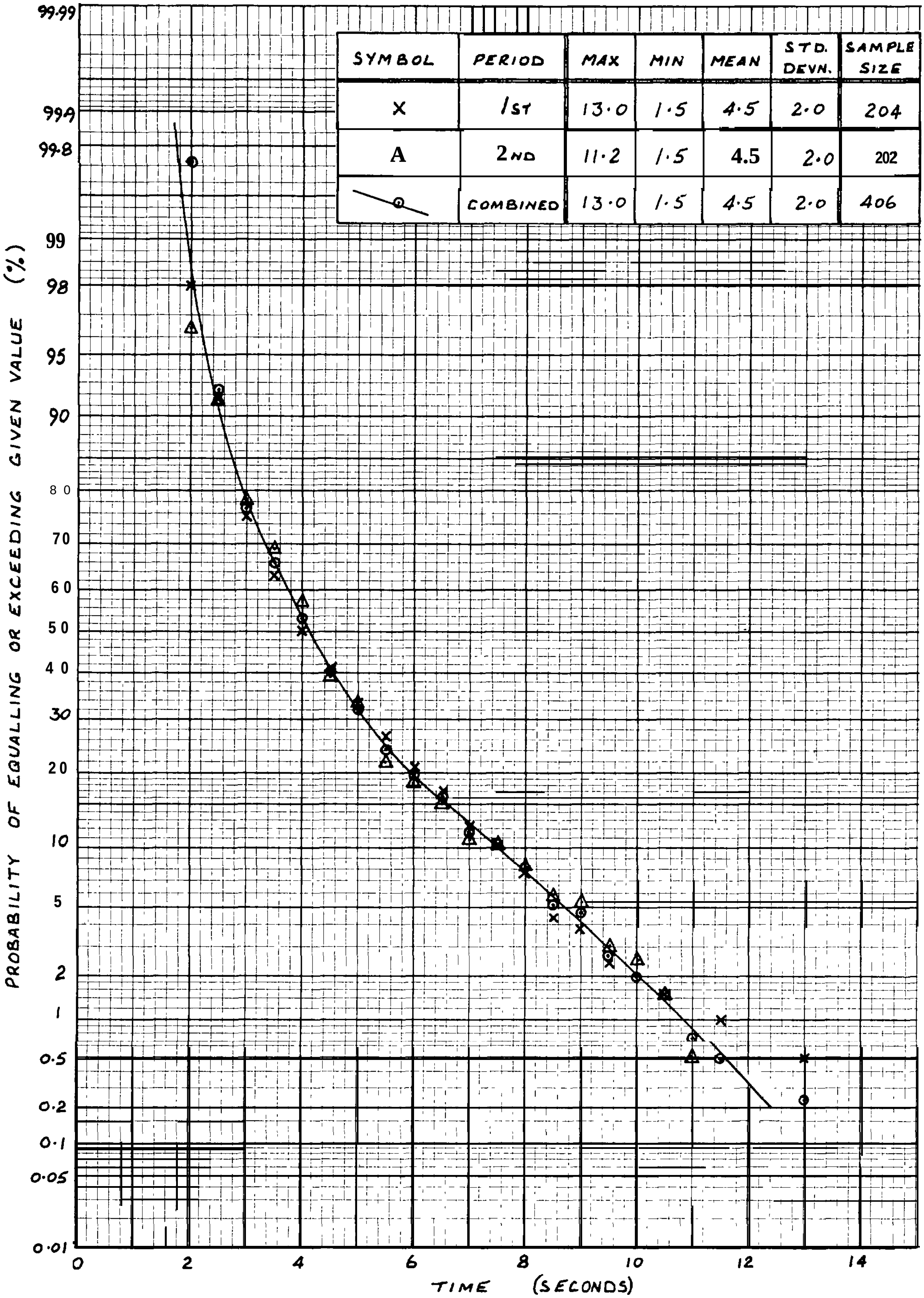
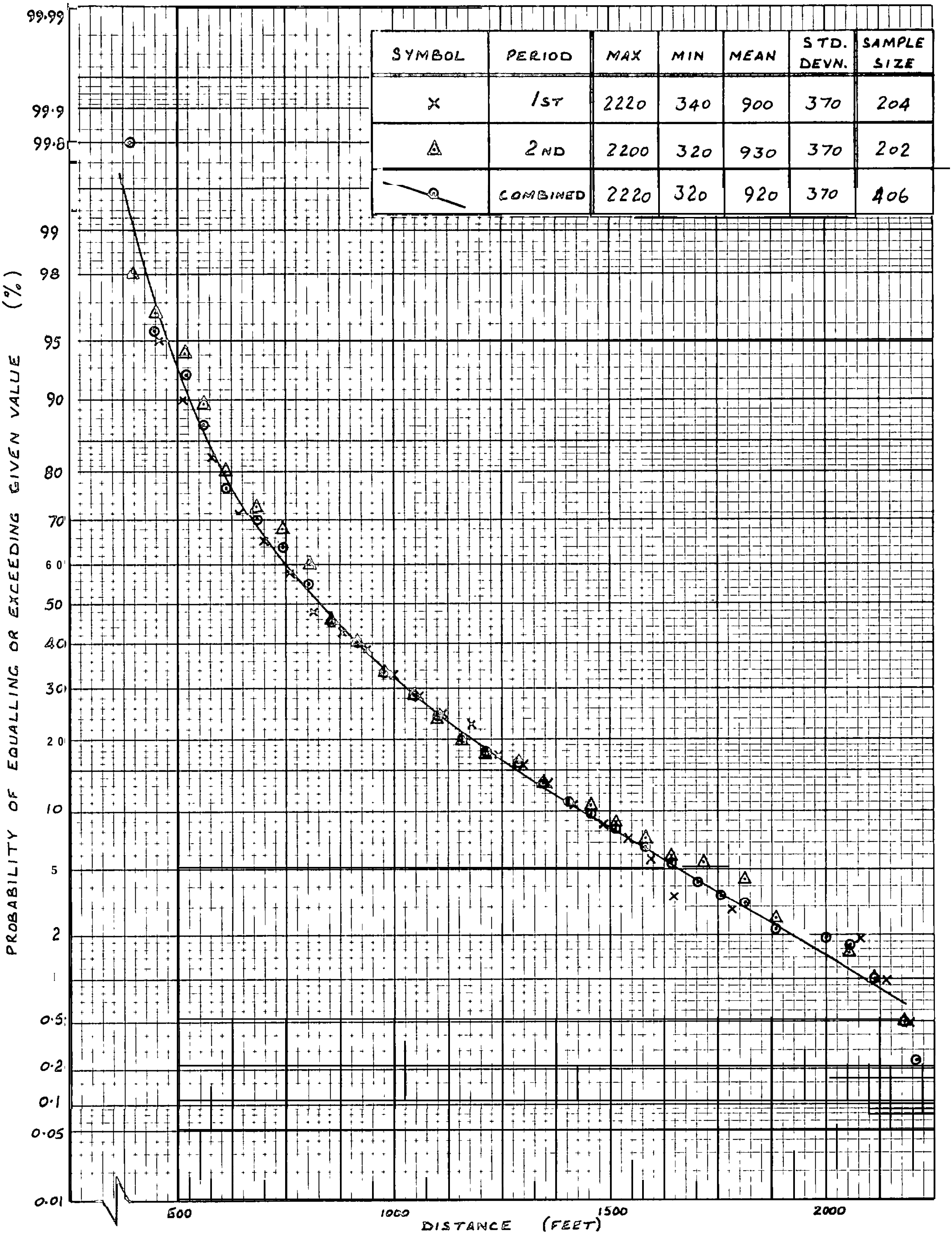


Fig.18 Pitch angle at second impact
Aircraft Type D_1



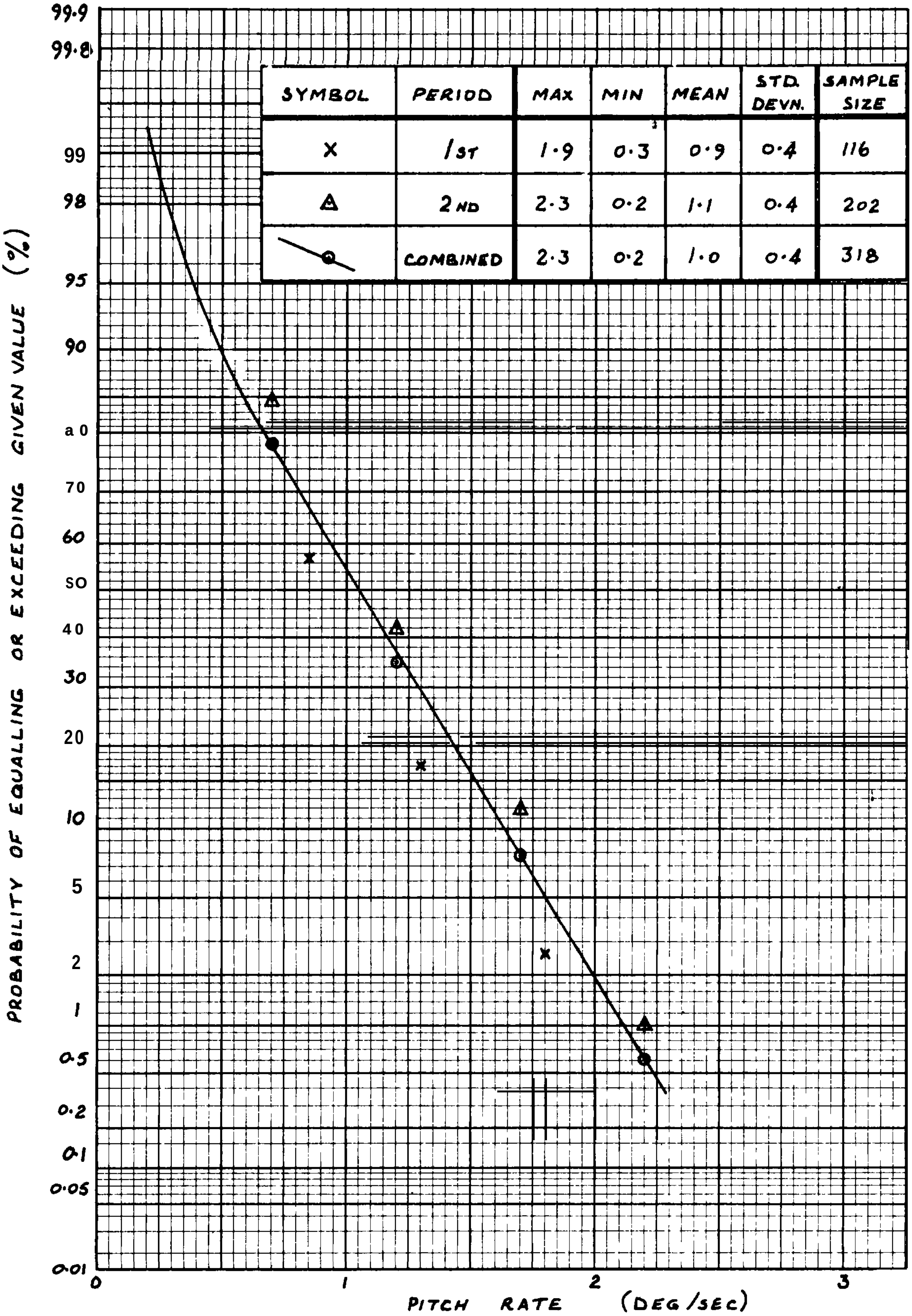
SYMBOL	PERIOD	MAX	MIN	MEAN	STD. DEVN.	SAMPLE SIZE
X	1st	13·0	1·5	4·5	2·0	204
A	2nd	11·2	1·5	4.5	2·0	202
—⊙—	COMBINED	13·0	1·5	4·5	2·0	406

Fig.19 Time from first impact to nosewheel impact
Aircraft Type D_1



SYMBOL	PERIOD	MAX	MIN	MEAN	STD. DEVN.	SAMPLE SIZE
×	1ST	2220	340	900	370	204
△	2ND	2200	320	930	370	202
—⊙—	COMBINED	2220	320	920	370	406

Fig.20 Distance travelled from first impact to nosewheel impact
Aircraft Type D_1



SYMBOL	PERIOD	MAX	MIN	MEAN	STD. DEVN.	SAMPLE SIZE
×	1st	1·9	0·3	0·9	0·4	116
△	2nd	2·3	0·2	1·1	0·4	202
—⊙—	COMBINED	2·3	0·2	1·0	0·4	318

Fig.21 Mean pitch rata during 2 s prior to nosewheel impact
Aircraft Type D_1

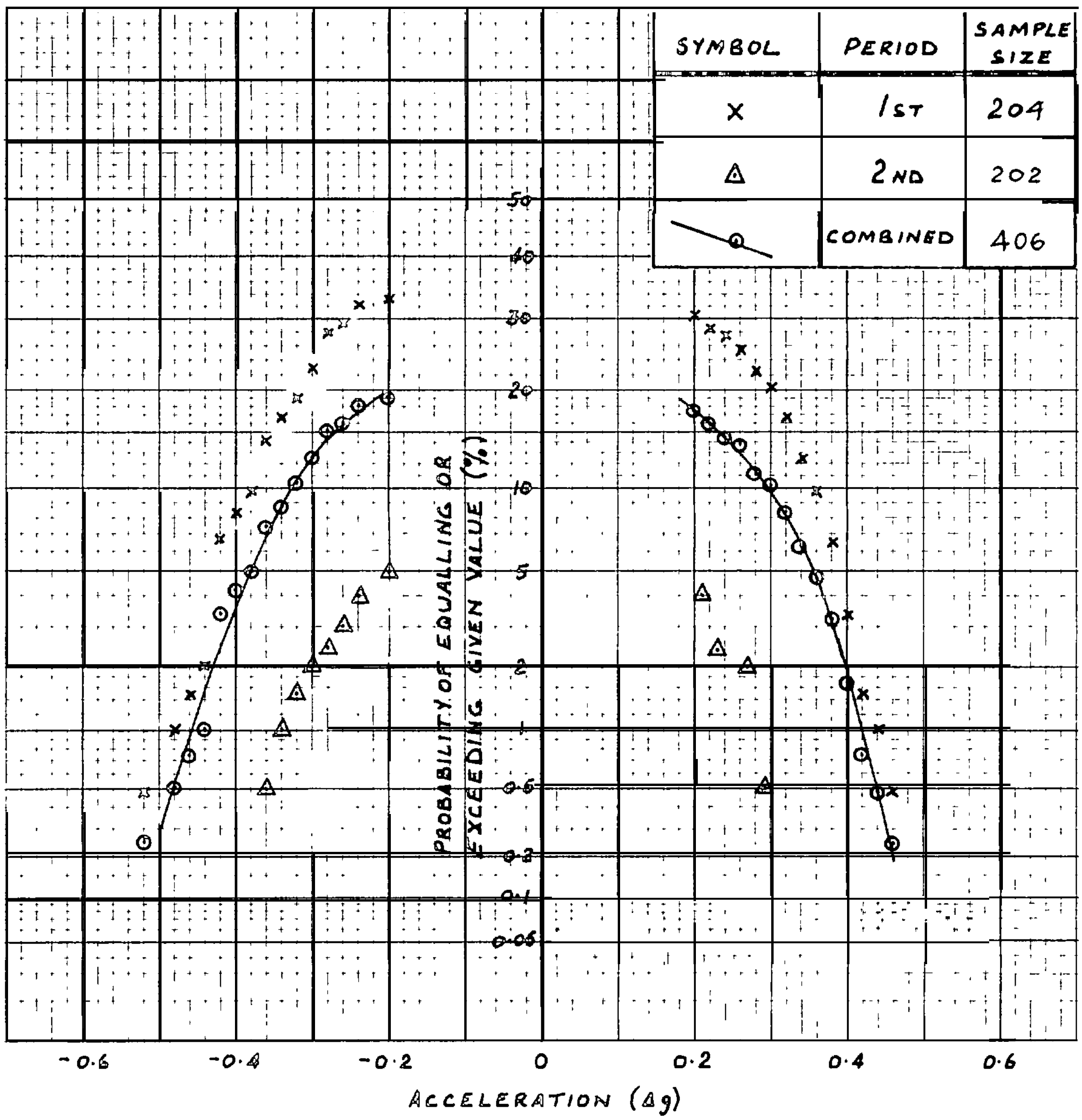


Fig.22 Extreme positive or negative CG normal acceleration increment above lg datum during landing run Aircraft Type D_1

		BELOW GLIDE PATH				ABOVE GLIDE PATH				
SYMBOL	PERIOD	MAX	MIN	MEAN	STD. DEVN.	MAX	MIN	MEAN	STD. DEVN.	SAMPLE SIZE
×	1ST	116	1	49	31	142	0	39	32	175
Δ	2ND	172	1	45	40	190	0	35	36	177
—⊙—	COMBINED	172	1	47	35	190	0	36	54	352

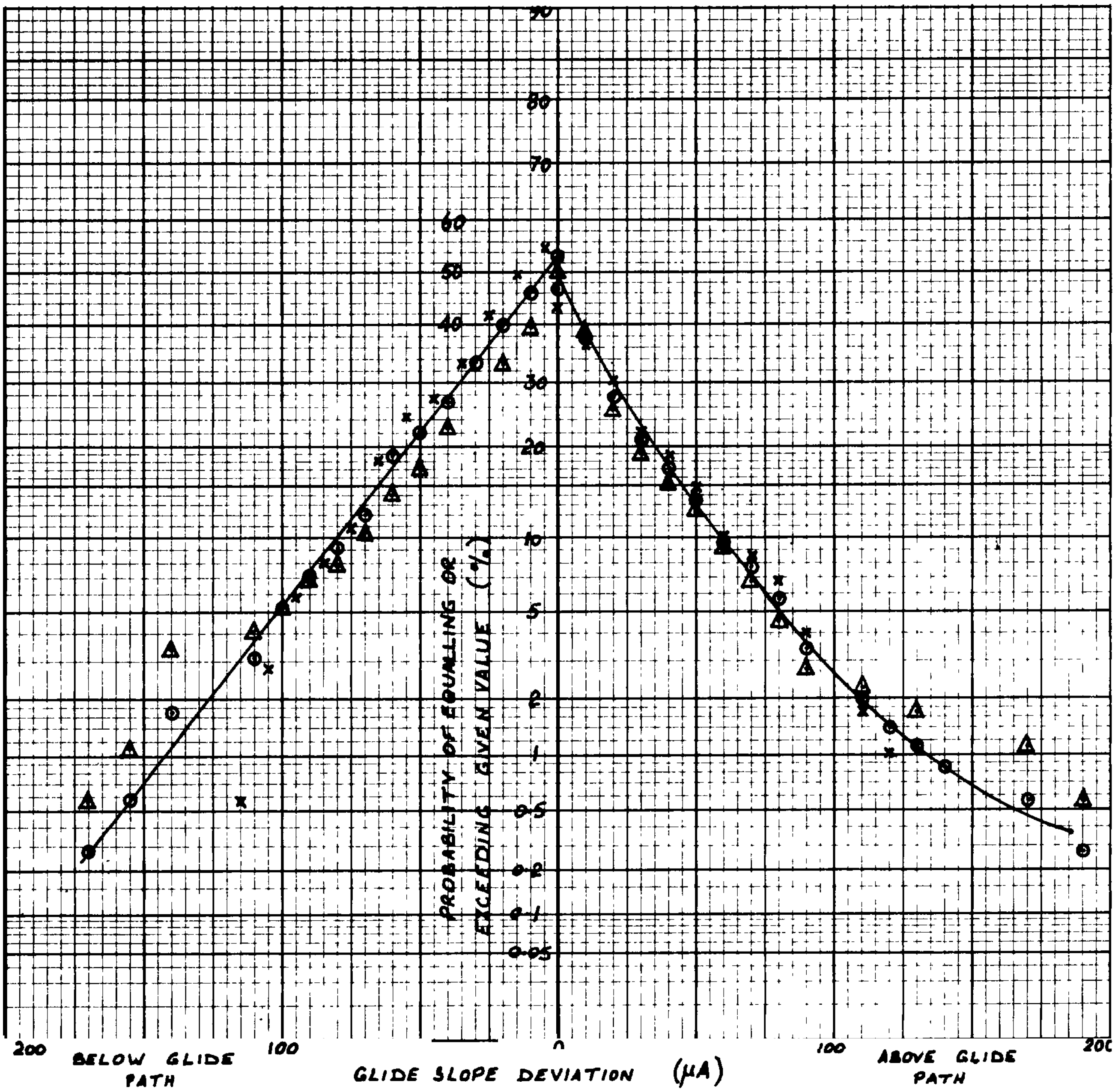
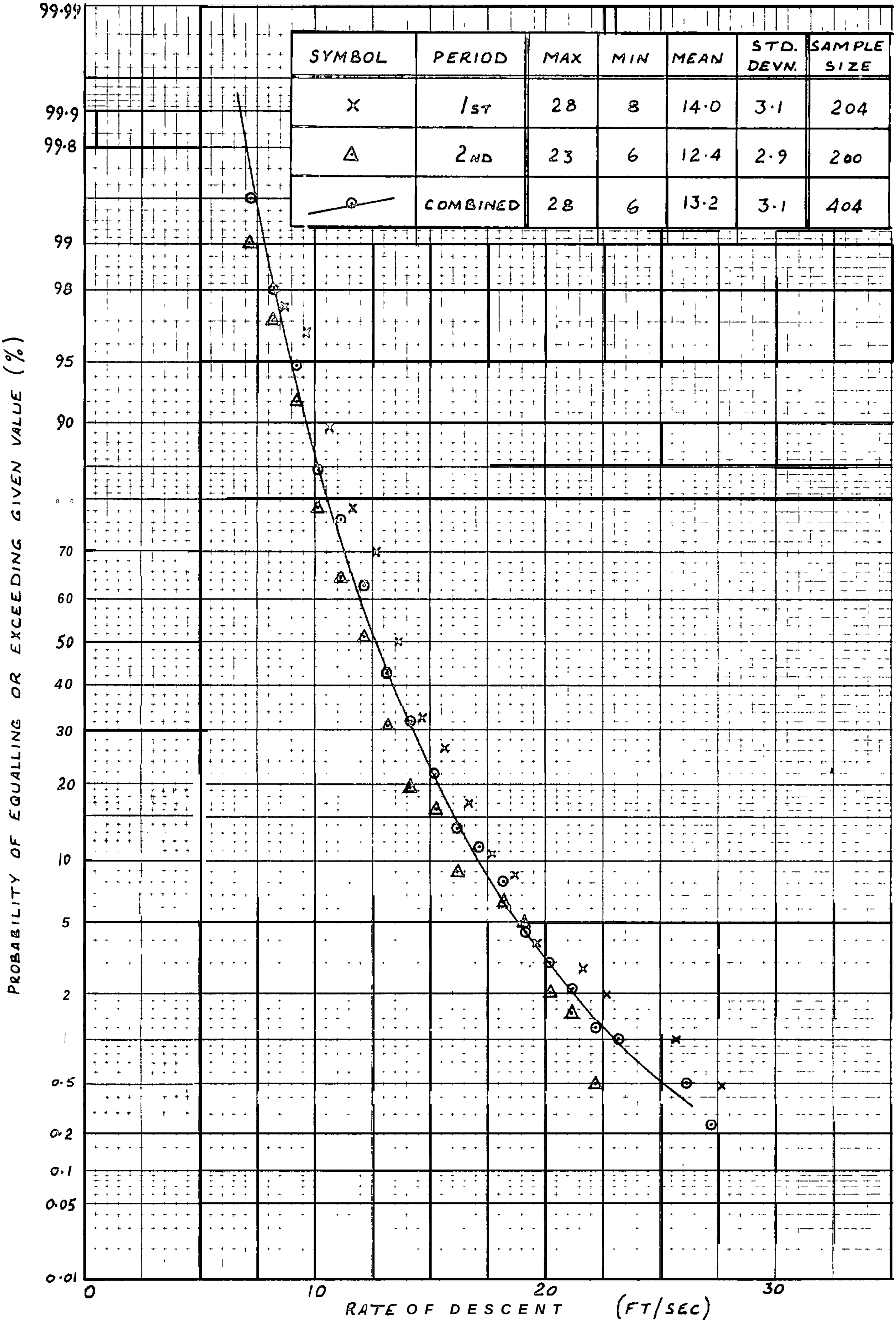


Fig.23 Glide slope deviation from zero at a height of 150 ft
Aircraft Type E_1



SYMBOL	PERIOD	MAX	MIN	MEAN	STD. DEVN.	SAMPLE SIZE
×	1ST	28	8	14.0	3.1	204
△	2ND	23	6	12.4	2.9	200
—⊙—	COMBINED	28	6	13.2	3.1	404

Fig.24 Rate of descent at a height of 150 ft (radio altitude)
Aircraft Type E_1

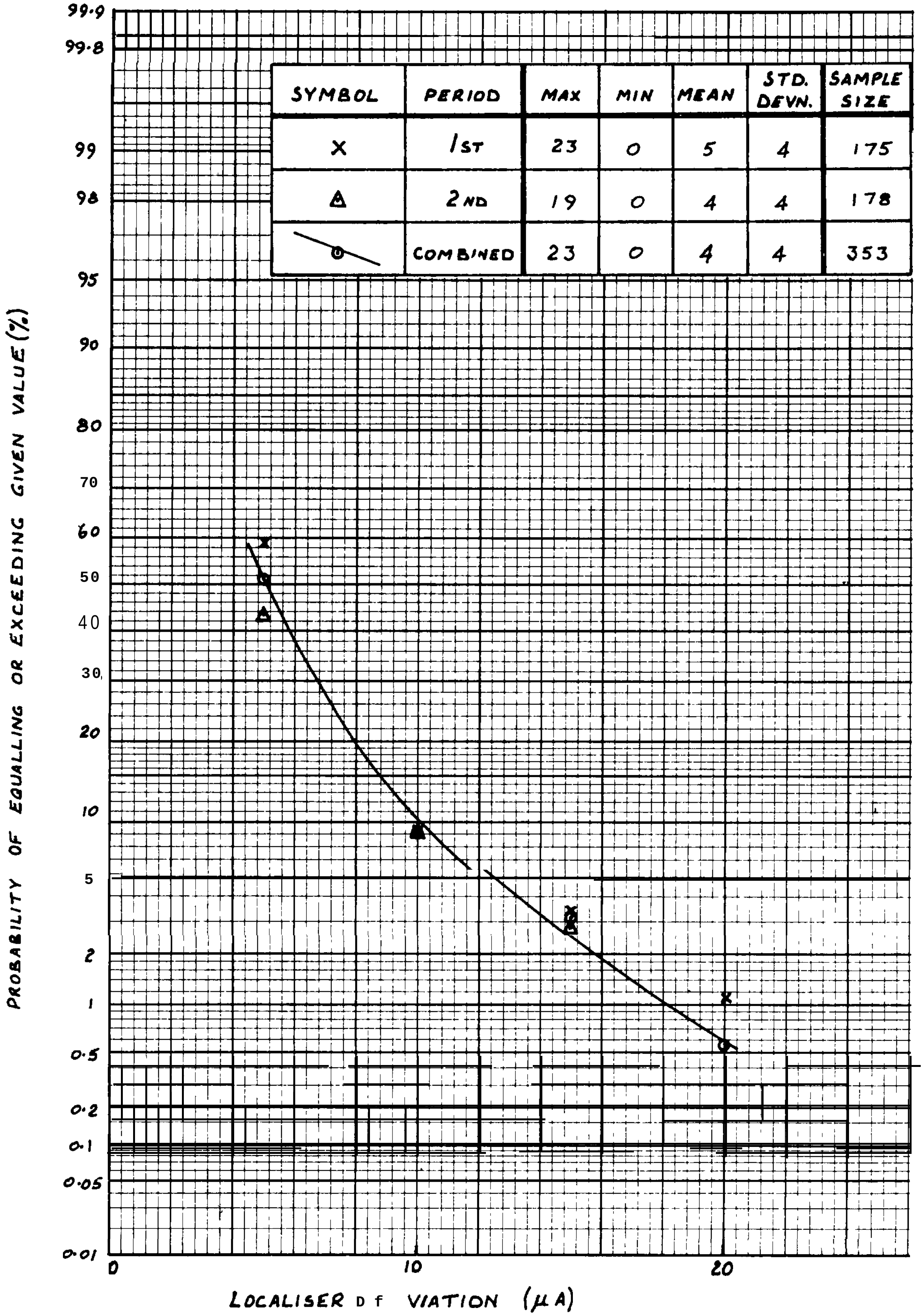
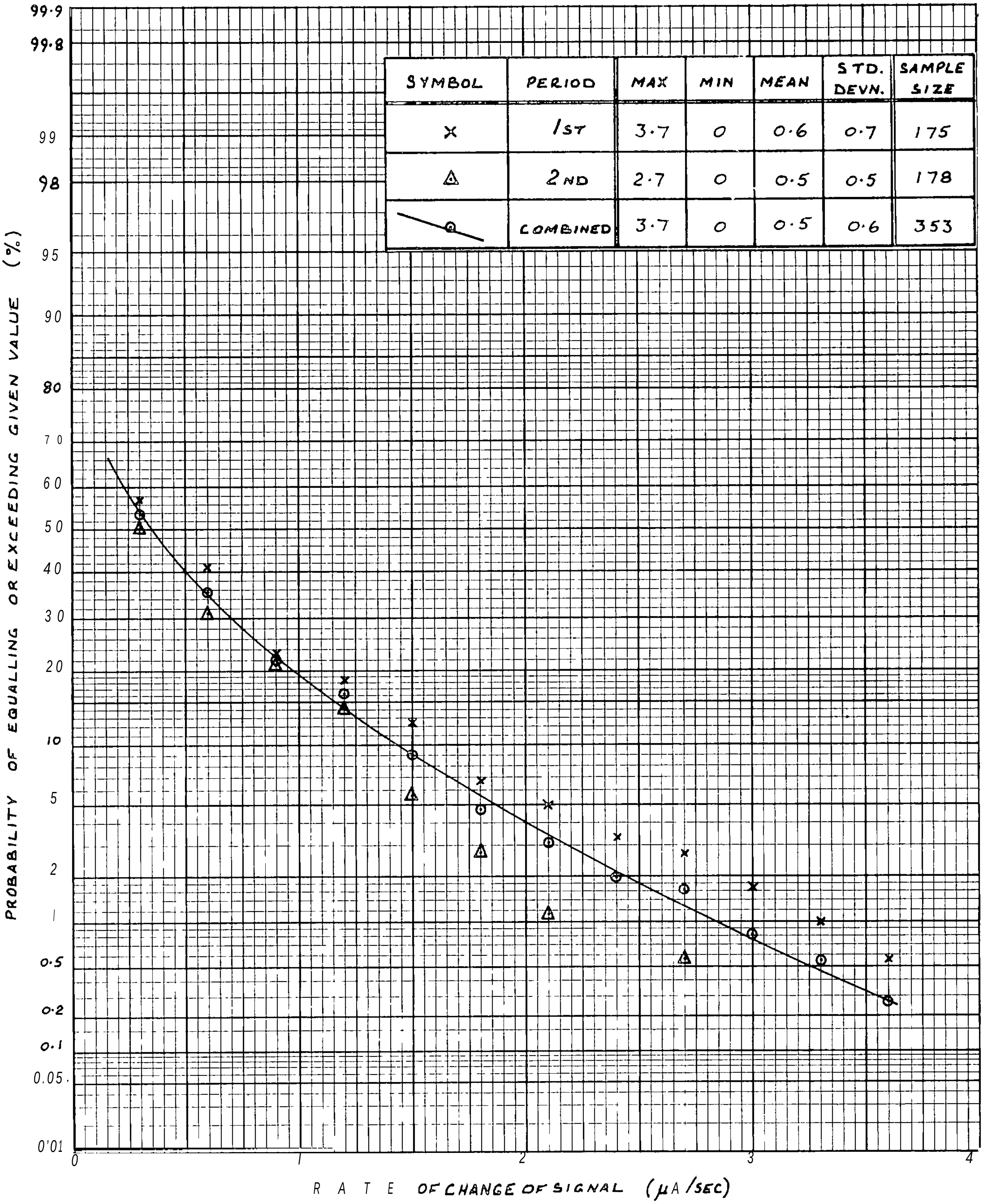
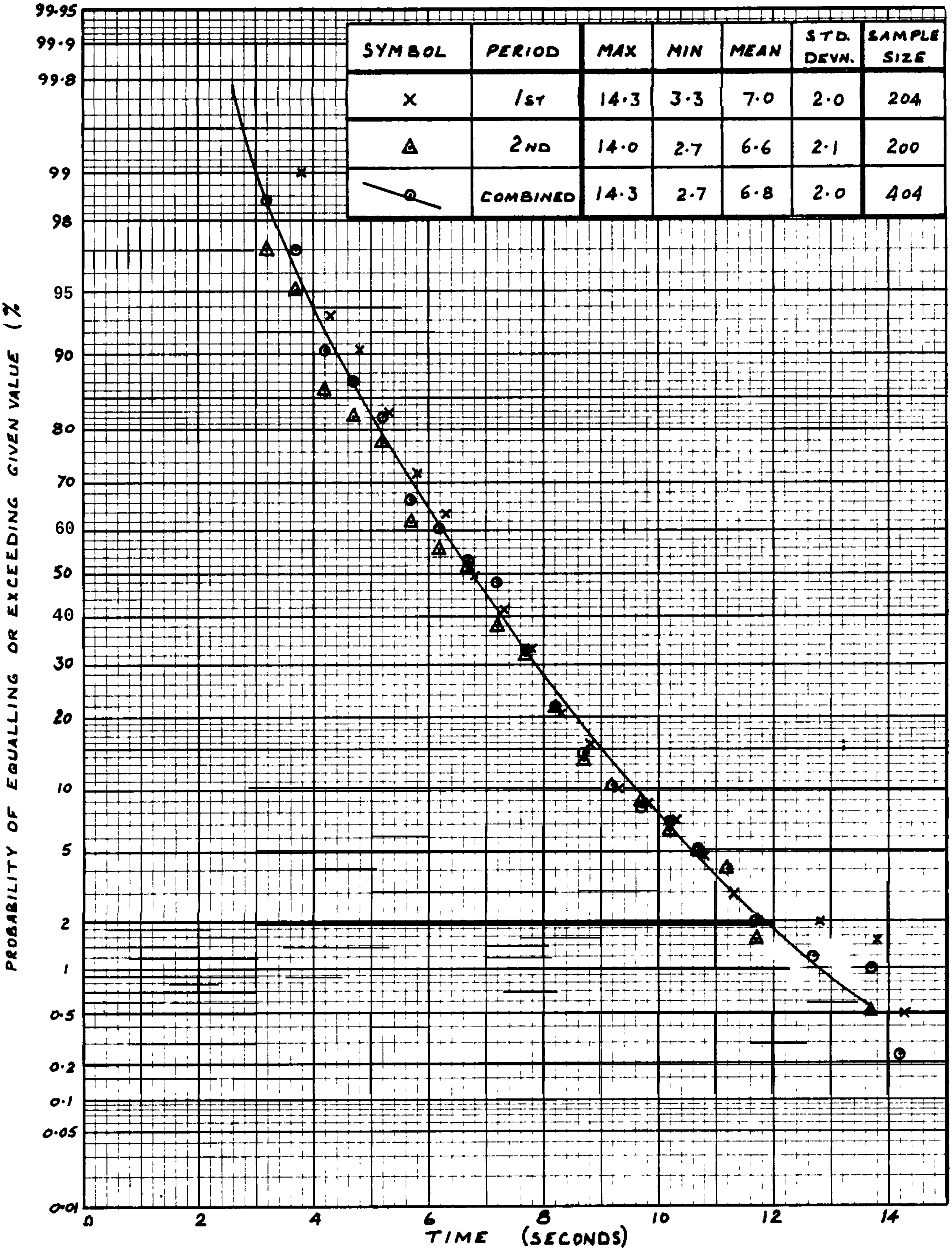


Fig.25 Localiser deviation from zero at a height of 150 ft
Aircraft Type E_1



SYMBOL	PERIOD	MAX	MIN	MEAN	STD. DEVN.	SAMPLE SIZE
×	1ST	3·7	0	0·6	0·7	175
Δ	2ND	2·7	0	0·5	0·5	178
—⊙—	COMBINED	3·7	0	0·5	0·6	353

Fig.26 Localiser deviation rate at a height of 450 ft
Aircraft Type E_1



SYMBOL	PERIOD	MAX	MIN	MEAN	STD. DEVN.	SAMPLE SIZE
×	1ST	14·3	3·3	7·0	2·0	204
△	2ND	14·0	2·7	6·6	2·1	200
—⊙—	COMBINED	14·3	2·7	6·8	2·0	404

Fig.27 Time from flare initiation to **touchdown**
Aircraft Type E_1

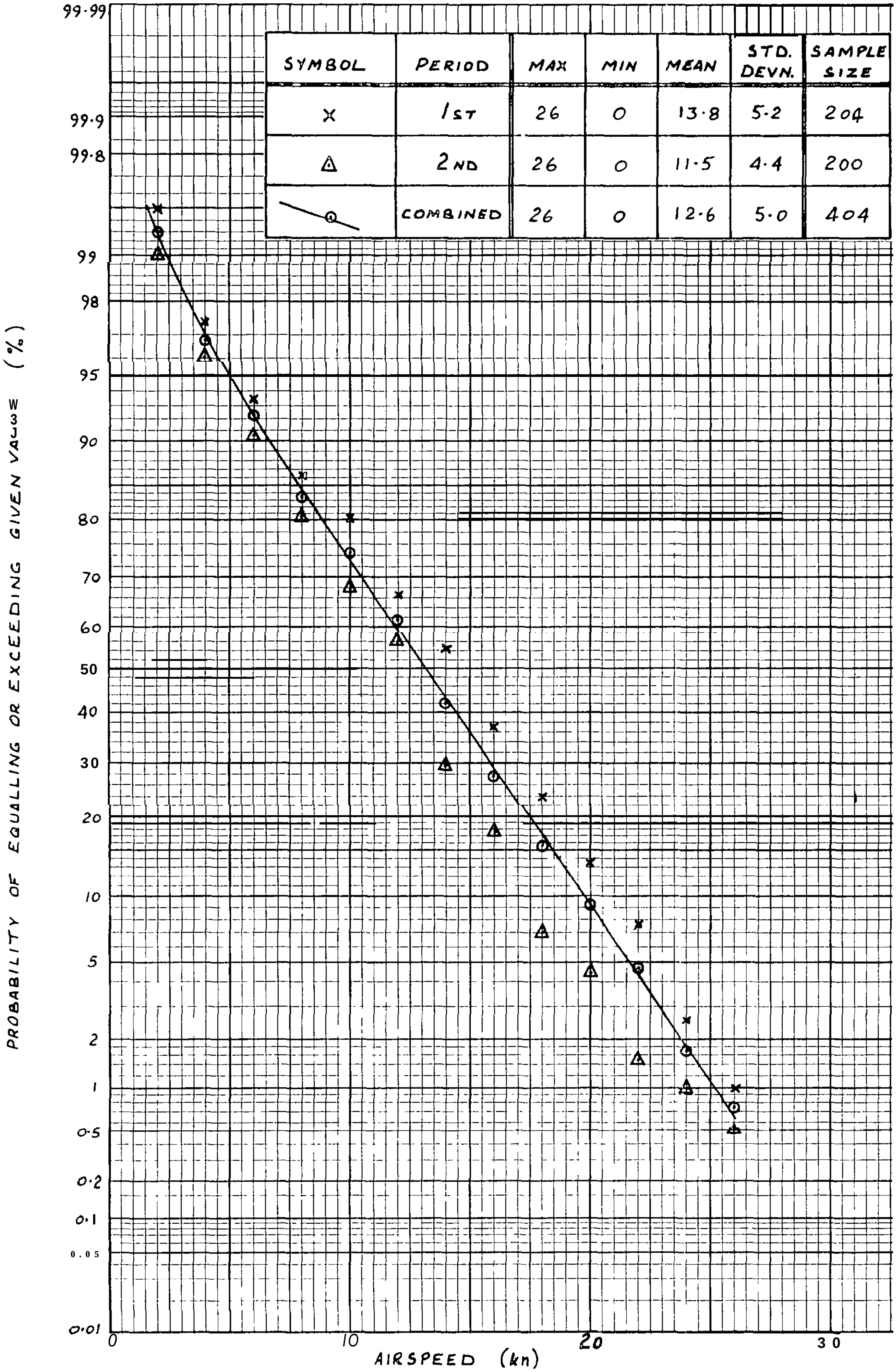


Fig.28 Airspeed loss from height of 150 ft to touchdown
Aircraft Type E_1

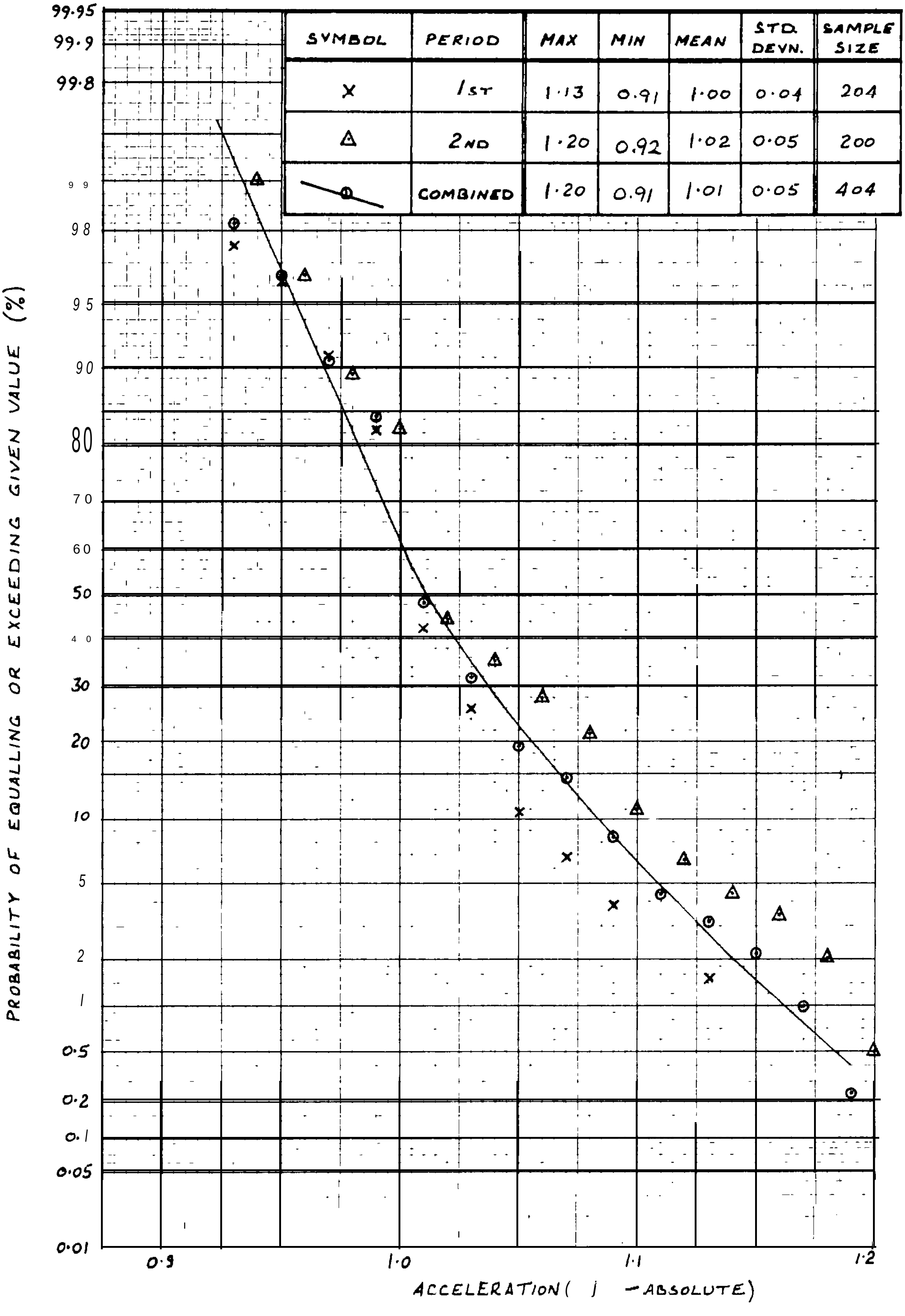
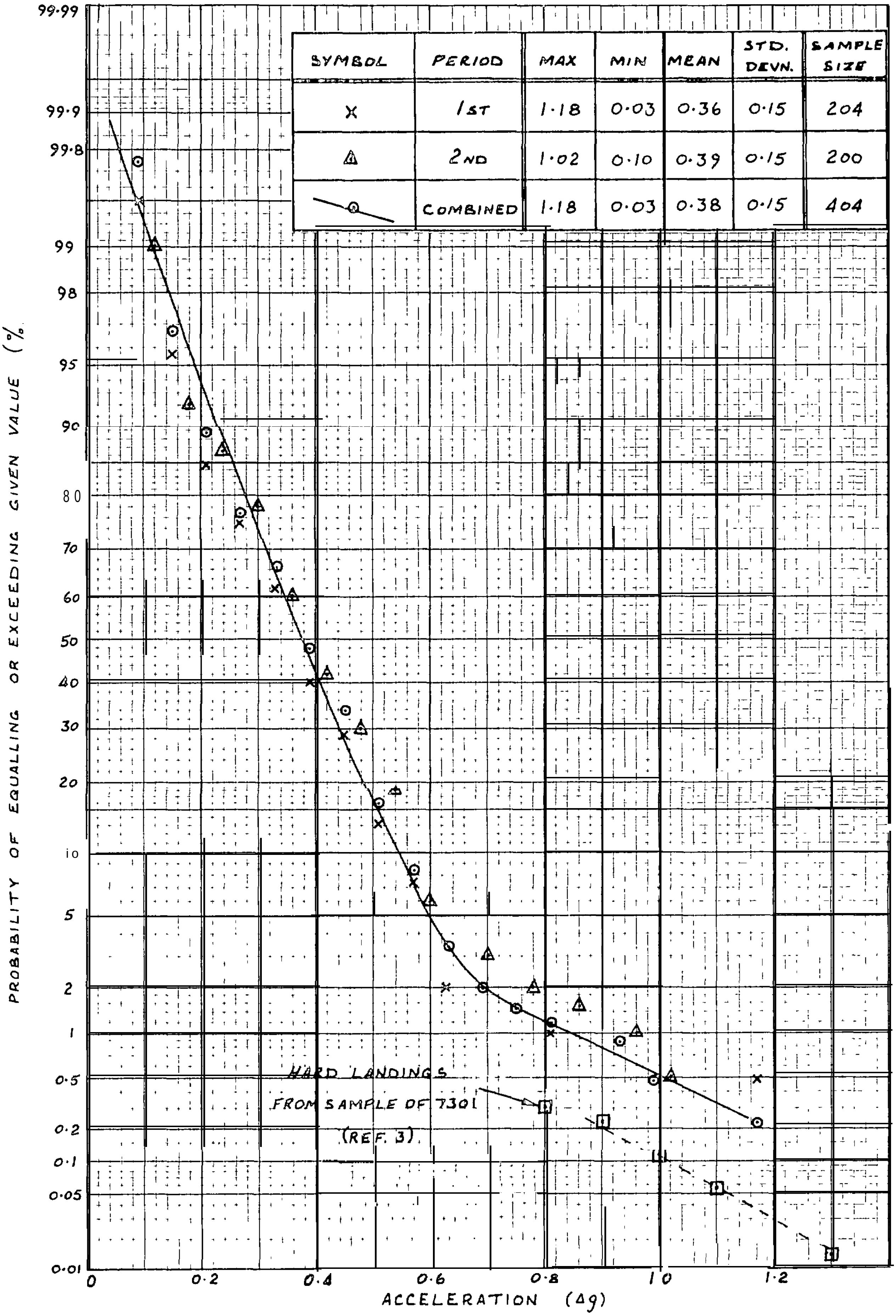
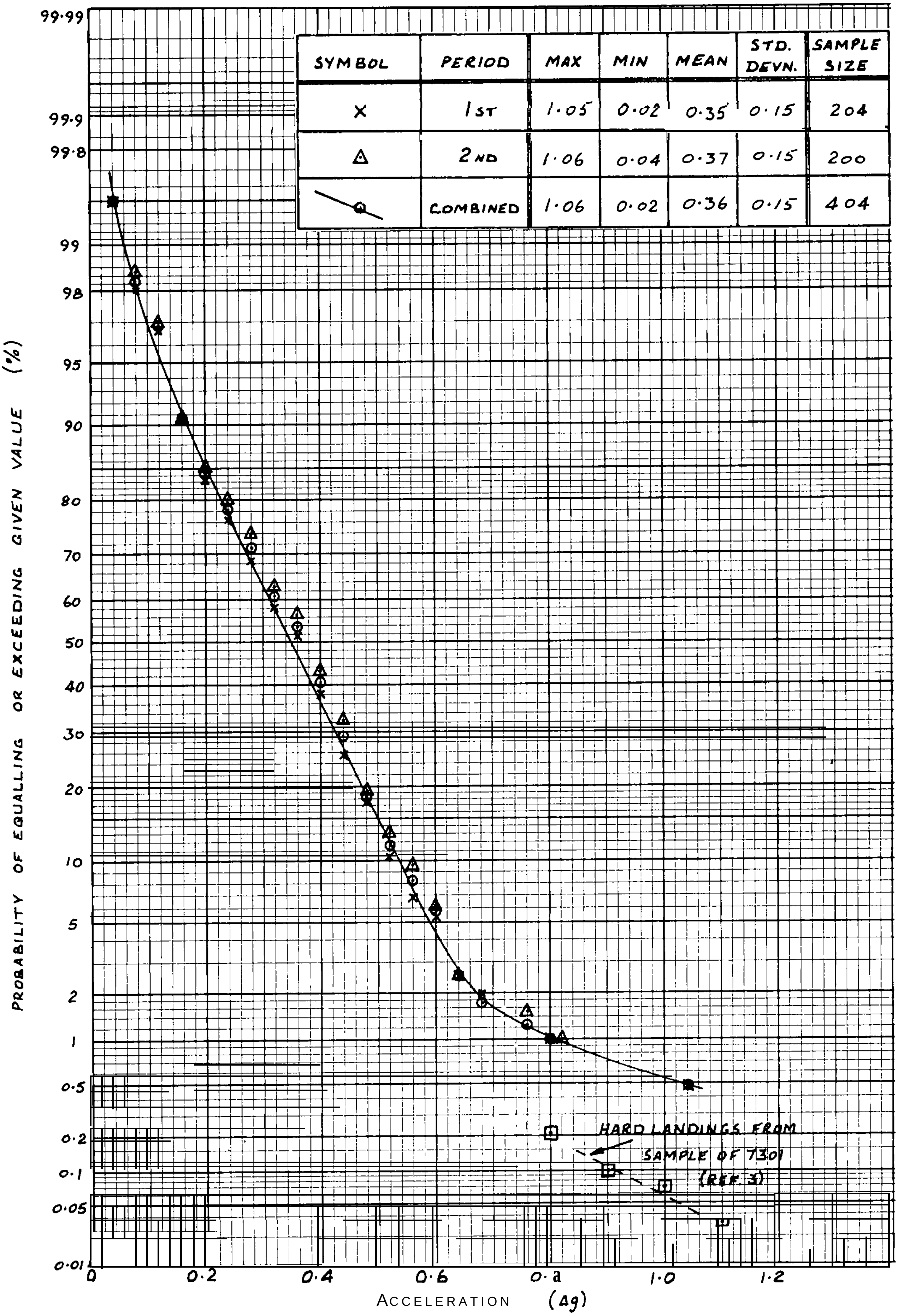


Fig.29 CG normal acceleration due to aerodynamic lift at first impact
Aircraft Type E_1



SYMBOL	PERIOD	MAX	MIN	MEAN	STD. DEVN.	SAMPLE SIZE
×	1ST	1·18	0·03	0·36	0·15	204
△	2ND	1·02	0·10	0·39	0·15	200
—⊙—	COMBINED	1·18	0·03	0·38	0·15	404

Fig.30 Peak CG normal acceleration increment above 1g datum at first impact
Aircraft Type E_1



SYMBOL	PERIOD	MAX	MIN	MEAN	STD. DEVN.	SAMPLE SIZE
×	1ST	1·05	0·02	0·35	0·15	204
△	2ND	1·06	0·04	0·37	0·15	200
—○—	COMBINED	1·06	0·02	0·36	0·15	404

Fig.31 **Ground-forced peak CG normal acceleration at first impact**
Aircraft Type E_1

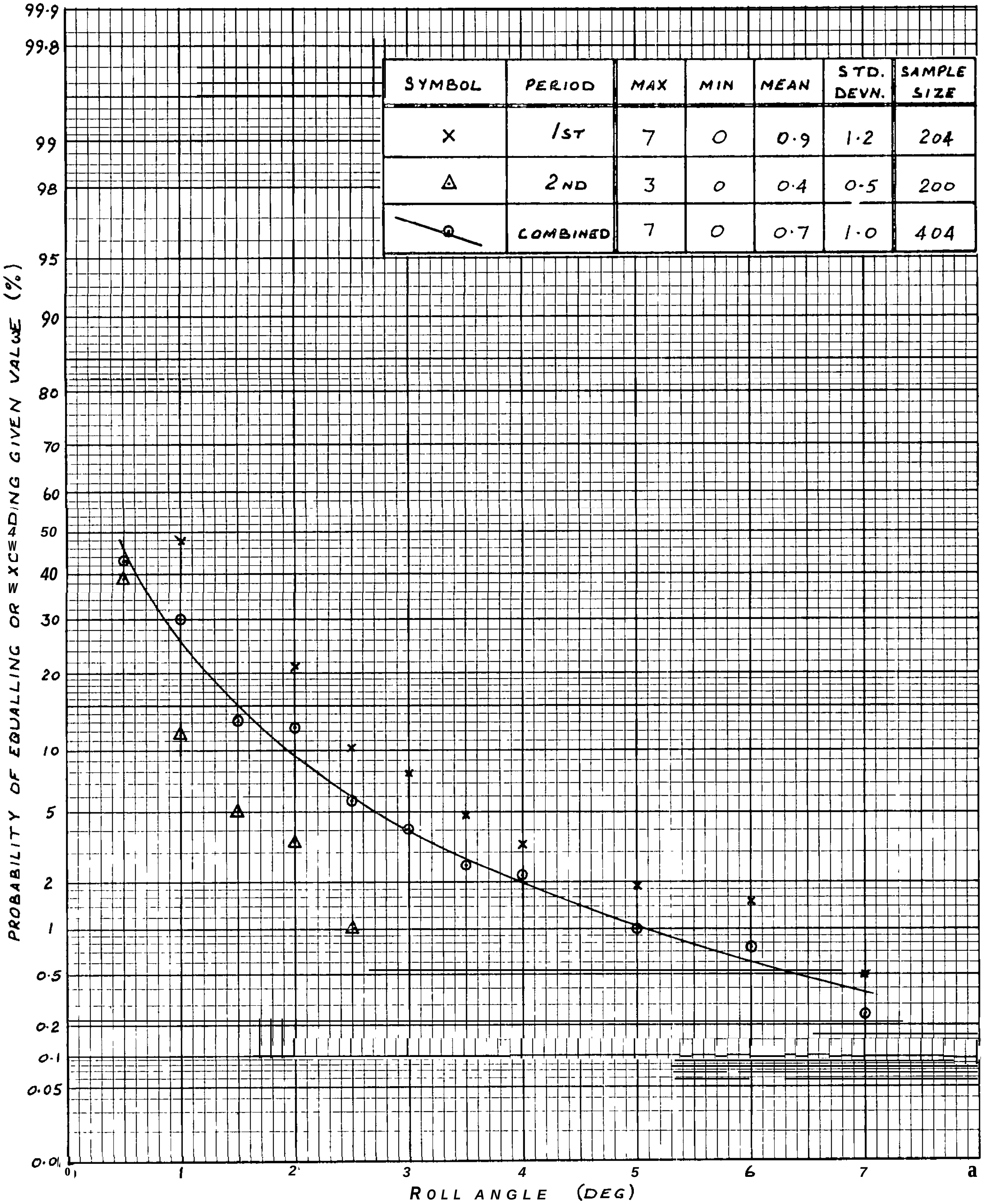
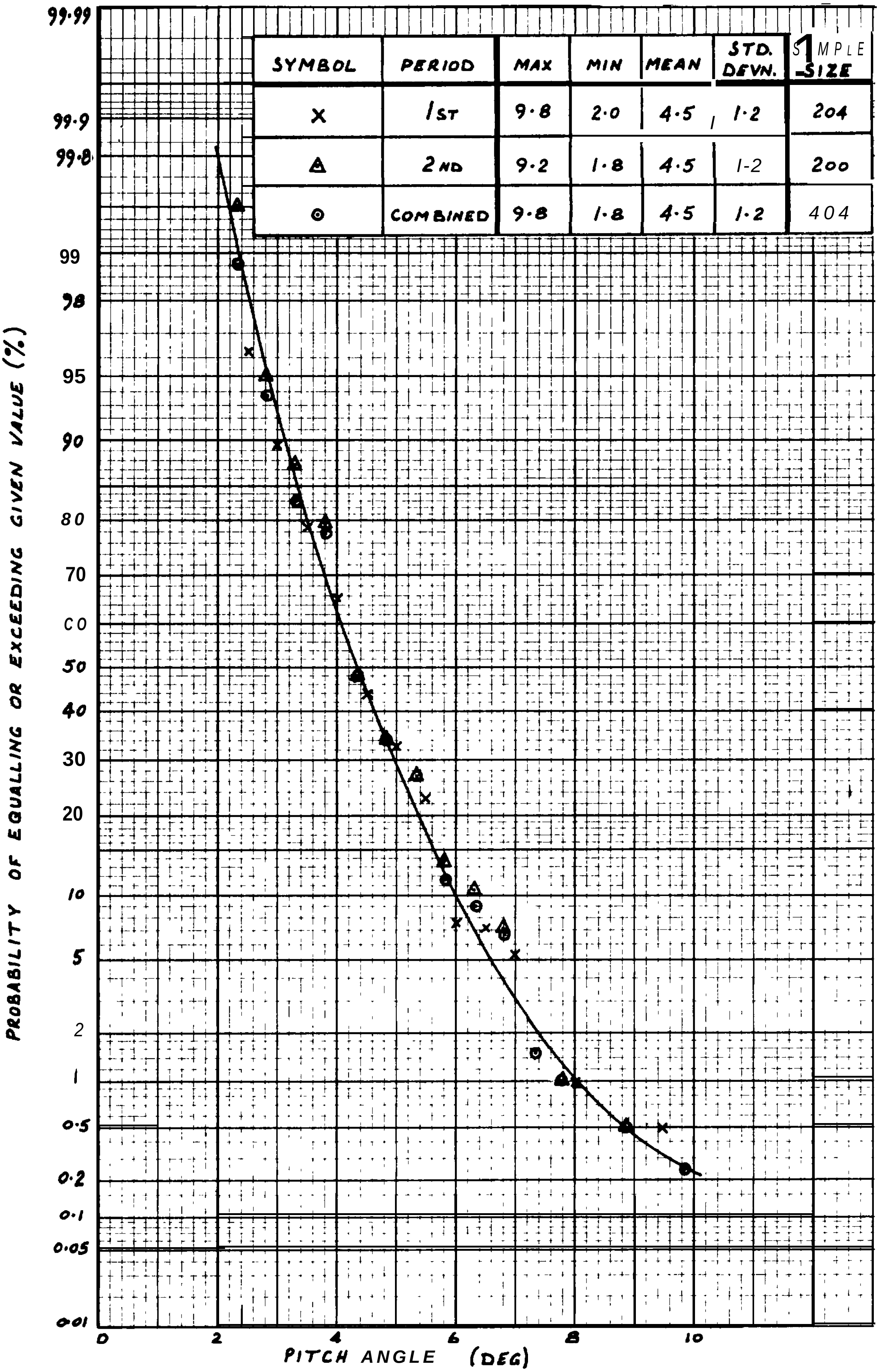
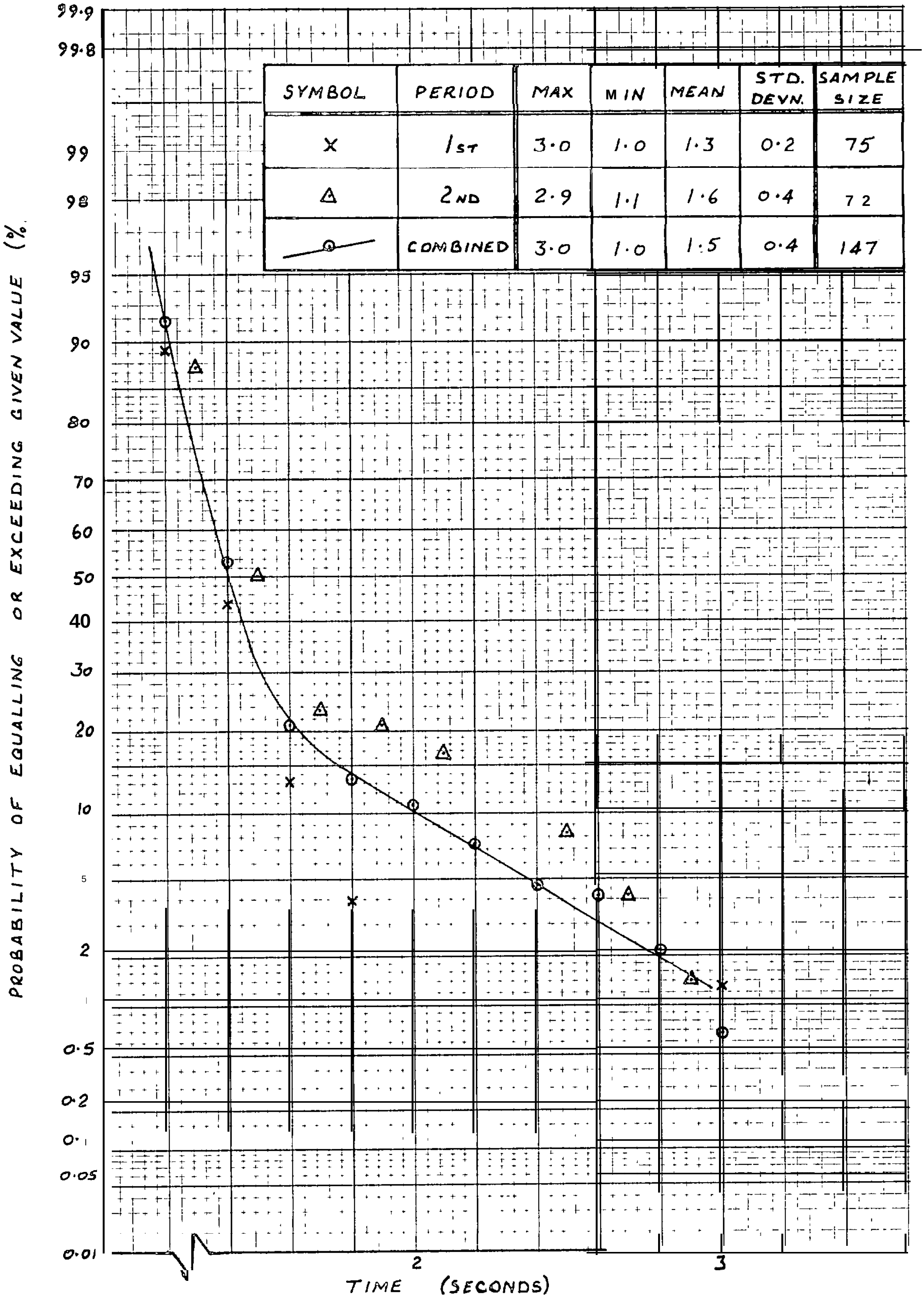


Fig.32 Roll angle at first impact
Aircraft Type E_1



SYMBOL	PERIOD	MAX	MIN	MEAN	STD. DEVN.	SAMPLE SIZE
×	1ST	9·8	2·0	4·5	1·2	204
△	2ND	9·2	1·8	4·5	1-2	200
⊙	COMBINED	9·8	1·8	4·5	1·2	404

Fig.33 Pitch angle at first impact
Aircraft Type E_1



SYMBOL	PERIOD	MAX	MIN	MEAN	STD. DEVN.	SAMPLE SIZE
×	1ST	3.0	1.0	1.3	0.2	75
△	2ND	2.9	1.1	1.6	0.4	72
—⊙—	COMBINED	3.0	1.0	1.5	0.4	147

Fig.34 Time from first to second impact
Aircraft Type E_1

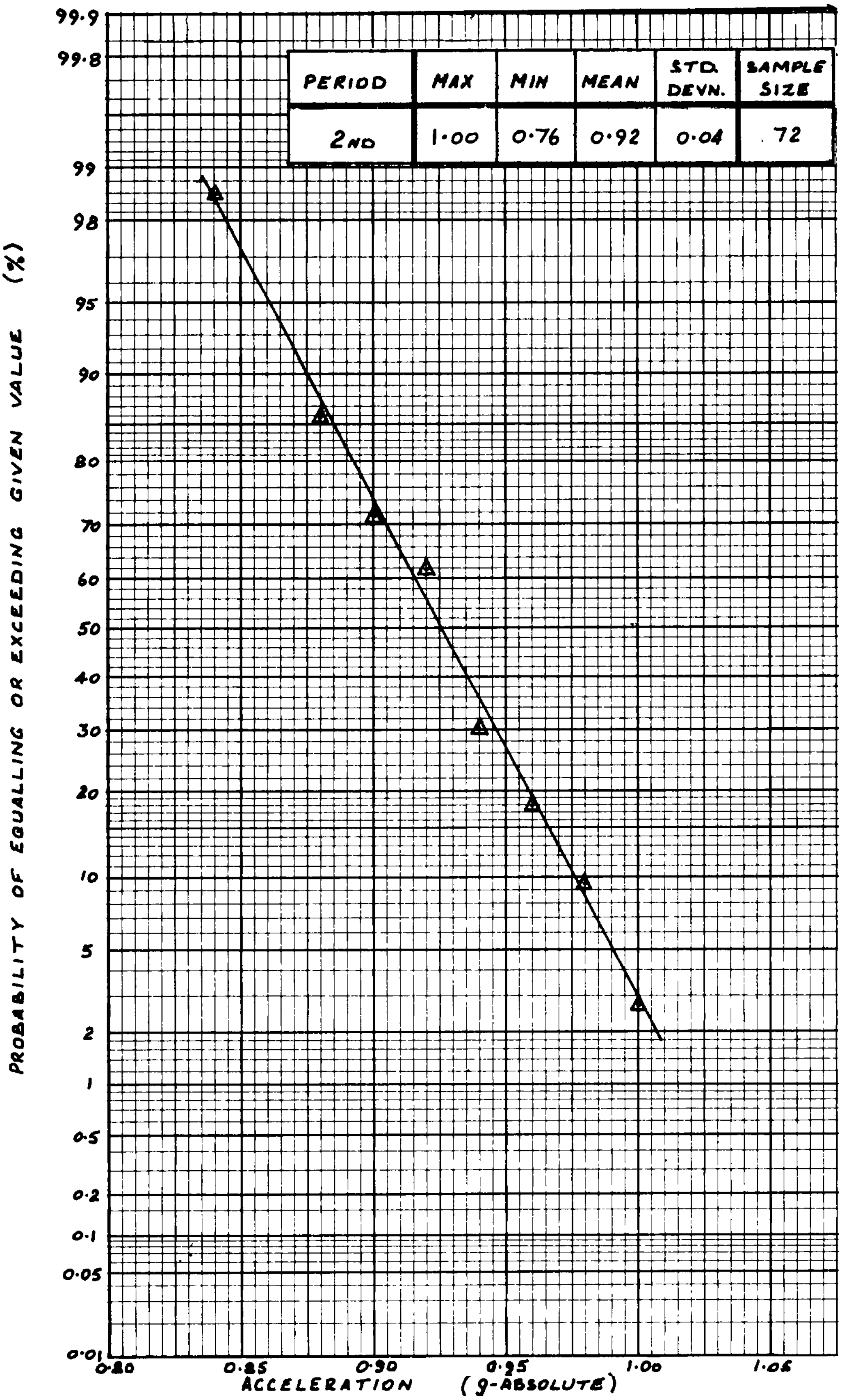
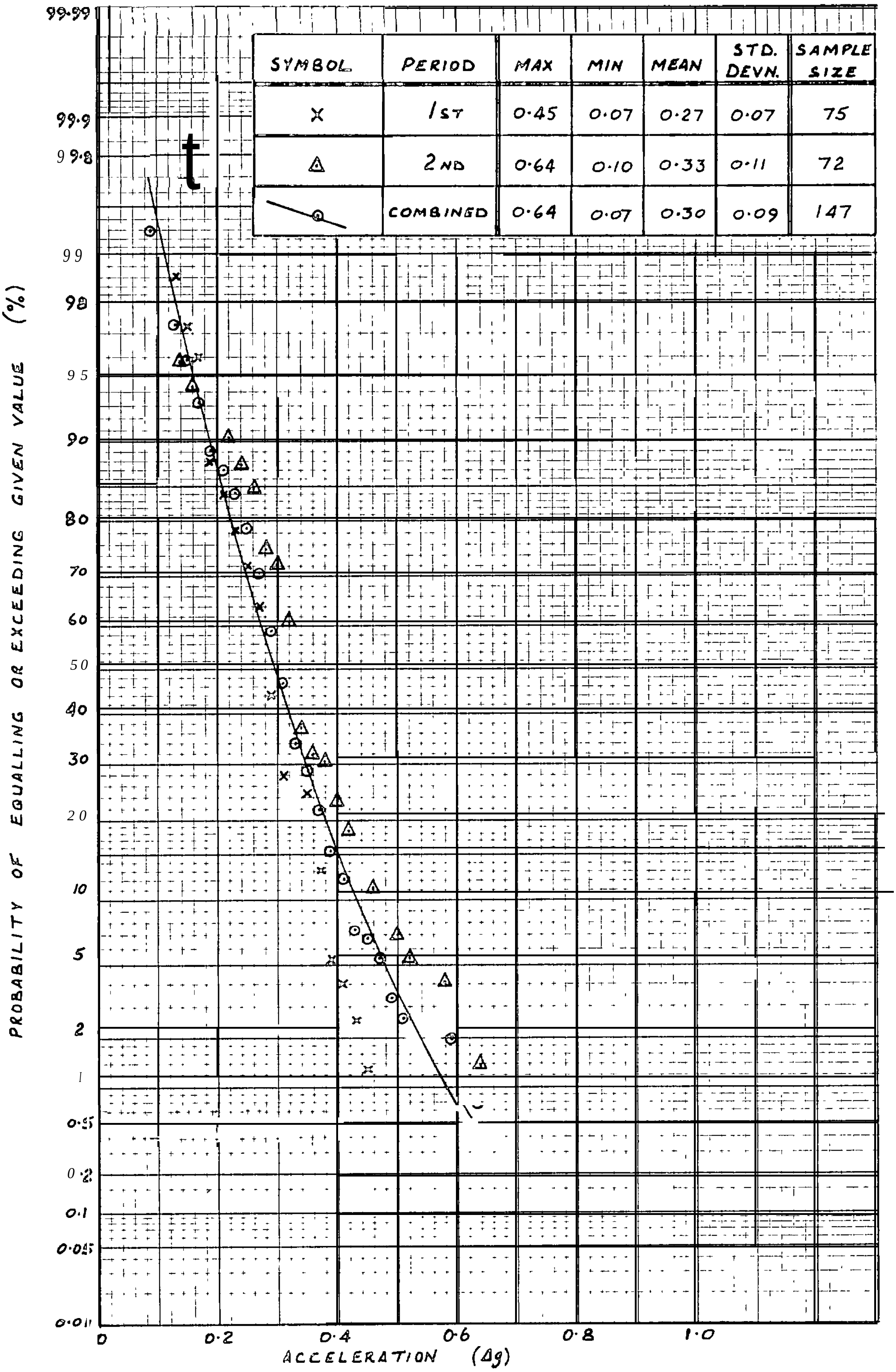


Fig.36 CG normal acceleration due to aerodynamic lift at second impact
Aircraft Type E_1



SYMBOL	PERIOD	MAX	MIN	MEAN	STD. DEVN.	SAMPLE SIZE
×	1ST	0·45	0·07	0·27	0·07	75
△	2ND	0·64	0·10	0·33	0·11	72
—⊙—	COMBINED	0·64	0·07	0·30	0·09	147

Fig.36 Peak CG normal acceleration increment above 1g datum at second impact
Aircraft Type E_1

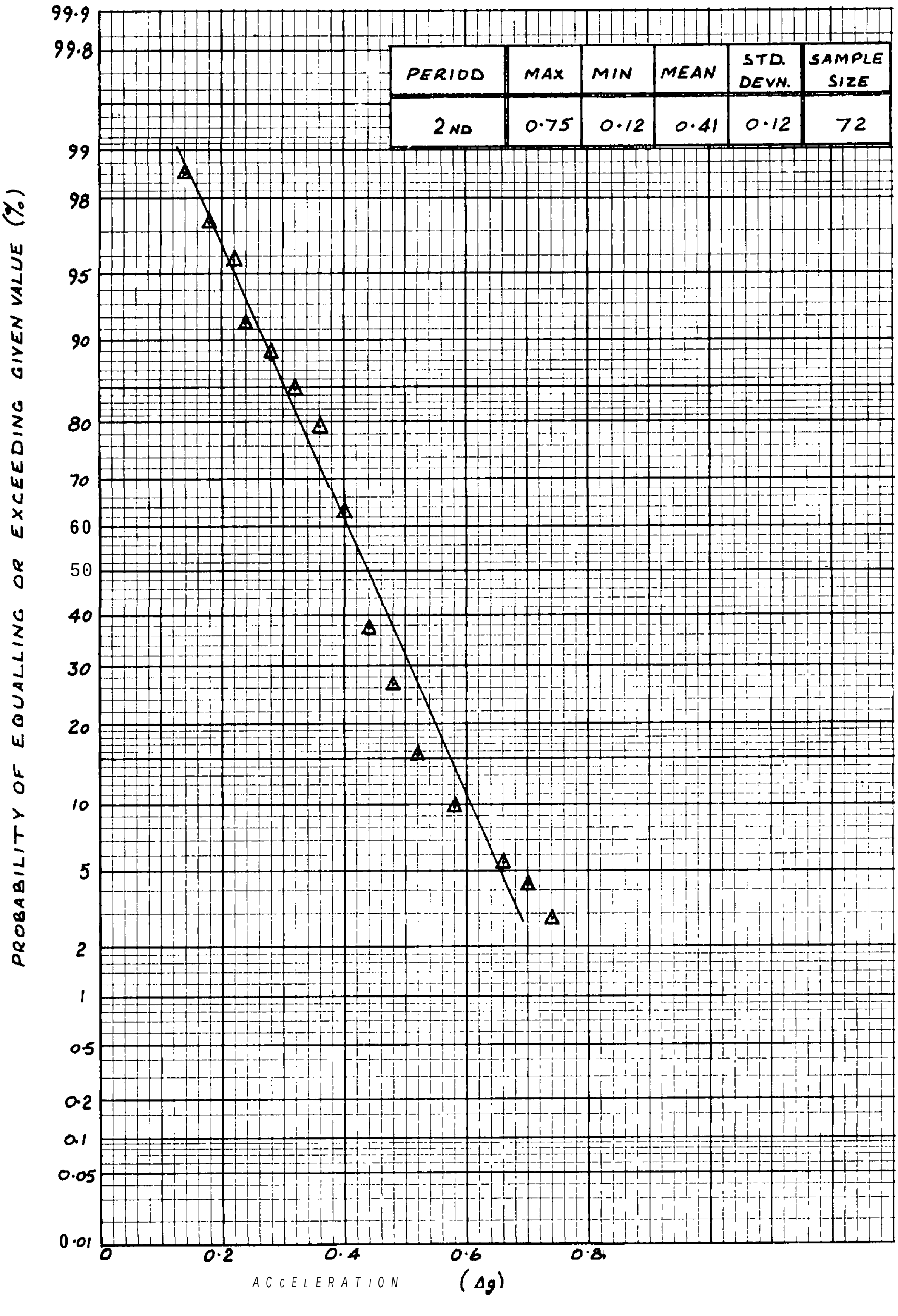


Fig.37 Ground-forced peak CG normal acceleration at second impact Aircraft Type E_1

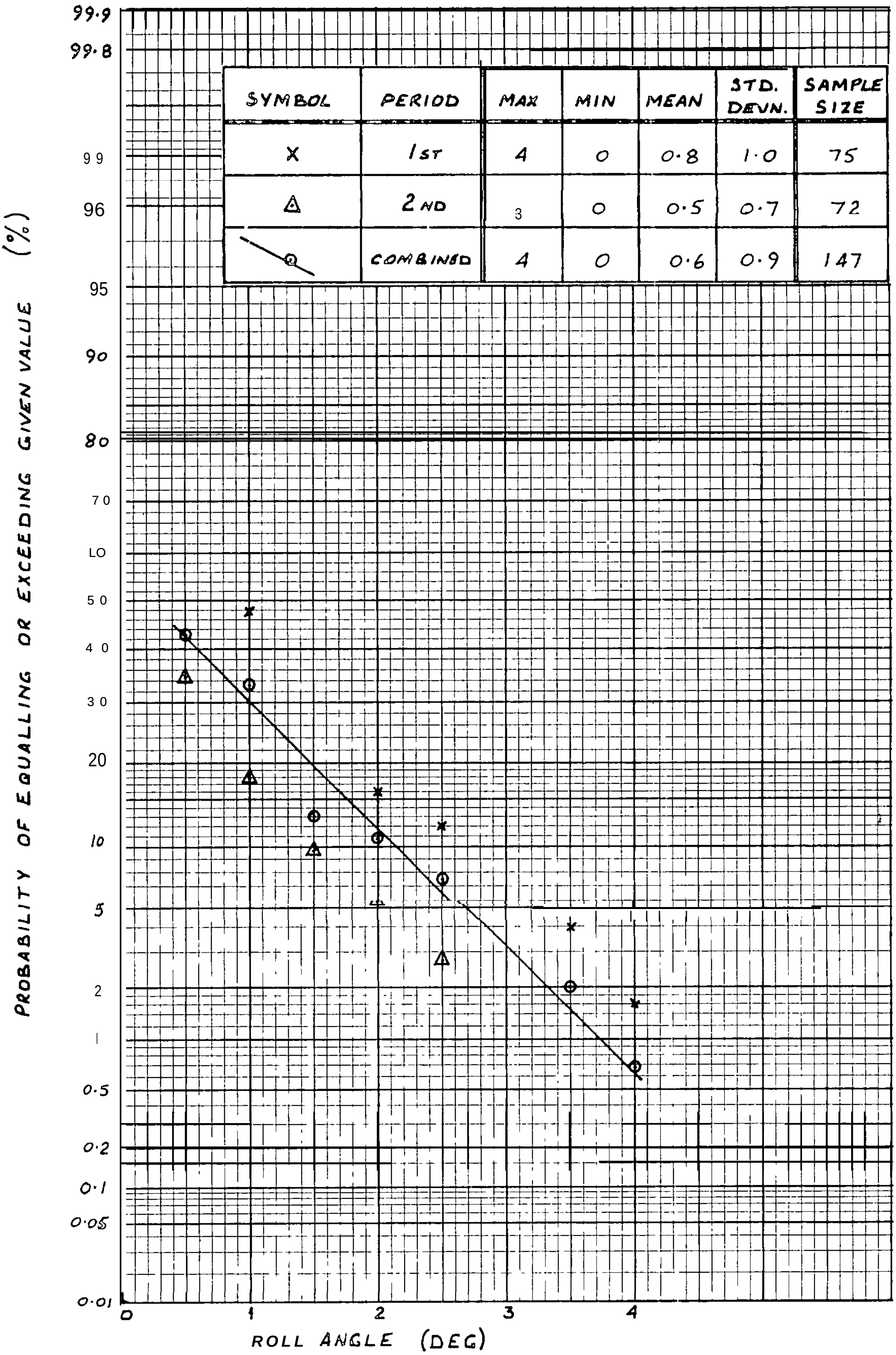


Fig.38 **Roll angle at second impact**
Aircraft Type E_1

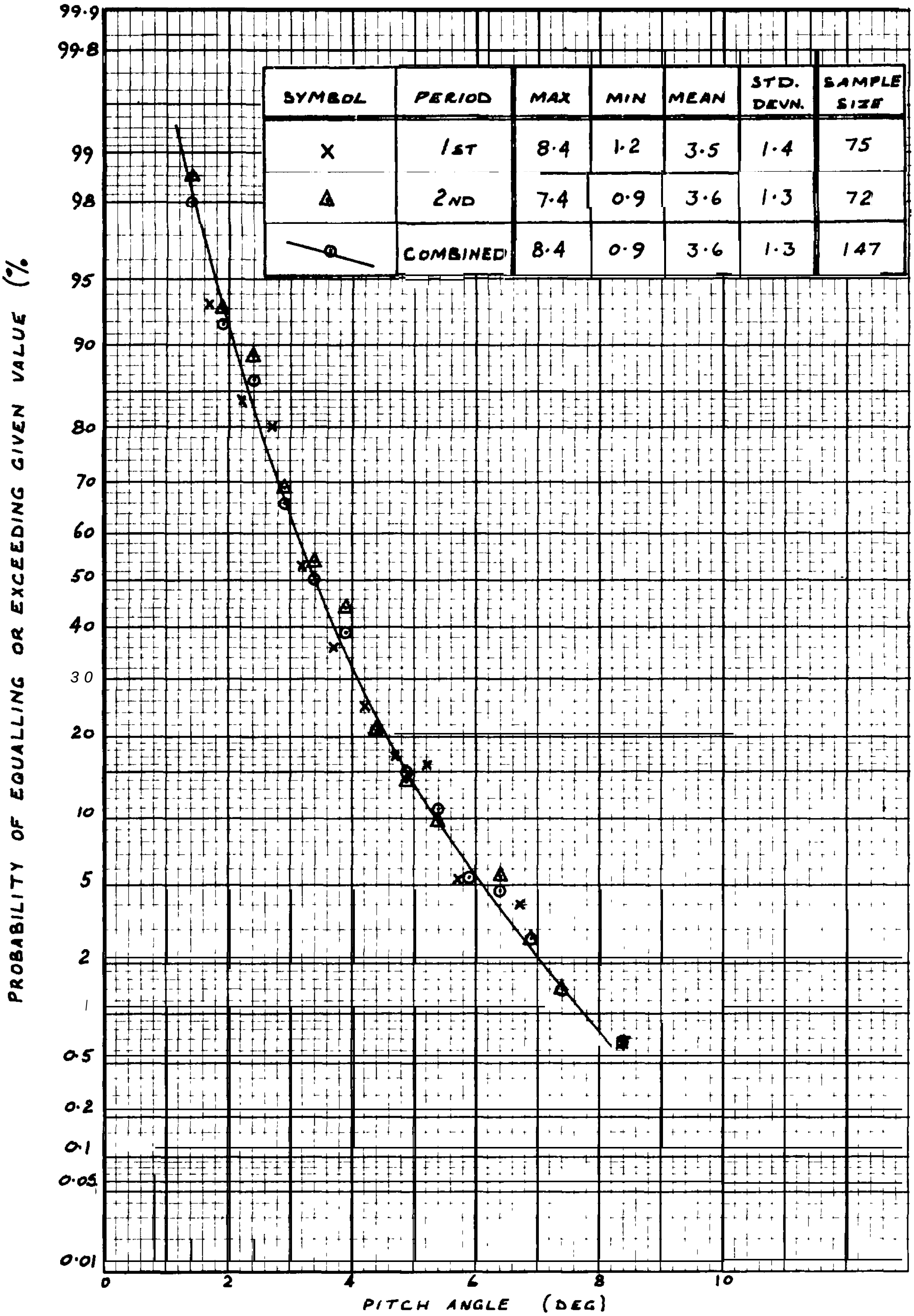
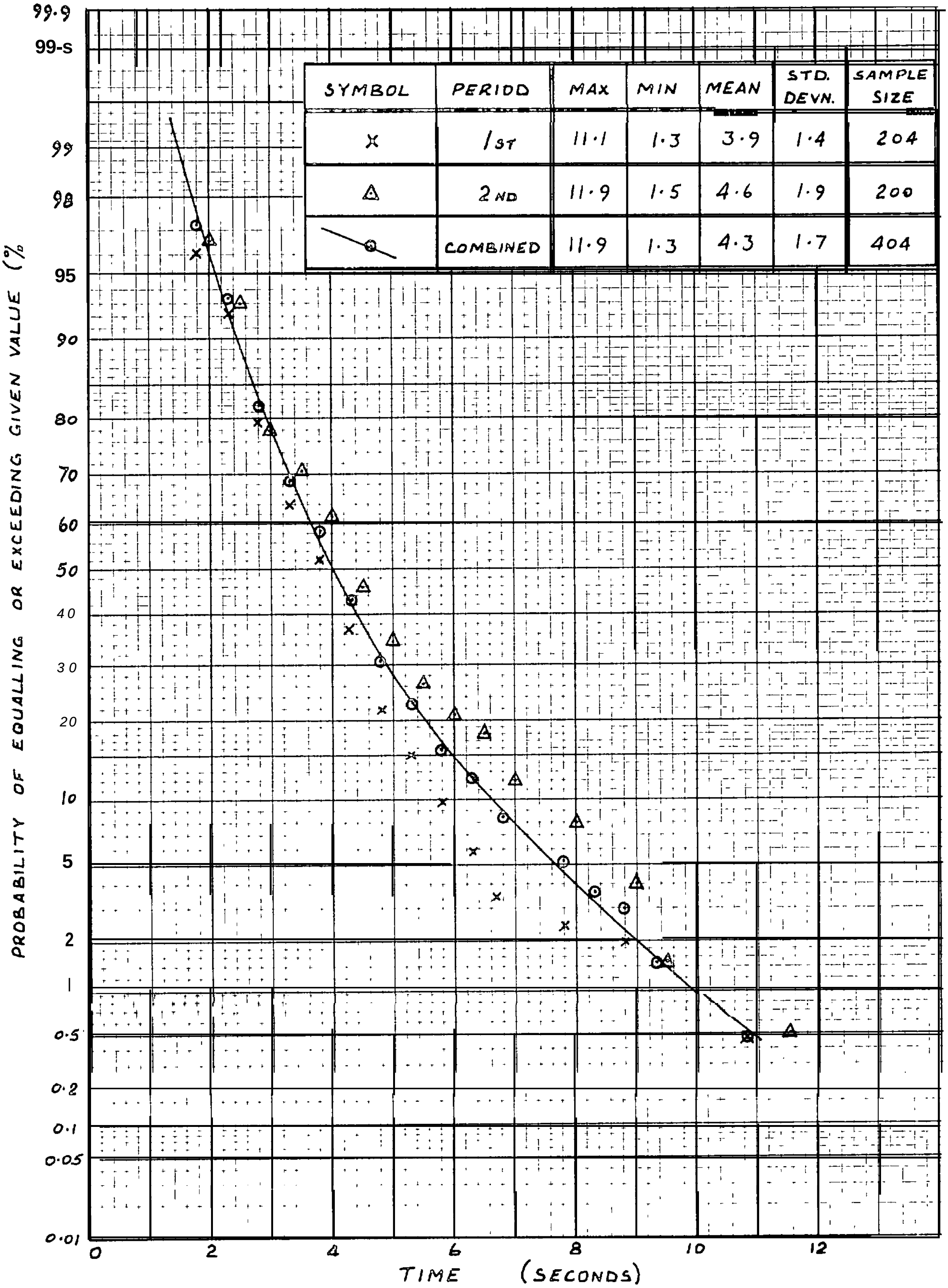


Fig.39 Pitch angle at second impact
Aircraft Type E_1



SYMBOL	PERIOD	MAX	MIN	MEAN	STD. DEVN.	SAMPLE SIZE
×	1st	11·1	1·3	3·9	1·4	204
△	2nd	11·9	1·5	4·6	1·9	200
—⊙—	COMBINED	11·9	1·3	4·3	1·7	404

Fig.48 Time from first impact to nosewheel impact
Aircraft Type E_1

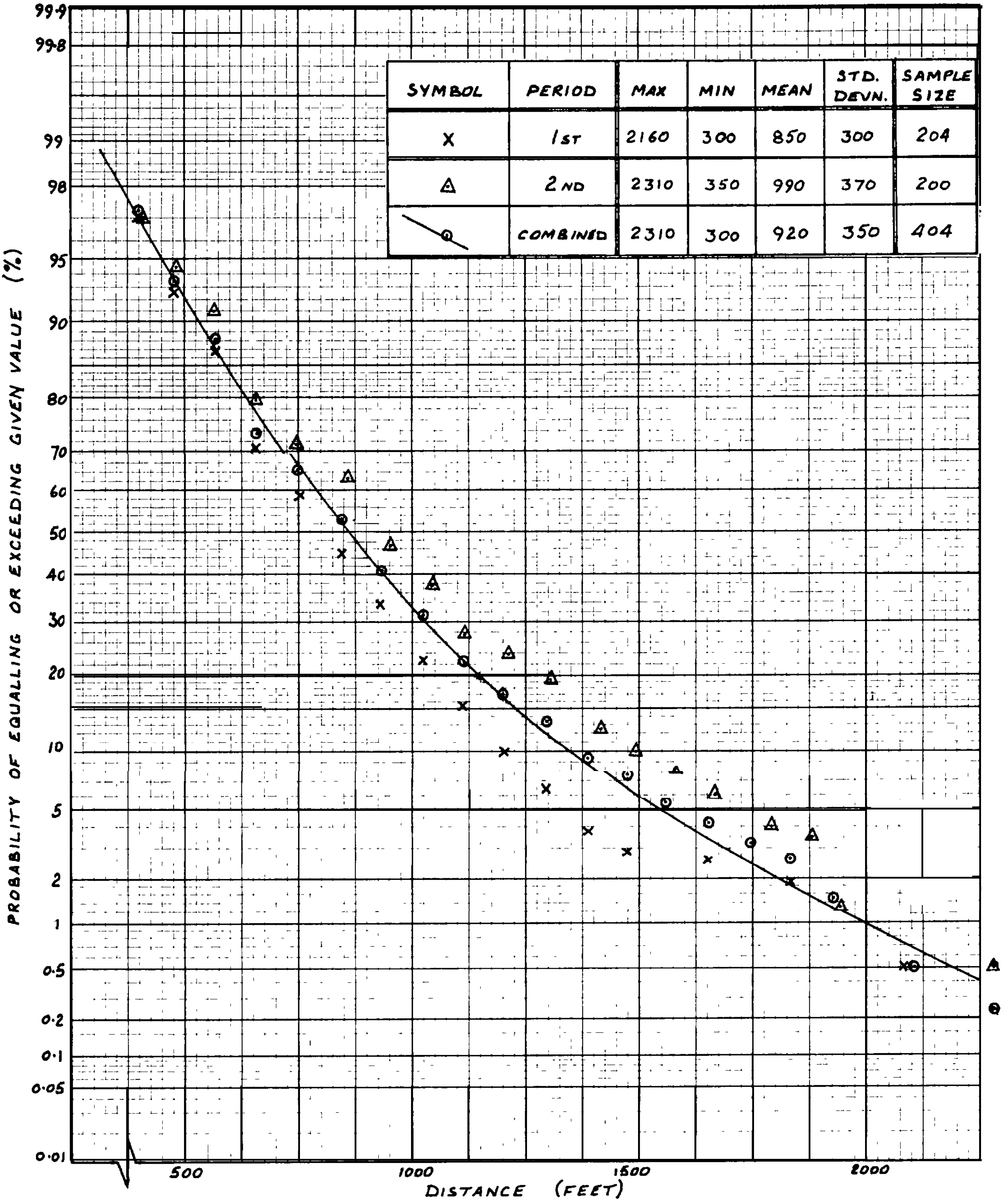


Fig.41 Distance travelled from first impact to nosewheel impact
Aircraft Type E_1

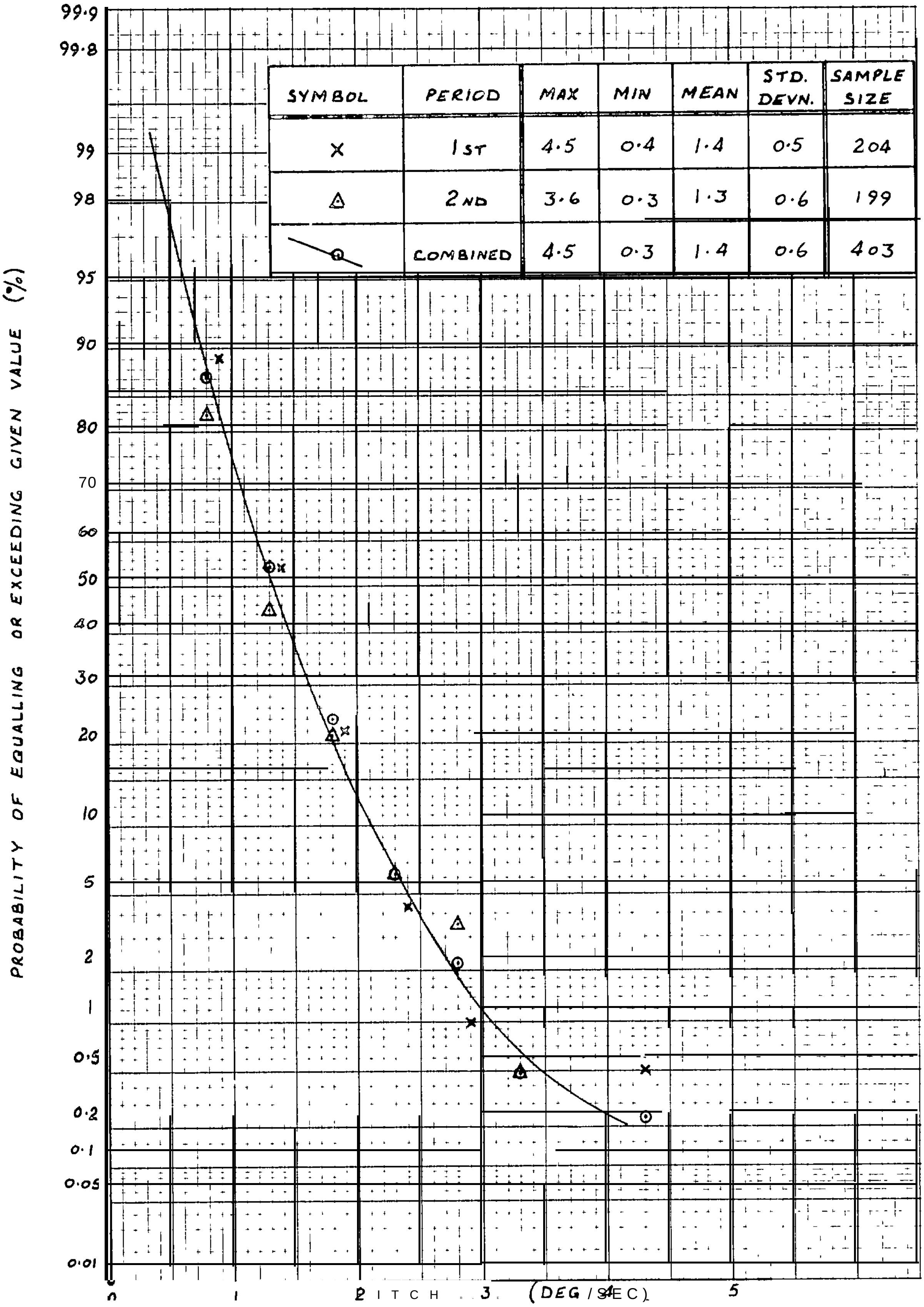


Fig.42 Mean pitch rate during 2 s prior to nosewheel impact
Aircraft Type E_1

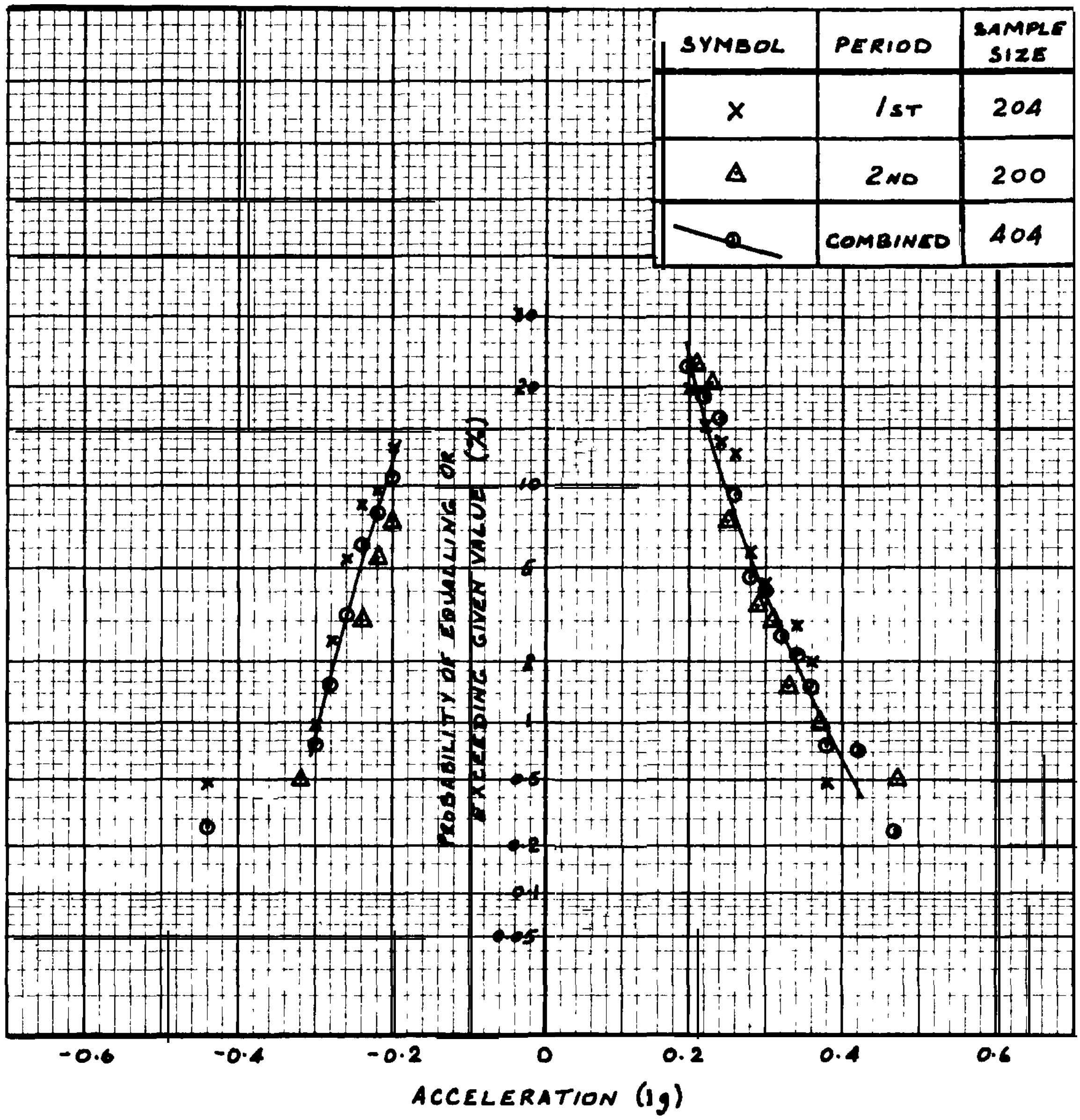


Fig.43 Extreme positive or negative CG normal acceleration increment above 1g datum during landing run Aircraft Type E_1

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May 1972

Hutton, G. B.

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A statistical study was conducted of a number of performance and flying control parameters on two aircraft types during final approach and landing. Approximately 200 landings from each of two periods with a gap of one year were studied on both aircraft types and the results show the probability of meeting or exceeding various values of each parameter together with mean values and standard deviations.

There was generally little difference in the results of the two periods sampled (above 5% probability) on either aircraft type, the most significant being the CG normal acceleration at touchdown on one aircraft type studied.

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