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Online Instructor's Manual
to accompany

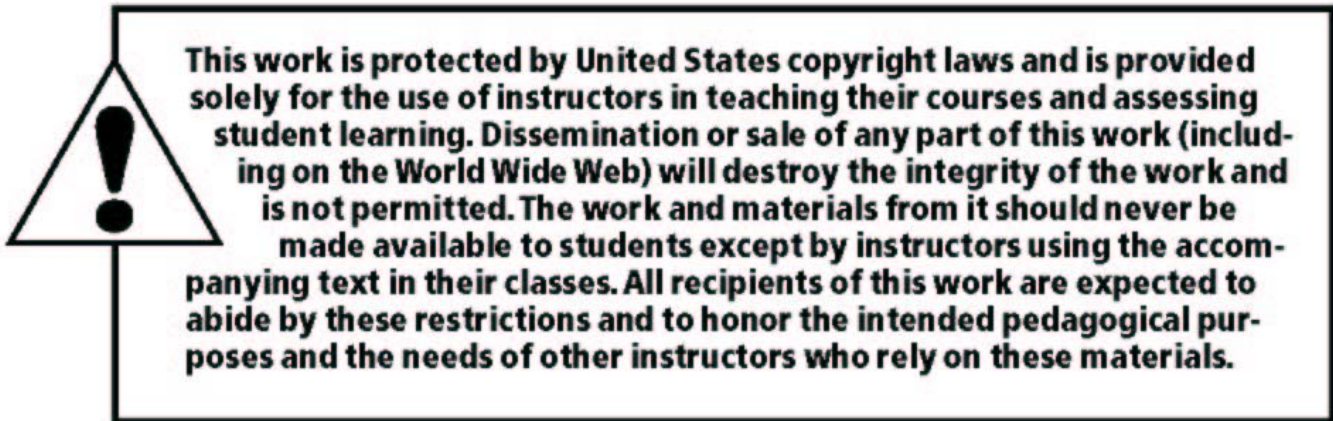
Quality Control

Eighth Edition

Dale H. Besterfield Ph.D., P.E.



Upper Saddle River, New Jersey
Columbus, Ohio



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Instructors of classes using Besterfield, *Quality Control*, 8th ed., may reproduce material from the instructor's manual for classroom use.

10 9 8 7 6 5 4 3 2 1



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PREFACE

This manual has been published to simplify the instructor's tasks of developing learning activities and evaluating performance. It is based on the experience of the author and is meant to serve as a guide. Each instructor will need to modify this information for the particular course objectives and the ability level of the students.

For those teachers who are familiar with the *Seventh Edition* of the textbook, information on the major changes to the *Eighth Edition* is provided. This information should simplify the transition to the latest edition.

A typical course outline for a three-semester hour course is shown on Page 3. The learning activities are based on 45 class meetings of 50 minutes each. Since it is difficult to cover all of the material in a typical three-semester hour course, this outline concentrates on the quantifiable aspects of quality control. The instructor may wish to place greater emphasis on the first three chapters, which are non-quantifiable and build a transition to the statistical aspects of quality..

Solutions for the problems start on Page 4. The author has found it advantageous to post the solutions. This action allows students to determine if their methods and answer are correct.

Typical multiple-choice test questions are given and an asterisk indicates the correct answer. These questions can be modified in a number of ways depending on the creativity of the instructor. Answers to test problems are also given. Since the tables in the body of the text and in the Appendix are needed to solve the problems, an open-book type examination should be considered. The instructor may also consider providing copies of the tables and using a closed-book format. Regardless, the multiple-choice questions can be given in the closed-book format. The author has found that allowing the students 3x5 cards for formulas and other information is a great learning experience.

Major Changes to the Eighth Edition

General

1. Problems to exercises.
2. Objectives added to each chapter.
3. Where appropriated changed product to product or service.
4. Where appropriated changed company to organization
5. Footnotes are provided for more advanced topics.
6. Changed exercise notation to include the chapter such as 1-1, ..., 1-6; 2-1, ..., 2-8, etc.

Chapter 1

1. Added ASQ definition of quality.
2. Changed slide projector to plasma TV in Table 1-1.
3. Modified Figure 1-1.
4. Added exercises.

Chapter 2

1. Added Lean to Figure 2-1 along with other modifications.
2. Added time line to annual quality improvement program.
3. Added that performance measures should not be used as a “whip.”
4. Clarified Figure 2-7 with a footnote.
5. Revised Figure 2-8 and Table 2-4

Chapter 3

1. Moved scatter diagram to Chapter 4

Chapter 4

1. Changed weekly wage numbers for example on range
2. Added coefficient of variation to other measures
3. Added least squares calculations to scatter diagram.

Chapter 5

1. Added additional statistical information to six sigma.
2. Added exponential moving average chart with exercises.
3. Added ARL

Chapter 6

1. Added footnotes as links to recent literature on T^2 multivariate chart and deviation chart.

Chapter 7

1. Added mean and standard deviation formulas to hypergeometric, binomial, and Poisson distributions.
2. Added exercises 17 and 18 and renumbered the rest.
3. Eliminated examples and exercises concerning approximation techniques because they are obsolete.

Chapter 8

1. Added information on sample size and confidence limits.

Chapter 9

1. Changed meaning of AQL

Chapter 10

1. Latest standards revision.

Chapter 11

1. Added a section on test design with footnotes to advanced material.

Chapter 12

1. Added footnotes to information on use of these techniques for innovative design.

TYPICAL COURSE OUTLINE

<u>Meeting</u>	<u>Topic</u>	<u>Chapter</u>
1	Introduction to Quality	1
2 and 3	TQM - Principle practices	2
4	TQM - Tools & Techniques	3
5 thru 9	Fundamentals of Statistics	4
10 thru 15	Control Charts for Variables	5
16	Examination I	
17 and 18	Additional SPC Techniques for Variables	6
19 thru 23	Fundamentals of Probability	7
24 thru 28	Control Charts for Attributes	8
29	Examination II	
30 thru 39	Lot-by-Lot Acceptance Sampling by Attributes	9
40 thru 43	Acceptance Sampling Plan Systems	10
44	Reliability (non quantitative)	11
45	Examination III	

Chapter 3. TQM—TOOLS AND TECHNIQUES

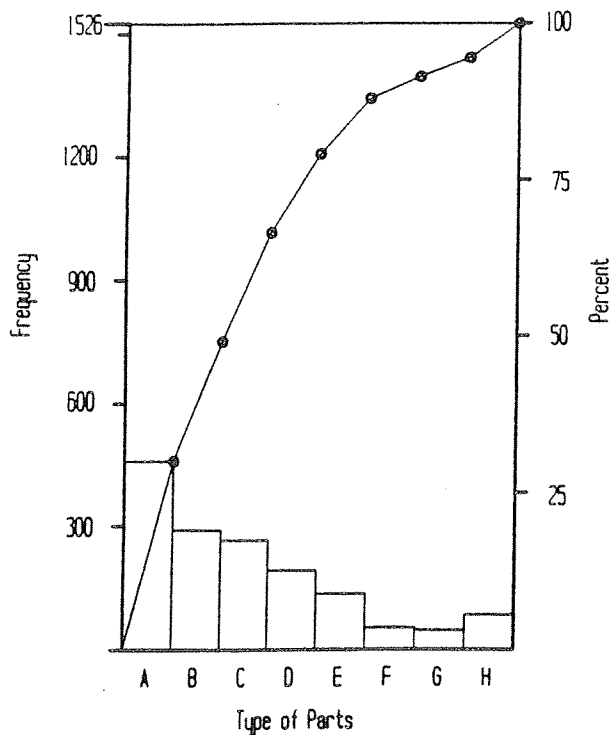
1. Replacement Parts: (6-month period)

	<u>Frequency</u>	<u>Percent</u>	<u>Cumulative Frequency</u>	<u>Cumulative Percent</u>
A. front burners	460	.30	460	.30
B. rear burners	290	.19	750	.49
C. oven regulators	265	.17	1015	.66
D. oven door	193	.13	1208	.79
E. burner control	135	.09	1343	.88
F. timer	53	.03	1396	.91
G. drawer rollers	46	.03	1442	.94
H. All others	84	.06	1526	1.00
	1526	1.00		

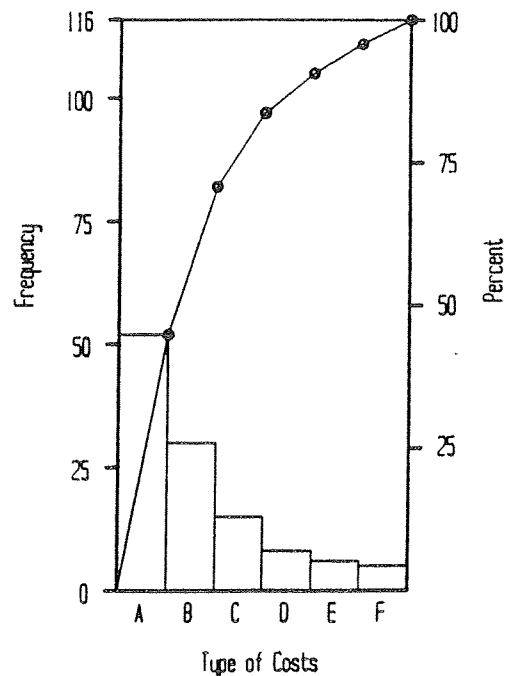
2. Downtime Costs: (3-month period) in thousands of dollars

	<u>Frequency</u>	<u>Percent</u>	<u>Cumulative Frequency</u>	<u>Cumulative Percent</u>
A. lost cooling	52	.45	52	.45
B. back pressure reg.	30	.26	82	.71
C. adjust feed worm	15	.13	97	.84
D. valve replacement	8	.07	105	.91
E. jam copperhead	6	.05	111	.96
F. All others	5	.04	116	1.00
	116	1.00		

(1)



(2)



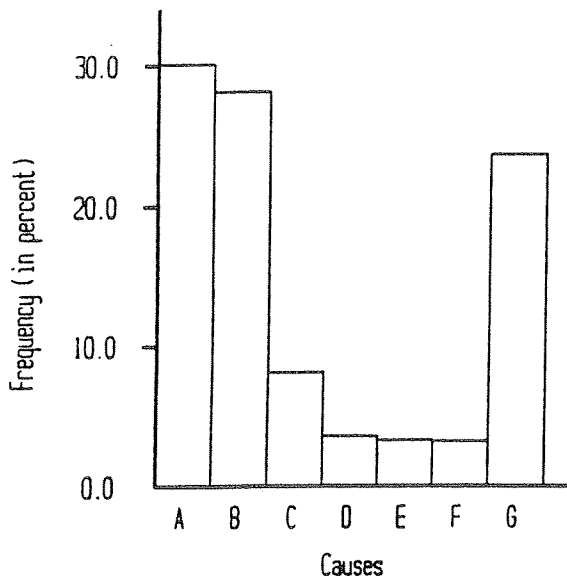
3 Cause of accident in percent

a. right-of-way violation	30.1
b. driving too fast for condition	28.1
c. following too closely	8.1
d. improper turn	3.6
e. driving left of center	3.3
f. improper overtaking	3.2
g. all other	<u>23.6</u>
	100.0

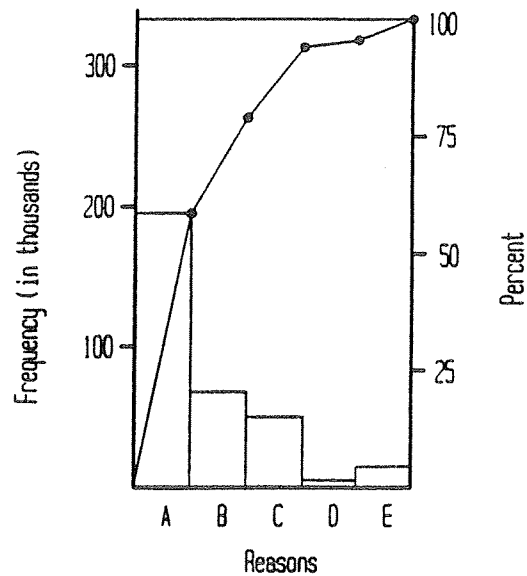
4. Reason for Shipment Return: (quarter)
in thousands

	<u>Frequency</u>	<u>Percent</u>	<u>Cumulative Frequency</u>	<u>Cumulative Percent</u>
A. refused	195	.585	195	.59
B. wrong address	68	.20	263	.79
C. wrong selection	50	.15	313	.94
D. order canceled	5	.02	318	.96
E. All other	<u>15</u>	<u>.045</u>	333	1.00
	333	1.00		

(3)

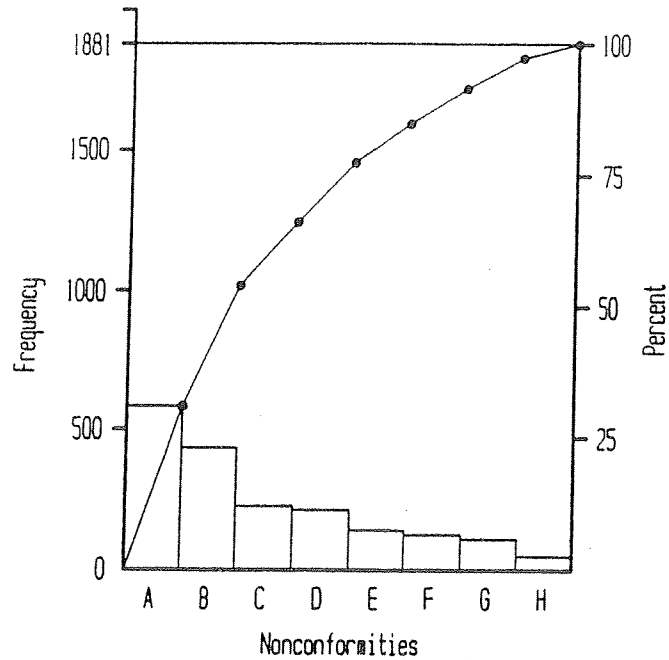


(4)

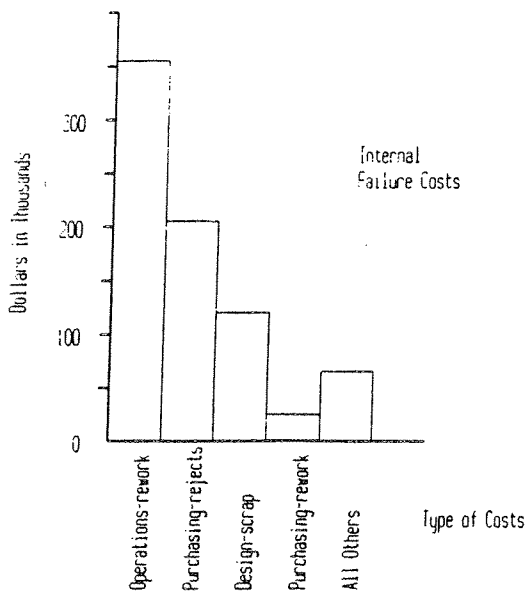


5. Paint Nonconformities: (1-month)

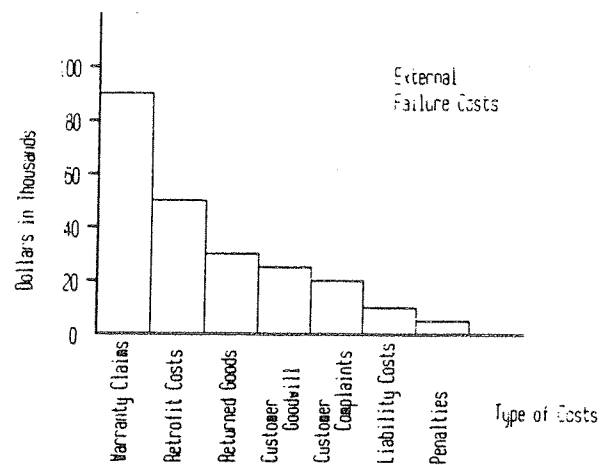
	Frequency	Percent	Cumulative Frequency	Cumulative Percent
A. light spray	582	.31	582	.31
B. runs	434	.23	1016	.54
C. drips	227	.12	1243	.66
D. blisters	212	.11	1455	.77
E. splatter	141	.07	1596	.84
F. bad paint	126	.07	1722	.91
G. overspray	109	.06	1831	.97
H. All others	50	.03	1881	1.00
	1881	1.00		



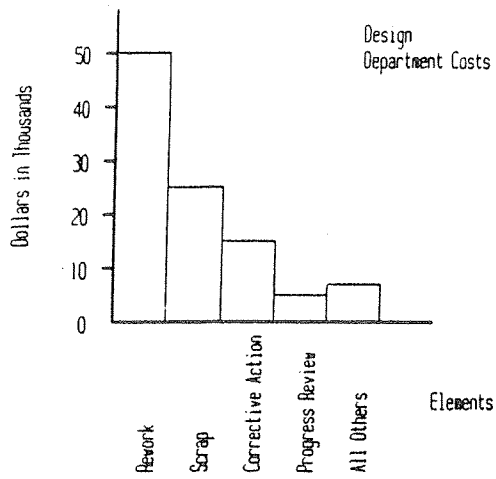
6.



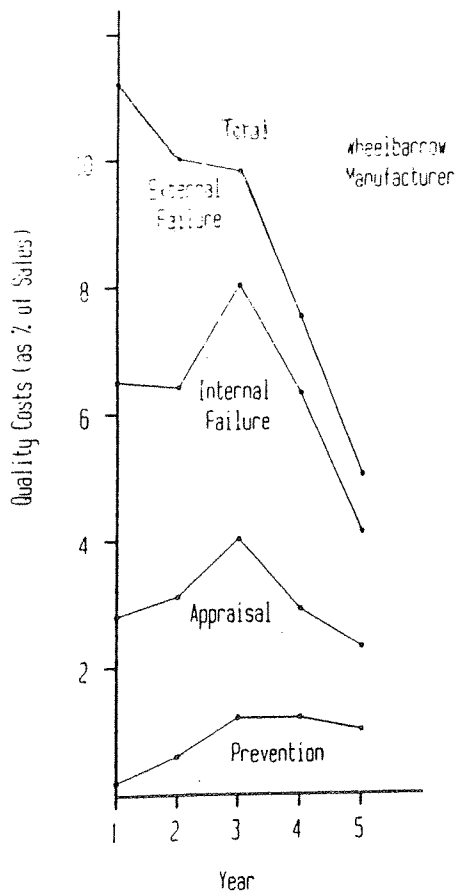
7.



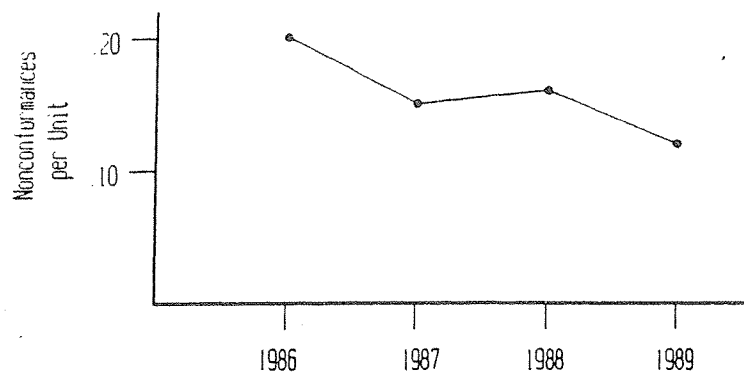
8.



9.



10.



There is a downward trend over the four years.

11-13. See pages 79-82 for examples.

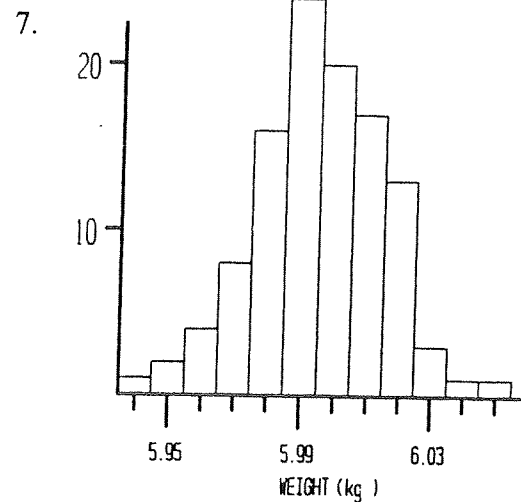
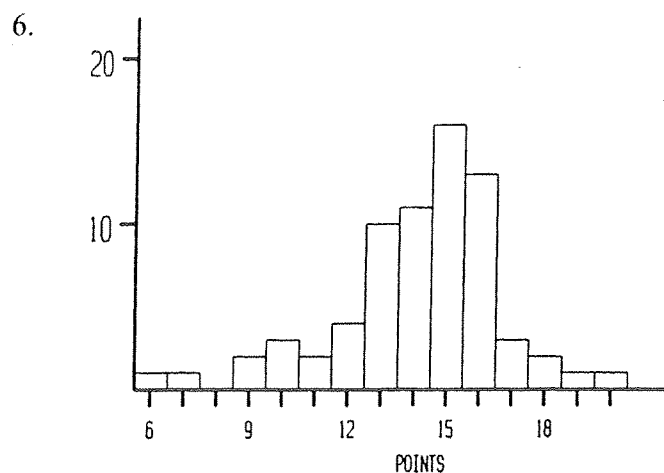
Chapter 4. FUNDAMENTALS OF STATISTICS

1. 0.86, 0.63, 0.15, 0.48

2, 3.	Number	Boundaries	Precision	g.p.e.	r.e.
(a)	8.24	$8.235 < 8.24 < 8.45$	0.01	0.005	0.0006
(b)	522	$521.5 < 522 < 522.5$	1	0.5	0.001
(c)	6.3×10	$625 < 630 < 635$	10	5	0.002
(d)	0.02	$0.015 < 0.02 < 0.025$	0.01	0.005	0.3

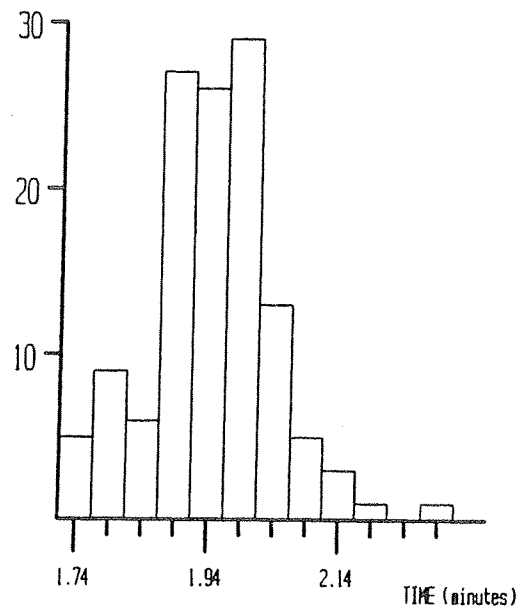
4. 2.84×10^2 , 22, 0.64, 0.8937, 0.9

5. 66.4, 379.1, 5, 4.652, 6.2×10^2

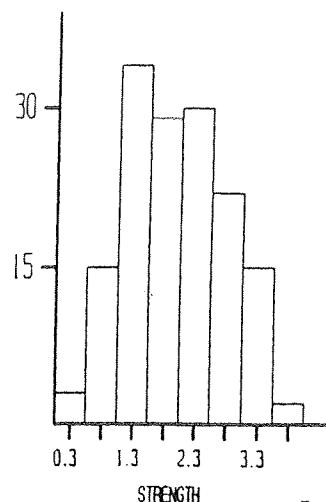


8.

<u>Cell Boundaries</u>	<u>Cell Midpoint</u>	<u>Frequency</u>
1.72-1.76	1.74	5
1.77-1.81	1.79	9
1.82-1.86	1.84	6
1.87-1.91	1.89	27
1.92-1.96	1.94	26
1.97-2.01	1.99	29
2.02-2.06	2.04	13
2.07-2.11	2.09	5
2.12-2.16	2.14	3
2.17-2.21	2.19	1
2.22-2.26	2.24	0
2.27-2.31	2.29	1



9.	Cell Boundaries	Cell Midpoints	Frequency
	0.05-0.54	0.3	3
	0.55-1.04	0.8	15
	1.05-1.54	1.3	34
	1.55-2.04	1.8	29
	2.05-2.54	2.3	30
	2.55-3.04	2.8	22
	3.05-3.54	3.3	15
	3.55-4.04	3.8	2



10.

Scores	Freq.	Relative Freq.	Cumulative Freq.	Relative Cumulative Freq.
6	1	$1/70 = 0.014$	$0+1 = 1$	$1/70 = 0.014$
7	1	$1/70 = 0.014$	$1+1 = 2$	$2/70 = 0.029$
8	0	$0/70 = 0$	$2+0 = 2$	$2/70 = 0.029$
9	2	$2/70 = 0.029$	$2+2 = 4$	$4/70 = 0.057$
10	3	$3/70 = 0.043$	$4+3 = 7$	$7/70 = 0.100$
11	2	$2/70 = 0.029$	$7+2 = 9$	$9/70 = 0.129$
12	4	$4/70 = 0.057$	$9+4 = 13$	$13/70 = 0.186$
13	10	$10/70 = 0.143$	$13+10 = 23$	$23/70 = 0.329$
14	11	$11/70 = 0.157$	$23+11 = 34$	$34/70 = 0.486$
15	16	$16/70 = 0.229$	$34+16 = 50$	$50/70 = 0.714$
16	13	$13/70 = 0.186$	$50+13 = 63$	$63/70 = 0.900$
17	3	$3/70 = 0.043$	$63+3 = 66$	$66/70 = 0.943$
18	2	$2/70 = 0.029$	$66+2 = 68$	$68/70 = 0.971$
19	1	$1/70 = 0.014$	$68+1 = 69$	$69/70 = 0.986$
20	<u>1</u>	$1/70 = 0.014$	$69+1 = 70$	$70/70 = 1.000$
	70	1.00		

Graph not shown, but similar to Problem 13

11.

Weights	Freq.	Relative Freq.	Cumulative Freq.	Relative Cumulative Freq.
5.94	1	$1/110 = 0.9\%$	$0+1 = 1$	$1/110 = 0.9\%$
5.95	2	$2/110 = 1.8$	$1+2 = 3$	$3/110 = 2.7$
5.96	4	$4/110 = 3.6$	$3+4 = 7$	$7/110 = 6.4$
5.97	8	$8/110 = 7.3$	$7+8 = 15$	$15/110 = 13.6$
5.98	16	$16/110 = 14.5$	$15+16 = 31$	$31/110 = 28.2$
5.99	24	$24/110 = 21.8$	$31+24 = 55$	$55/110 = 50.0$
6.00	20	$20/110 = 18.2$	$55+20 = 75$	$75/110 = 68.2$
6.01	17	$17/110 = 15.5$	$75+17 = 92$	$92/110 = 83.6$
6.02	13	$13/110 = 11.8$	$92+13 = 105$	$105/110 = 95.4$
6.03	3	$3/110 = 2.7$	$105+3 = 108$	$108/110 = 98.2$
6.04	1	$1/110 = 0.9$	$108+1 = 109$	$109/110 = 99.1$
6.05	<u>1</u>	$1/110 = 0.9$	$109+1 = 110$	$110/110 = 100.0\%$
	110	99.9%		

Graph not shown, but similar to Problem 13

12.

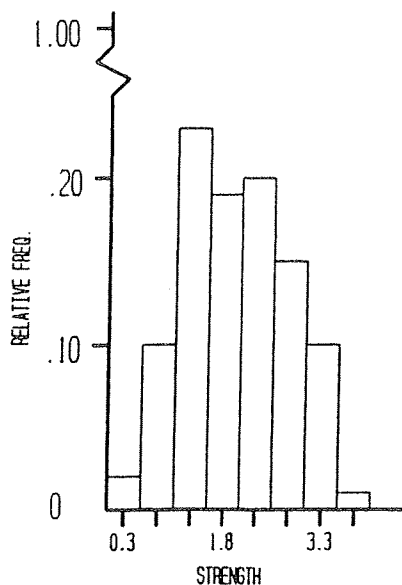
Cell Midpoint	Freq.	Relative Freq.	Cumulative Freq.	Relative Cumulative Freq.
1.74	5	$5/125 = 0.040$	$0+5 = 5$	$5/125 = 0.040$
1.79	9	$9/125 = 0.072$	$5+9 = 14$	$14/125 = 0.112$
1.84	6	$6/125 = 0.048$	$14+6 = 20$	$20/125 = 0.160$
1.89	27	$27/125 = 0.216$	$20+27 = 47$	$47/125 = 0.376$
1.94	26	$26/125 = 0.208$	$47+26 = 73$	$73/125 = 0.584$
1.99	29	$29/125 = 0.232$	$73+29 = 102$	$102/125 = 0.816$
2.04	13	$13/125 = 0.104$	$102+13 = 115$	$115/125 = 0.920$
2.09	5	$5/125 = 0.040$	$115+5 = 120$	$120/125 = 0.960$
2.14	3	$3/125 = 0.024$	$120+3 = 123$	$123/125 = 0.984$
2.19	1	$1/125 = 0.008$	$123+1 = 124$	$124/125 = 0.992$
2.24	0	$0/125 = 0$	$124+0 = 124$	$124/125 = 0.992$
2.29	1	$1/125 = 0.008$	$124+1 = 125$	$125/125 = 1.000$
	<u>125</u>	<u>1.000</u>		

Graph not shown, but similar to Problem 13

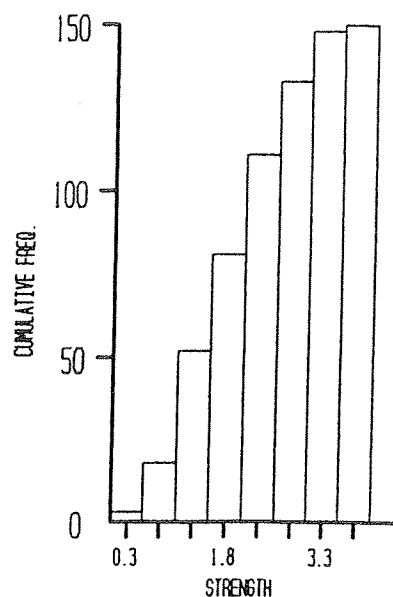
13.

Cell Midpoint	Freq.	Relative Freq.	Cumulative Freq.	Relative Cumulative Freq.
0.3	3	$3/150 = 0.020$	$0+3 = 3$	$3/150 = 0.020$
0.8	15	$15/150 = 0.100$	$3+15 = 18$	$18/150 = 0.120$
1.3	34	$34/150 = 0.227$	$18+34 = 52$	$52/150 = 0.347$
1.8	29	$29/150 = 0.193$	$52+29 = 81$	$81/150 = 0.540$
2.3	30	$30/150 = 0.200$	$81+30 = 111$	$111/150 = 0.740$
2.8	22	$22/150 = 0.147$	$111+22 = 133$	$133/150 = 0.888$
3.3	15	$15/150 = 0.100$	$133+15 = 148$	$148/150 = 0.987$
3.8	2	$2/150 = 0.013$	$148+2 = 150$	$150/150 = 1.000$
	<u>150</u>	<u>1.000</u>		

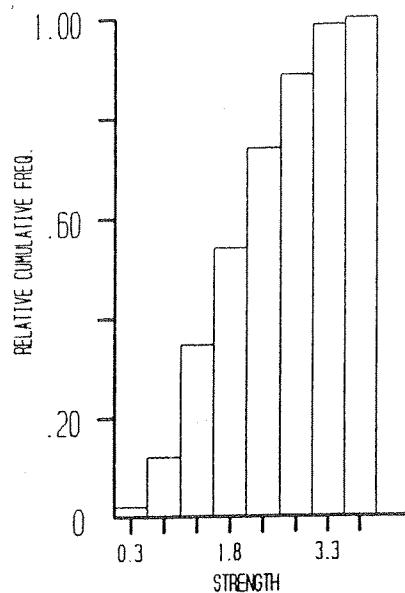
13a



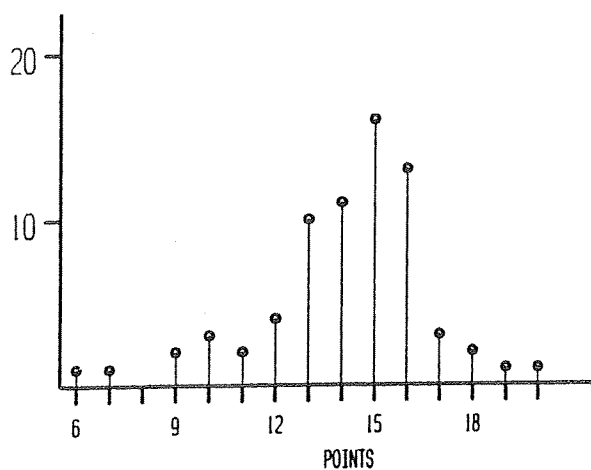
13b



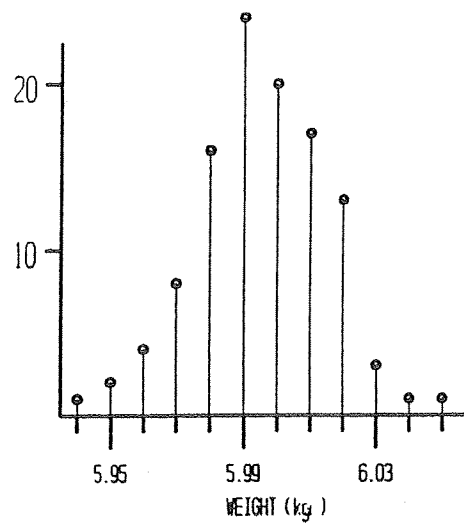
13c



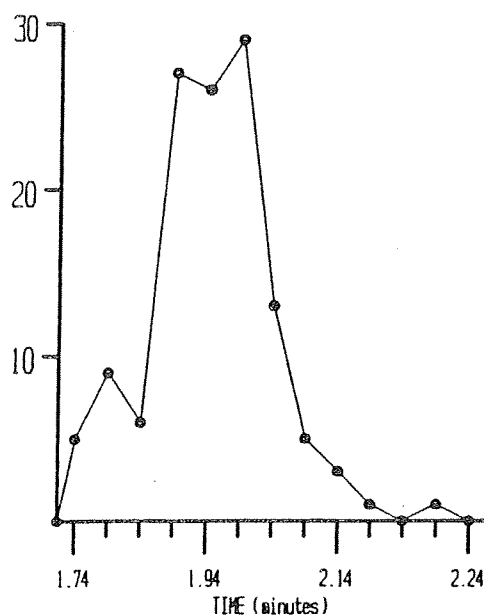
14a



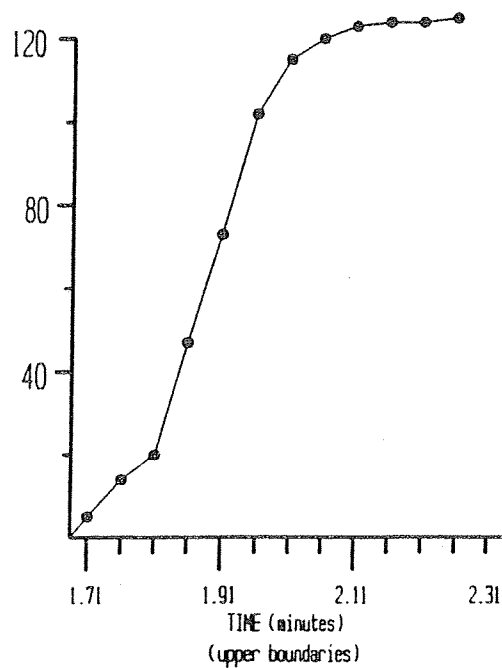
14b



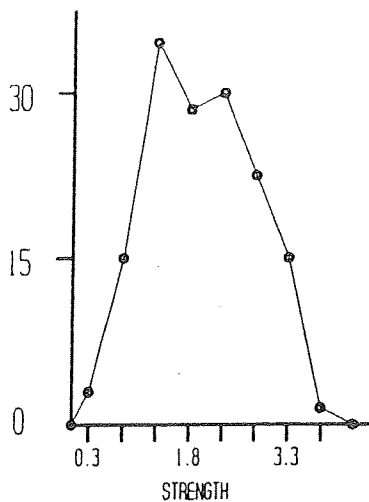
15a



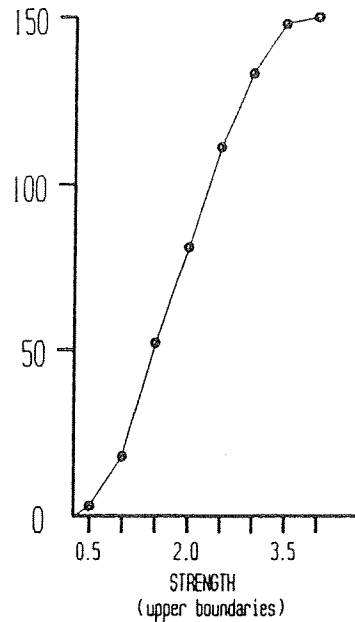
15b



16a



16b



$$17. \quad \bar{X} = \Sigma x/n = \frac{115 + 113 + 121 + 115 + 116}{5} = 116 \text{ volts}$$

$$18. \quad \bar{X} = \frac{\Sigma x}{n} = \frac{25.6 + 24.8 + 22.6 + 21.3 + 19.6 + 18.5 + 16.2 + 15.5}{8} = 20.5 \text{ m}$$

19.	$\frac{x}{148}$	$\frac{f}{2}$	$\frac{fx}{296}$	$\begin{aligned} \bar{X} &= \frac{\Sigma fx}{n} \\ &= \frac{19,508}{206} \\ &= 95 \text{ db} \end{aligned}$
	139	3	417	
	130	8	1,040	
	121	11	1,331	
	112	27	3,024	
	103	35	3,605	
	94	43	4,042	
	85	33	2,805	
	76	20	1,520	
	67	12	804	
	58	6	348	
	49	4	196	
	40	2	80	
		<u>206</u>	<u>19,508</u>	

20.	$\frac{x}{3.5}$	$\frac{f}{6}$	$\frac{fx}{21.0}$	$\begin{aligned} \bar{X} &= \frac{\Sigma fx}{n} \\ &= \frac{276.7}{65} \\ &= 4.3 \text{ kg} \end{aligned}$
	3.8	9	34.2	
	4.1	18	73.8	
	4.4	14	61.6	
	4.7	13	61.1	
	5.0	5	25.0	
		<u>65</u>	<u>276.7</u>	

$$21. \quad \bar{X}_w = \Sigma w\bar{X} / \Sigma w$$

$$= \frac{(3)(3320) + (2)(3180)}{3 + 2}$$

$$= 3264 \text{ h}$$

$$22. \bar{\chi}_w = \Sigma w\bar{\chi} / \Sigma w$$

$$= \frac{(24)(1.75) + (18)(1.79) + (29)(1.68)}{24 + 18 + 29}$$

$$= 1.73 \text{ m}$$

$$23. \text{ a. } 8, 11, 15, 18, 22; \text{ Md} = 15$$

$$\text{ b. } 28, 33, 35, 36, 38, 43; \text{ Md} = \frac{35 + 36}{2} = 35.5$$

$$24. \text{ a. } \text{Md} = L + \left(\frac{\frac{n}{2} - cf}{f} \right) i = 1.915 + \left(\frac{\frac{125}{2} - 47}{26} \right) 0.05 = 1.94$$

$$\text{ b. } \text{Md} = 1.55 + \left(\frac{\frac{150}{2} - 52}{29} \right) 0.5 = 1.95$$

$$\text{ c. } \text{Md} = 90 + \left(\frac{\frac{206}{2} - 77}{43} \right) 9 = 95 \text{ db}$$

$$\text{ d. } \text{Md} = 4.0 + \left(\frac{\frac{65}{2} - 15}{18} \right) .3 = 4.3$$

$$\text{ e. } \text{Md} = 1.60 + \left(\frac{\frac{88}{2} - 39}{12} \right) 0.3 = 1.73$$

$$\text{ f. } \text{Md} = 1450 + \left(\frac{\frac{77}{2} - 19}{22} \right) 300 = 1716$$

$$25. 55, \text{ none}, 14 \text{ and } 17$$

$$26. 15, 5.99, 1.99, 1.3, 94, 4.1$$

$$27. \text{ a. } R = H - L = 25 - 14 = 11$$

$$\text{ c. } R = H - L = 20 - 6 = 14$$

$$\text{ b. } R = 45 - 39 = 6$$

$$\text{ d. } R = 6.05 - 5.94 = 0.11$$

$$28. s = \sqrt{\frac{n\Sigma\chi^2 - (\Sigma\chi)^2}{n(n-1)}} = \sqrt{\frac{5(7152350) - (5980)^2}{5(5-1)}} = 8.2 \text{ vib/sec}$$

$$29. s = \sqrt{\frac{4(0.024) - (.308)^2}{4(4-1)}} = 0.004 \text{ mm}$$

30.

Mid-point	Freq.		
(x)	(f)	(fx)	(fx ²)
.5	1	.5	0.3
.8	16	12.8	10.2
1.1	12	13.2	14.5
1.4	10	14.0	19.6
1.7	12	20.4	34.7
2.0	18	36.0	72.0
2.3	16	36.8	84.6
2.6	3	7.8	20.3
	<u>88</u>	<u>141.5</u>	<u>256.2</u>

$$s = \sqrt{\frac{n \sum f X^2 - (\sum f X)^2}{n(n-1)}}$$

$$= \sqrt{\frac{88(256.2) - (141.5)^2}{88(88-1)}}$$

$$= .57\%$$

31a. Mid-point

Mid-point	Freq.		
(x)	(f)	(fx)	(fx ²)
0.3	3	0.9	0.27
0.8	15	12.0	9.60
1.3	34	44.2	57.46
1.8	29	52.2	93.96
2.3	30	69.0	158.70
2.8	22	61.6	172.48
3.3	15	49.5	163.35
3.8	<u>2</u>	<u>7.6</u>	<u>28.88</u>
	<u>150</u>	<u>297.0</u>	<u>684.70</u>

$$s = \sqrt{\frac{n \sum f X^2 - (\sum f X)^2}{n(n-1)}}$$

$$= \sqrt{\frac{150(684.7) - (297.0)^2}{150(150-1)}}$$

$$= 0.8$$

31b Mid-point

Mid-point	Freq.		
(x)	(f)	(fx)	(fx ²)
148	2	296	43,808
139	3	417	57,963
130	8	1,040	135,200
121	11	1,331	161,051
112	27	3,024	338,688
103	35	3,605	371,315
94	43	4,042	379,948
85	33	2,805	238,425
76	20	1,520	115,520
67	12	804	53,868
58	6	348	20,184
49	4	196	9,604
40	<u>2</u>	<u>80</u>	<u>3,200</u>
	<u>206</u>	<u>19,508</u>	<u>1,928,774</u>

$$s = \sqrt{\frac{n \sum f X^2 - (\sum f X)^2}{n(n-1)}}$$

$$= \sqrt{\frac{206(1,928,774) - (19,508)^2}{206(206-1)}}$$

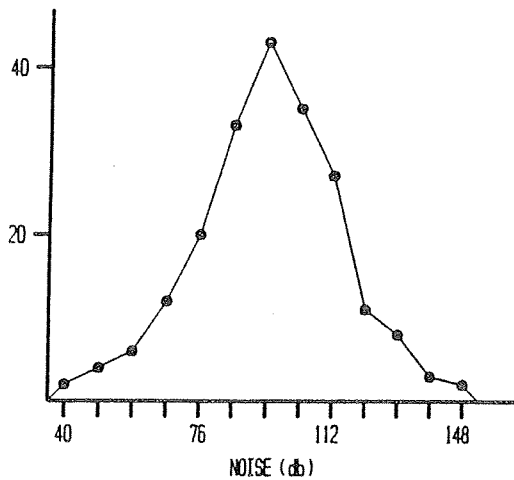
$$= 20 \text{ db}$$

Mid-point (χ)	Freq. (f)	($f\chi$)	($f\chi^2$)
1000	6	6000	6.00×10^6
1300	13	16900	21.97×10^6
1600	22	35200	56.32×10^6
1900	17	32300	61.37×10^6
2200	11	24200	53.24×10^6
2500	8	20000	50.00×10^6
	77	134.6×10^3	248.9×10^6

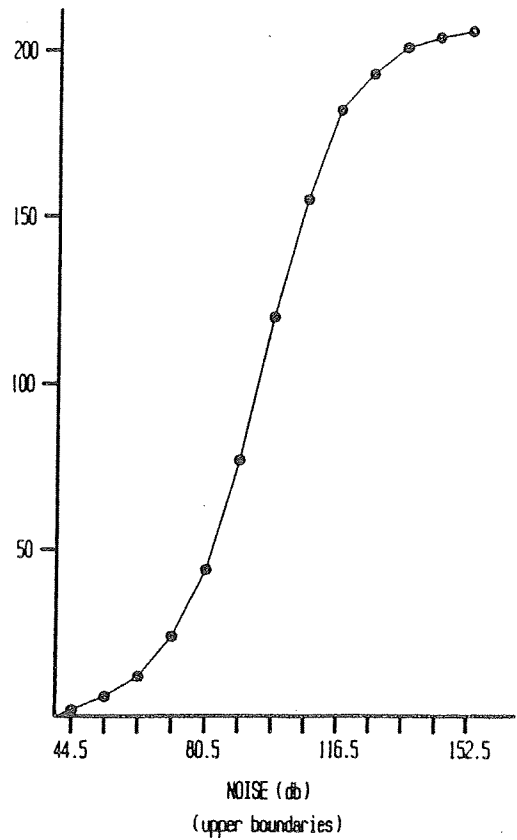
$$\bar{\chi} = \Sigma f\chi / n = 134.6 \times 10^3 / 77 = 1748 \text{ inspections}$$

$$s = \sqrt{\frac{n\Sigma f\chi^2 - (\Sigma f\chi)^2}{n(n-1)}} = \sqrt{\frac{77(248.9 \times 10^6) - (134.6 \times 10^3)^2}{77(77-1)}} = 423$$

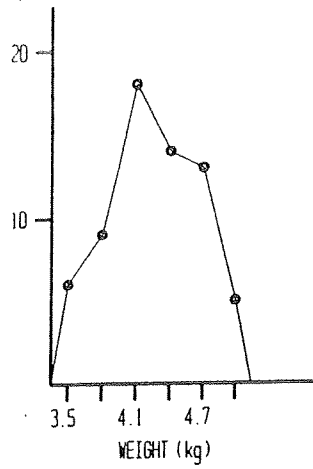
33a



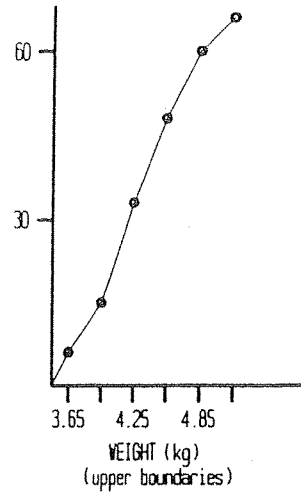
33b



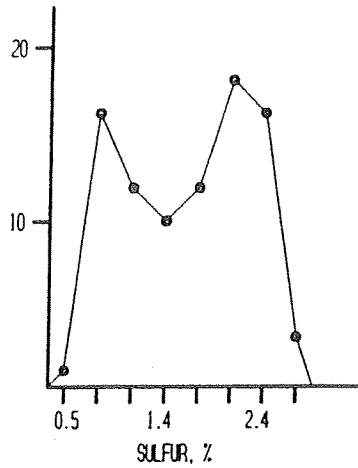
34a



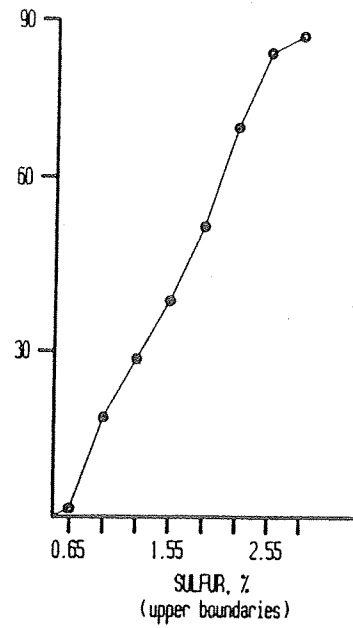
34b



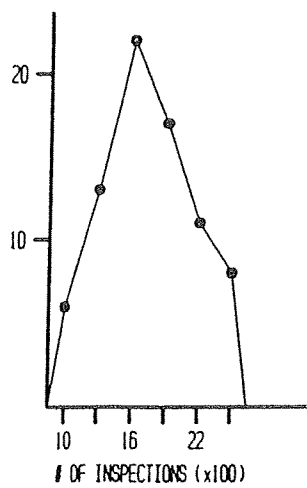
35a



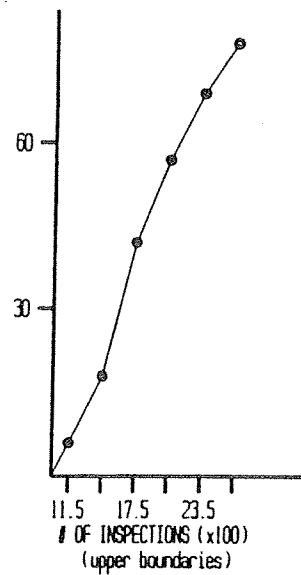
35b



36a



36b



37. Cell Mid- point	Freq.	Relative Freq.	Cumulative Freq.	Relative Cumulative Freq.
40	2	$2/206 = 0.010$	$0+2 = 2$	$2/206 = 0.010$
49	4	$4/206 = 0.019$	$2+4 = 6$	$6/206 = 0.029$
58	6	$6/206 = 0.029$	$6+6 = 12$	$12/206 = 0.058$
67	12	$12/206 = 0.058$	$12+12 = 24$	$24/206 = 0.117$
76	20	$20/206 = 0.097$	$24+20 = 44$	$44/206 = 0.214$
85	33	$33/206 = 0.160$	$44+33 = 77$	$77/206 = 0.374$
94	43	$43/206 = 0.209$	$77+43 = 120$	$120/206 = 0.583$
103	35	$35/206 = 0.170$	$120+35 = 155$	$155/206 = 0.752$
112	27	$27/206 = 0.131$	$155+27 = 182$	$182/206 = 0.883$
121	11	$11/206 = 0.053$	$182+11 = 193$	$193/206 = 0.937$
130	8	$8/206 = 0.039$	$193+8 = 201$	$201/206 = 0.976$
139	3	$3/206 = 0.015$	$201+3 = 204$	$204/206 = 0.990$
148	2	$2/206 = 0.010$	$204+2 = 206$	$206/206 = 1.000$
	<u>206</u>	<u>1.000</u>		

38. Cell Mid- point	Freq.	Relative Freq.	Cumulative Freq.	Relative Cumulative Freq.
3.5	6	$6/65 = 0.092$	$0+6 = 6$	$6/65 = 0.092$
3.8	9	$9/65 = 0.138$	$6+9 = 15$	$15/65 = 0.231$
4.1	18	$18/65 = 0.277$	$15+18 = 33$	$33/65 = 0.508$
4.4	14	$14/65 = 0.215$	$33+14 = 47$	$47/65 = 0.723$
4.7	13	$13/65 = 0.200$	$47+13 = 60$	$60/65 = 0.923$
5.0	5	$5/65 = 0.077$	$60+5 = 65$	$65/65 = 1.000$
	<u>65</u>	<u>0.999</u>		

39. Cell Mid- point	Freq.	Relative Freq.	Cumulative Freq.	Relative Cumulative Freq.
0.5	1	$1/88 = 0.011$	$0+1 = 1$	$1/88 = 0.010$
0.8	16	$16/88 = 0.182$	$1+16 = 17$	$17/88 = 0.156$
1.1	12	$12/88 = 0.136$	$17+12 = 29$	$29/88 = 0.330$
1.4	10	$10/88 = 0.114$	$29+10 = 39$	$39/88 = 0.443$
1.7	12	$12/88 = 0.136$	$39+12 = 51$	$51/88 = 0.580$
2.0	18	$18/88 = 0.205$	$51+18 = 69$	$69/88 = 0.784$
2.3	16	$16/88 = 0.182$	$69+16 = 85$	$85/88 = 0.966$
2.6	3	$3/88 = 0.034$	$85+3 = 88$	$88/88 = 1.000$
	<u>88</u>	<u>1.000</u>		

40. Cell Mid- point	Freq.	Relative Freq.	Cumulative Freq.	Relative Cumulative Freq.
1000	6	$6/77 = 0.078$	$0+6 = 6$	$6/77 = 0.078$
1300	13	$13/77 = 0.169$	$6+13 = 19$	$19/77 = 0.247$
1600	22	$22/77 = 0.286$	$19+22 = 41$	$41/77 = 0.532$
1900	17	$17/77 = 0.221$	$41+17 = 58$	$58/77 = 0.753$
2200	11	$11/77 = 0.143$	$58+11 = 69$	$69/77 = 0.896$
2500	8	$8/77 = 0.104$	$69+8 = 77$	$77/77 = 1.000$
	<u>77</u>	<u>1.001</u>		

41a	x	f	$(x_i - \bar{x})$	$f(x_i - \bar{x})^3$	$f(x_i - \bar{x})^4$
	6	1	-8.13	-537.37	4,368.80
	7	1	-7.13	-362.47	2,584.39
	8	0	-6.13	0	0
	9	2	-5.13	-270.01	1,385.16
	10	3	-4.13	-211.33	872.81
	11	2	-3.13	- 61.33	191.96
	12	4	-2.13	- 38.65	82.33
	13	10	-1.13	- 14.43	16.30
	14	11	-0.13	- 0.02	0
	15	16	0.87	10.54	9.17
	16	13	1.87	85.01	158.97
	17	3	2.87	70.92	203.54
	18	2	3.87	115.92	448.62
	19	1	4.87	115.50	562.49
	20	1	5.87	202.26	1,187.28
		<u>70</u>		<u>-895.46</u>	<u>12,071.82</u>

$$\bar{x} = 14.13 \quad s = 2.53$$

$$a_3 = \frac{\sum f(x_i - \bar{x})^3 / n}{s^3} = \frac{-895.46/70}{2.53^3} = -0.79$$

$$a_4 = \frac{\sum f(x_i - \bar{x})^4 / n}{s^4} = \frac{12071.82/70}{2.53^4} = 4.21$$

Distribution is very peaked and quite skewed to the left.

41b	x	f	$(x_i - \bar{x})$	$f(x_i - \bar{x})^3$	$f(x_i - \bar{x})^4$
	-6	1	-5.54	-170.03	941.97
	-5	2	-4.54	-187.15	849.68
	-4	4	-3.54	-177.45	628.16
	-3	8	-2.54	-131.10	332.99
	-2	16	-1.54	- 58.44	89.99
	-1	24	-0.54	- 3.78	2.04
	0	20	.46	1.95	.90
	1	17	1.46	40.45	59.06
	2	13	2.46	193.53	476.08
	3	3	3.46	124.26	429.96
	4	1	4.46	88.72	395.68
	5	1	5.46	162.77	888.73
		<u>110</u>		<u>-116.27</u>	<u>5,171.72</u>

Note: x is coded from 6.00.

$$\bar{x} = -0.46 \quad \text{True } \bar{x} = 5.9954 \quad s = 1.97$$

$$a_3 = \frac{\sum f(x_i - \bar{x})^3 / n}{s^3} = \frac{-116.27/110}{1.97^3} = -0.14$$

$$a_4 = \frac{\sum f(x_i - \bar{x})^4 / n}{s^4} = \frac{5171.72/110}{1.97^4} = 3.11$$

Distribution is slightly skewed to the left and not quite as peaked as normal.

41c	χ	f	$(\chi_i - \bar{\chi})$	$f(\chi_i - \bar{\chi})^3 \times 10^3$	$f(\chi_i - \bar{\chi})^4 \times 10^3$
	1.74	5	-.2032	-41.9509	8.5244
	1.79	9	-.1532	-32.3608	4.9577
	1.84	6	-.1032	- 6.5946	.6806
	1.89	27	-.0532	- 4.0654	.2163
	1.94	26	-.0032	- .0009	nil
	1.99	29	.0468	2.9726	.1391
	2.04	13	.0968	11.7915	1.1414
	2.09	5	.1468	15.8179	2.3221
	2.14	3	.1968	12.8663	4.5001
	2.19	1	.2468	15.0326	3.7101
	2.24	0	.2968	0	0
	2.29	1	.3468	41.7097	14.4649
		<u>125</u>		<u>+25.218 x 10³</u>	<u>40.6567 x 10³</u>

$$\bar{\chi} = 1.9432$$

$$s = .096249$$

$$a_3 = \frac{\sum f(\chi_i - \bar{\chi})^3 / n}{s^3} = \frac{25.218 \times 10^3 / 125}{.096249^3} = +0.23$$

$$a_4 = \frac{\sum f(\chi_i - \bar{\chi})^4 / n}{s^4} = \frac{40.6567 \times 10^3 / 125}{.096249^4} = 3.79$$

Distribution is slightly skewed to the right and somewhat peaked.

41d	χ	f	$(\chi_i - \bar{\chi})$	$f(\chi_i - \bar{\chi})^3$	$f(\chi_i - \bar{\chi})^4$
	0.3	3	-1.68	-14.2249	23.8978
	0.8	15	-1.18	-24.6455	29.0816
	1.3	34	-0.68	-10.6907	7.2697
	1.8	29	-0.18	- .1691	.0304
	2.3	30	.32	.9830	.3146
	2.8	22	.82	12.1301	9.9467
	3.3	15	1.32	34.4995	45.5394
	3.8	2	1.82	12.0571	21.9439
		<u>150</u>		<u>9.9395</u>	<u>138.0242</u>

$$\bar{\chi} = 1.98$$

$$s = 0.8053512$$

$$a_3 = \frac{\sum f(\chi_i - \bar{\chi})^3 / n}{s^3} = \frac{9.9395 / 150}{.8053512^3} = +.13$$

$$a_4 = \frac{\sum f(\chi_i - \bar{\chi})^4 / n}{s^4} = \frac{138.0242 / 150}{.8053512^4} = 2.19$$

Slightly skewed to the right and flatter than normal.

41e	$\bar{x}$	f	$(x_i - \bar{x})$	$f(x_i - \bar{x})^3$	$f(x_i - \bar{x})^4$
	3.5	6	-0.7569	-2.6018	1.96927
	3.8	9	-0.4569	- .8584	.3922
	4.1	18	-0.1569	- .0695	.0109
	4.4	14	0.1431	.0410	.0059
	4.7	13	0.4431	1.1310	.5011
	5.0	5	0.7431	2.0517	1.5246
		<u>65</u>		<u>-0.306</u>	<u>4.4040</u>

$$\bar{x} = 4.2569$$

$$s = 0.4212961$$

$$a_3 = \frac{\sum f(x_i - \bar{x})^3 / n}{s^3} = \frac{-0.306/65}{0.4212961^3} = -0.06$$

$$a_4 = \frac{\sum f(x_i - \bar{x})^4 / n}{s^4} = \frac{4.4040/65}{0.4212961^4} = 2.15$$

Distribution is essentially symmetrical and much flatter than normal.

41f	$\bar{x}$	f	$(x_i - \bar{x})$	$f(x_i - \bar{x})^3 \times 10^6$	$f(x_i - \bar{x})^4 \times 10^9$
	1000	6	-748	-2511	1878
	1300	13	-448	-1169	523
	1600	22	-148	- 71	11
	1900	17	+152	60	9
	2200	11	+452	1015	459
	2500	8	+752	3402	2558
		<u>77</u>		<u>+ 726 x 10⁶</u>	<u>5438 x 10⁹</u>

$$\bar{x} = 1748$$

$$s = 423$$

$$a_3 = \frac{\sum f(x_i - \bar{x})^3 / n}{s^3} = \frac{726 \times 10^6 / 77}{423^3} = +0.10$$

$$a_4 = \frac{\sum f(x_i - \bar{x})^4 / n}{s^4} = \frac{5438 \times 10^9 / 77}{423^4} = 2.21$$

Distribution is essentially symmetrical and much flatter than normal.

42. Max. of 134.5 db (x_i)

from 17 $\bar{x} = 94.7$

$\sigma = 19.925$

$$z_1 = \frac{x_i - \mu}{\sigma}$$

$$z_1 = \frac{134.5 - 94.7}{19.925}$$

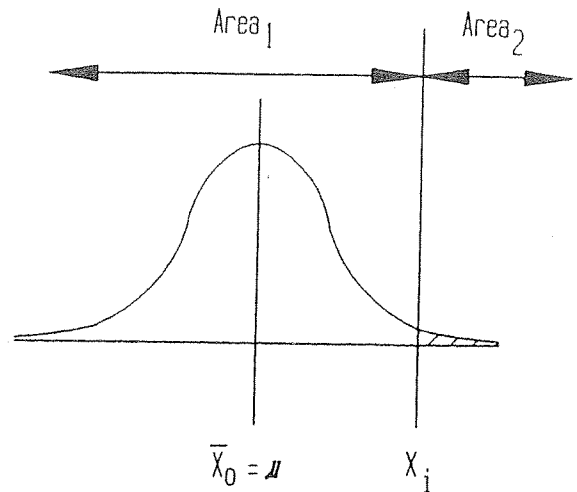
$$z_1 = 2.00$$

$$\text{Area}_1 = 0.9773$$

$$\text{Area}_2 = 1.000 - \text{Area}_1$$

$$\text{Area}_2 = 1.00 - 0.9773$$

$$\text{Area}_2 = 0.0227 \text{ or } 2.8\%$$



43. Min. of 3.65 (x_i)

Max. of 4.85 (x_i)

from 18 $\bar{x} = 4.25$

$\sigma = .4213$

$$z_1 = \frac{x_i - \mu}{\sigma}$$

$$z_1 = \frac{3.65 - 4.26}{.4213}$$

$$z_1 = -1.45$$

$$\text{Area}_1 = 0.0734$$

$$z_2 = \frac{x_i - \mu}{\sigma}$$

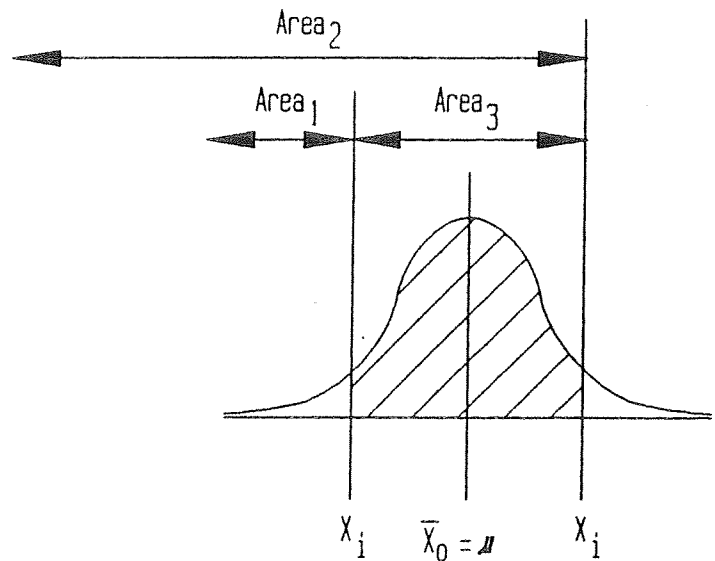
$$z_2 = \frac{4.85 - 4.26}{.4213}$$

$$z_2 = 1.40 \quad \text{Area}_2 = 0.9192$$

$$\text{Area}_3 = \text{Area}_2 - \text{Area}_1$$

$$\text{Area}_3 = 0.9192 - 0.0735$$

$$\text{Area}_3 = 0.8457 \text{ or } 84.6\%$$



44. Max. of 2.25 (x_i)

From 28 $\bar{x} = 1.65$

$\sigma = 0.617$

$$z_1 = \frac{x_i - \mu}{\sigma}$$

$$z_1 = \frac{2.25 - 1.65}{0.617}$$

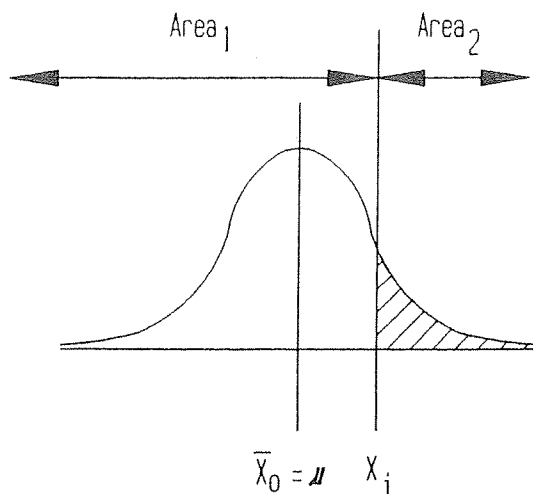
$$z_1 = 0.97$$

$$\text{Area}_1 = 0.8340$$

$$\text{Area}_2 = 1.000 - \text{Area}_1$$

$$\text{Area}_2 = 1.000 - 0.8340$$

$$\text{Area}_2 = 0.166 \text{ or } 16.6\%$$



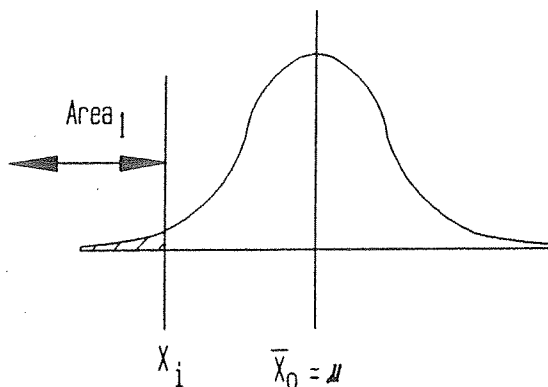
45a $z = \frac{x_i - \mu}{\sigma}$

$$z = \frac{8.30 - 9.07}{0.40}$$

$$z = -1.93 \text{ Rounded}$$

From Table A₁

$$\text{Area}_1 = 0.0268 \text{ or } 2.68\%$$



45b $z_1 = \frac{x_i - \mu}{\sigma}$

$$z_1 = \frac{10.00 - 9.07}{0.40}$$

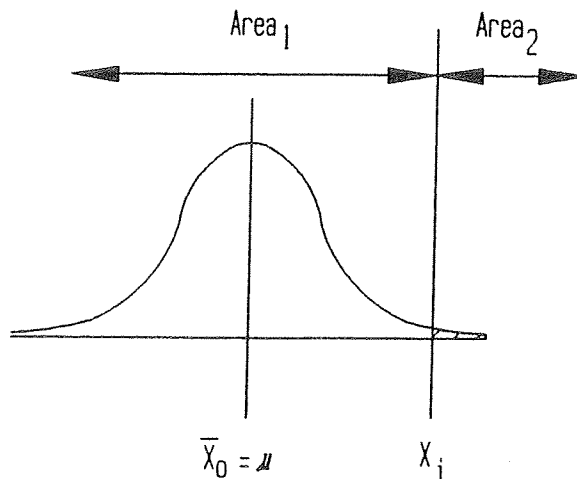
$$z_1 = +2.33 \text{ Rounded}$$

$$\text{Area}_1 = 0.9901$$

$$\text{Area}_2 = 1.000 - \text{Area}_1$$

$$\text{Area}_2 = 1.000 - 0.9901$$

$$\text{Area}_2 = 0.0099 \text{ or } 0.99\%$$



45c $z_1 = \frac{x_i - \mu}{\sigma}$

$$z_1 = \frac{8.00 - 9.07}{0.40}$$

$$z_1 = -2.68$$

$$\text{Area}_1 = 0.0037$$

$$z_2 = \frac{x_i - \mu}{\sigma}$$

$$z_2 = \frac{10.10 - 9.07}{0.40}$$

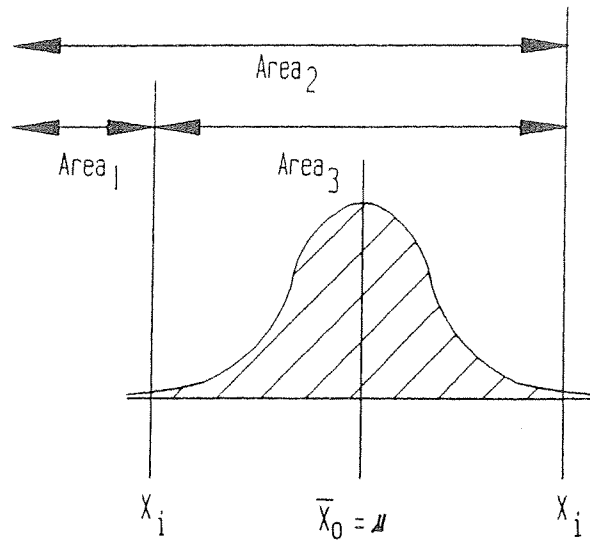
$$z_2 = +2.58$$

$$\text{Area}_2 = 0.9951$$

$$\text{Area}_3 = \text{Area}_2 - \text{Area}_1$$

$$\text{Area}_3 = 0.9951 - 0.0037$$

$$\text{Area}_3 = 0.9914 \text{ or } 99.14\%$$

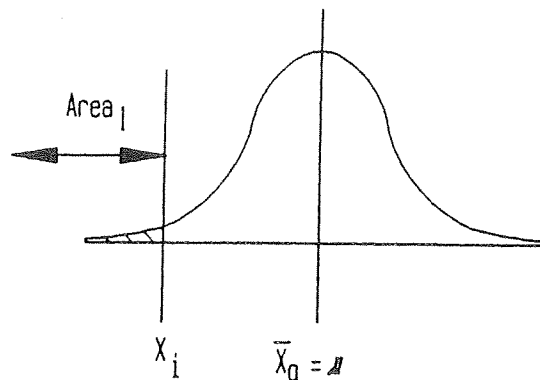


46a. $z_1 = \frac{x_i - \mu}{\sigma}$

$$z_1 = \frac{13 - 16}{1.5}$$

$$z_1 = -2.00$$

$$\text{Area}_1 = 0.0228 \text{ or } 2.28\%$$



46b. $z_1 = \frac{x_i - \mu}{\sigma}$

$$z_1 = \frac{20 - 16}{1.5}$$

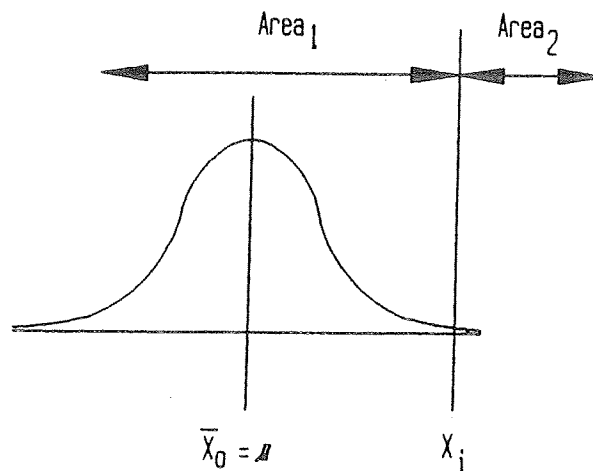
$$z_1 = +2.67$$

$$\text{Area}_1 = 0.9962$$

$$\text{Area}_2 = 1.000 - \text{Area}_1$$

$$\text{Area}_2 = 1.000 - 0.9962$$

$$\text{Area}_2 = 0.0038 \text{ or } 0.38\%$$



46c $\text{Area}_1 = 0.0228$

$$z_2 = \frac{x_i - \mu}{\sigma}$$

$$z_2 = \frac{20.5 - 16}{1.5}$$

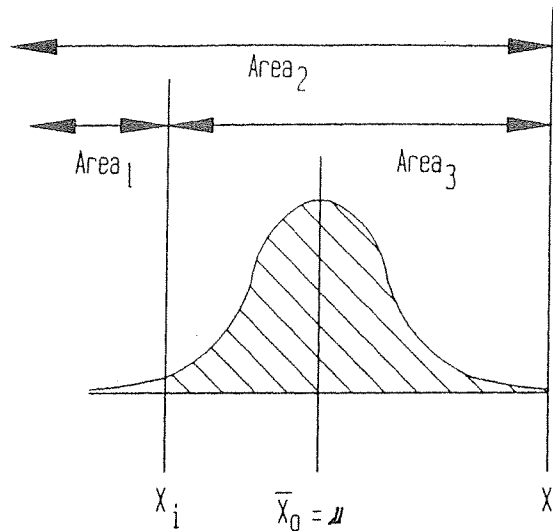
$$z_2 = +3.00$$

$$\text{Area}_2 = 0.99865$$

$$\text{Area}_3 = \text{Area}_2 - \text{Area}_1$$

$$\text{Area}_3 = 0.99865 - 0.0228$$

$$\text{Area}_3 = 0.9759 \text{ or } 97.59\%$$



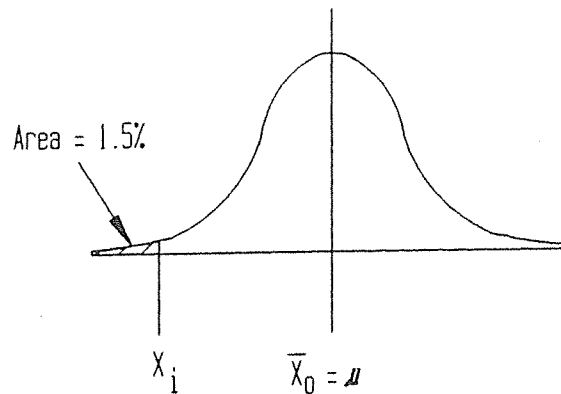
47. From Table A

For 1.5%, $z_1 = -2.17$

$$z_1 = \frac{x_i - \mu}{\sigma}$$

$$-2.17 = \frac{0.567 - \bar{x}_0}{0.018}$$

$$\bar{x}_0 = .606 \text{ g}$$

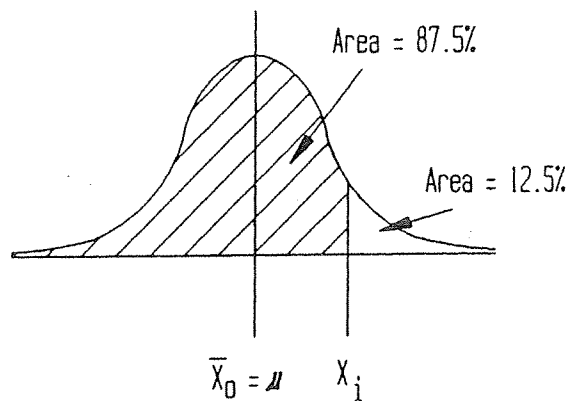


48. If rework % is 12.5%, Area to the left is 87.5% and has a Z value of +1.15.

$$z_1 = \frac{x_i - \mu}{\sigma}$$

$$1.15 = \frac{25.38 - \bar{x}_0}{0.01}$$

$$\bar{x}_0 = 25.37 \text{ mm}$$



49a Not normal

49b Normal

49c Not normal

49d Not normal, but symmetrical

49e Not normal, but symmetrical

49f Not normal, but symmetrical