

Statistical Testing of Electric Meters

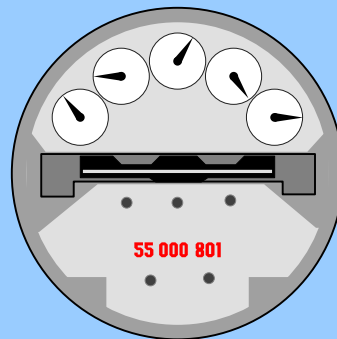
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What is Statistical Testing?

Statistical testing is the testing of a population or group for specific characteristics or parameters using a valid statistically-derived sampling plan.



Features of a Statistical Sampling/Testing Plan

- Homogeneous Population(s)
- Sample(s) of a Suitable Size for the Plan
- Random Sample Selection of Items to Be Tested
- Expectation that the Group or Population Being Tested Fits the Statistical Model

Features of a Statistical Sampling/Testing Plan: Homogeneous Population(s)

- The groups or populations being sampled and tested are made up of the same or similar items, items which operate in the same way and were made in the same manner.
- For electric meters, this has traditionally been interpreted as being meters of a specific meter type from a manufacturer (i.e. AB1, J5S, MX, etc.).

Features of a Statistical Sampling/Testing Plan: Suitably Sized Samples

- The sample size for each group must be large enough to provide a statistically valid sample for the group's population.
- The larger the group's population, then the larger the sample will be up to a certain point.

Features of a Statistical Sampling/Testing Plan:

Random Sample Selection

- Every item within the group or population has an equal chance of being selected as part of the sample for testing.
- Random sample selection is critical to providing for a statistically valid sample.

Features of a Statistical Sampling/Testing Plan: Population Fits the Statistical Model (Part 1)

- The statistical model being used for the sampling/testing plan needs to match the actual distribution of the population.
- In most circumstances, one is looking at a normal or Gaussian distribution (i.e. a Bell curve).
- This can be checked using a histogram plot or a correlation analysis.

Features of a Statistical Sampling/Testing Plan: Population Fits the Statistical Model (Part 2)

- For mechanical and electromechanical meters, a normal distribution fits the actual data fairly well.
- For electronic or solid-state meters, there is some question due to the failure modes of these meters. These meter types are fairly recent designs, and not enough data has been seen yet to verify a normal distribution.

Why Use a Statistical Sampling/Testing Plan?

- Focuses testing on the proper meters.
- Minimizes number of meters to be tested; usually requires less than 30% of what a periodic testing plan requires.
- Can provide data and analysis tools for use in understanding what is happening with meters installed in the field or for use in the purchasing of new meters.

What Statistical Sampling/Testing Plan to Use?

- Pre-defined statistical plans
- Plans defined by state regulations
- Create your own

ANSI C12.1-2001 Code for Electricity Metering Guidance

Paragraph 5.1.4.3.3 Statistical sampling plan

“The statistical sampling plan used shall conform to accepted principles of statistical sampling based on either variables or attributes methods. Meters shall be divided into homogeneous groups, such as manufacturer and manufacturer’s type. The groups may be further divided into subdivision within the manufacturer’s type by major design modifications.”

NOTE - Examples of statistical sampling plans can be found in ANSI/ASQC Z1.9, the ANSI version of MIL-STD-414 and ANSI/ASQC Z1.4, the ANSI version of MIL-STD-105.

ANSI/ASQC Z1.4-1993

Sampling Procedures and Tables for Inspection by Attributes

- Based on MIL-STD-105
- Uses attributes (pass/fail, yes/no, etc.) as the basis for its analysis
- Variety of special and general inspection levels
- Various sampling plans (single, double, & multiple)
- Wide range of Acceptable Quality Levels (AQL's)

ANSI/ASQC Z1.4

Inspection Levels

Inspection Levels:

- Special Levels S-1 through S-4
 - Used for quick sampling and testing in certain circumstances
 - Small sample sizes
 - Not used for meter testing
- General Inspection Levels I, II, and III
 - Level I is reduced inspection
 - Level II is normal inspection (This level is the one that is normally used.)
 - Level III is tightened inspection
- Inspection level is used in conjunction with group size in Table I to determine sample size code letters.

ANSI/ASQC Z1.4 - Table I

TABLE I—Sample size code letters

(See 9.2 and 9.3)

Lot or batch size	Special inspection levels				General inspection levels		
	S-1	S-2	S-3	S-4	I	II	III
2 to 8	A	A	A	A	A	A	B
9 to 15	A	A	A	A	A	B	C
16 to 25	A	A	B	B	B	C	D
26 to 50	A	B	B	C	C	D	E
51 to 90	B	B	C	C	C	E	F
91 to 150	B	B	C	D	D	F	G
151 to 280	B	C	D	E	E	G	H
281 to 500	B	C	D	E	F	H	J
501 to 1200	C	C	E	F	G	J	K
1201 to 3200	C	D	E	G	H	K	L
3201 to 10000	C	D	F	G	J	L	M
10001 to 35000	C	D	F	H	K	M	N
35001 to 150000	D	E	G	J	L	N	P
150001 to 500000	D	E	G	J	M	P	Q
500001 and over	D	E	H	K	N	Q	R

ANSI/ASQC Z1.4 - Table II-A

Table II-A—Single sampling plans for normal inspection (Master table)

(See 9.4 and 9.5)

Sample size code letter	Sample size	Acceptable Quality Levels (normal inspection)																									
		0.010	0.015	0.025	0.040	0.065	0.10	0.15	0.25	0.40	0.65	1.0	1.5	2.5	4.0	6.5	10	15	25	40	65	100	150	250	400	650	1000
		Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re
A	2	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
B	3	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
C	5	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
D	8	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
E	13	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
F	20	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
G	32	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
H	50	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
J	80	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
K	125	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
L	200	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
M	315	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
N	500	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
P	800	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
Q	1250	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
R	2000	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑

↓ = Use first sampling plan below arrow. If sample size equals, or exceeds, lot or batch size, do 100 percent inspection.
 ↑ = Use first sampling plan above arrow.
 Ac = Acceptance number.
 Re = Rejection number.

ANSI/ASQC Z1.4 - Table II-B

Table II-B—Single sampling plans for tightened inspection (Master table)

(See 9.4 and 9.5)

Sample size code letter	Sample size	Acceptable Quality Levels (tightened inspection)																									
		0.010	0.015	0.025	0.040	0.065	0.10	0.15	0.25	0.40	0.65	1.0	1.5	2.5	4.0	6.5	10	15	25	40	65	100	150	250	400	650	1000
		Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re
A	2	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
B	3	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
C	5	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
D	8	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
E	13	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
F	20	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
G	32	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
H	50	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
J	80	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
K	125	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
L	200	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
M	315	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
N	500	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
P	800	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
Q	1250	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
R	2000	0 1	↑	↓	1 2	2 3	3 4	5 6	8 9	12 13	18 19	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
S	3150	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓

↓ = Use first sampling plan below arrow. If sample size equals or exceeds lot or batch size, do 100 percent inspection.
 ↑ = Use first sampling plan above arrow.
 Ac = Acceptance number.
 Re = Rejection number.

ANSI/ASQC Z1.4 - Table II-C

Table II-C—Single sampling plans for reduced inspection (Master table)

(See 9.4 and 9.5)

Sample size code letter	Sample size	Acceptable Quality Levels (reduced inspection)†																									
		0.010	0.015	0.025	0.040	0.065	0.10	0.15	0.25	0.40	0.65	1.0	1.5	2.5	4.0	6.5	10	15	25	40	65	100	150	250	400	650	1000
		Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re
A	2	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
B	2	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
C	2	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
D	3	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
E	5	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
F	8	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
G	13	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
H	20	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
J	32	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
K	50	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
L	80	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
M	125	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
N	200	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
P	315	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
Q	500	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
R	800	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓

↓ = Use first sampling plan below arrow. If sample size equals or exceeds lot or batch size, do 100 percent inspection.

↑ = Use first sampling plan above arrow.

Ac = Acceptance number.

Re = Rejection number.

† = If the acceptance number has been exceeded, but the rejection number has not been reached, accept the lot, but reinstate normal inspection (see 10.1.4).

ANSI/ASQC Z1.4 - Table III-A

DOUBLE
NORMAL
PLANS

Table III-A—Double sampling plans for normal inspection (Master table)

(See 9.4 and 9.5)

Sample size code letter	Sample	Sample size	Cumulative sample size	Acceptable Quality Levels (normal inspection)																											
				0.010	0.015	0.025	0.040	0.065	0.10	0.15	0.25	0.40	0.65	1.0	1.5	2.5	4.0	6.5	10	15	25	40	65	100	150	250	400	650	1000		
				Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re
A																															
B	First Second	2 3	2 4																												
C	First Second	3 6	3 6																												
D	First Second	5 10	5 10																												
E	First Second	8 16	8 16																												
F	First Second	13 26	13 26																												
G	First Second	20 40	20 40																												
H	First Second	32 64	32 64																												
J	First Second	50 100	50 100																												
K	First Second	80 160	80 160																												
L	First Second	125 250	125 250																												
M	First Second	200 400	200 400																												
N	First Second	315 630	315 630																												
P	First Second	500 1000	500 1000																												
Q	First Second	800 1600	800 1600																												
R	First Second	1250 2500	1250 2500																												

- ↓ = Use first sampling plan below arrow. If sample size equals or exceeds lot or batch size, do 100 percent inspection.
- ↑ = Use first sampling plan above arrow.
- Ac = Acceptance number.
- Re = Rejection number.
- * = Use corresponding single sampling plan (or alternatively, use double sampling plan below, where available).

ANSI/ASQC Z1.4 - Table IV-A (portion)

MULTIPLE
NORMAL
PLANS

Table IV-A—Multiple sampling plans for normal inspection (Master table)
(Continued)

(See 9.4 and 9.5)

Sample size code letter	Sample	Sample size	Cumulative sample size	Acceptable Quality Levels (normal inspection)																											
				0.010	0.015	0.025	0.040	0.065	0.10	0.15	0.25	0.40	0.65	1.0	1.5	2.5	4.0	6.5	10	15	25	40	65	100	150	250	400	650	1000		
				Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re
K	First	32	32								# 2	# 2	# 3	# 4	0 4	0 5	1 7	2 9													
	Second	32	64					*			# 2	0 3	0 3	1 5	1 6	3 8	4 10	7 14													
	Third	32	96								0 2	0 3	1 4	2 6	3 8	6 10	8 13	15 19													
	Fourth	32	128								0 5	1 4	2 5	3 7	5 9	8 13	12 17	19 25													
	Fifth	32	160								1 3	2 4	3 6	5 8	7 11	11 15	17 20	25 29													
	Sixth	32	192								1 3	3 5	4 6	7 9	10 12	14 17	21 23	31 33													
	Seventh	32	224								2 3	4 5	6 7	9 10	13 14	18 19	25 26	37 38													
L	First	50	50					*			# 2	# 2	# 3	# 4	0 4	0 5	1 7	2 9													
	Second	50	100								# 2	0 3	0 3	1 5	1 6	3 8	4 10	7 14													
	Third	50	150								0 2	0 3	1 4	2 6	3 8	6 10	8 13	15 19													
	Fourth	50	200								0 3	1 4	2 5	3 7	5 9	8 13	12 17	19 25													
	Fifth	50	250								1 3	2 4	3 6	5 8	7 11	11 15	17 20	25 29													
	Sixth	50	300								1 3	3 5	4 6	7 9	10 12	14 17	21 23	31 33													
	Seventh	50	350								2 3	4 5	6 7	9 10	13 14	18 19	25 26	37 38													
M	First	80	80					*			# 2	# 2	# 3	# 4	0 4	0 5	1 7	2 9													
	Second	80	160								# 2	0 3	0 3	1 5	1 6	3 8	4 10	7 14													
	Third	80	240								0 2	0 3	1 4	2 6	3 8	6 10	8 13	15 19													
	Fourth	80	320								0 3	1 4	2 5	3 7	5 10	8 13	12 17	19 25													
	Fifth	80	400								1 3	2 4	3 6	5 8	7 11	11 15	17 20	25 29													
	Sixth	80	480								1 3	3 5	4 6	7 9	10 12	14 17	21 23	31 33													
	Seventh	80	560								2 3	4 5	6 7	9 10	13 14	18 19	25 26	37 38													
N	First	125	125					*			# 2	# 2	# 3	# 4	0 4	0 5	1 7	2 9													
	Second	125	250								# 2	0 3	0 3	1 5	1 6	3 8	4 10	7 14													
	Third	125	375								0 2	0 3	1 4	2 6	3 8	6 10	8 13	15 19													
	Fourth	125	500								0 3	1 4	2 5	3 7	5 10	8 13	12 17	19 25													
	Fifth	125	625								1 3	2 4	3 6	5 8	7 11	11 15	17 20	25 29													
	Sixth	125	750								1 3	3 5	4 6	7 9	10 12	14 17	21 23	31 33													
	Seventh	125	875								2 3	4 5	6 7	9 10	13 14	18 19	25 26	37 38													
P	First	200	200					*			# 2	# 2	# 3	# 4	0 4	0 5	1 7	2 9													
	Second	200	400								# 2	0 3	0 3	1 5	1 6	3 8	4 10	7 14													
	Third	200	600								0 2	0 3	1 4	2 6	3 8	6 10	8 13	15 19													
	Fourth	200	800								0 3	1 4	2 5	3 7	5 10	8 13	12 17	19 25													
	Fifth	200	1000								1 3	2 4	3 6	5 8	7 11	11 15	17 20	25 29													
	Sixth	200	1200								1 3	3 5	4 6	7 9	10 12	14 17	21 23	31 33													
	Seventh	200	1400								2 3	4 5	6 7	9 10	13 14	18 19	25 26	37 38													
Q	First	315	315					*			# 2	# 2	# 3	# 4	0 4	0 5	1 7	2 9													
	Second	315	630								# 2	0 3	0 3	1 5	1 6	3 8	4 10	7 14													
	Third	315	945								0 2	0 3	1 4	2 6	3 8	6 10	8 13	15 19													
	Fourth	315	1260								0 3	1 4	2 5	3 7	5 10	8 13	12 17	19 25													
	Fifth	315	1575								1 3	2 4	3 6	5 8	7 11	11 15	17 20	25 29													
	Sixth	315	1890								1 3	3 5	4 6	7 9	10 12	14 17	21 23	31 33													
	Seventh	315	2205								2 3	4 5	6 7	9 10	13 14	18 19	25 26	37 38													
R	First	500	500								# 2	# 2	# 3	# 4	0 4	0 5	1 7	2 9													
	Second	500	1000								# 2	0 3	0 3	1 5	1 6	3 8	4 10	7 14													
	Third	500	1500								0 2	0 3	1 4	2 6	3 8	6 10	8 13	15 19													
	Fourth	500	2000								0 3	1 4	2 5	3 7	5 10	8 13	12 17	19 25													
	Fifth	500	2500								1 3	2 4	3 6	5 8	7 11	11 15	17 20	25 29													
	Sixth	500	3000								1 3	3 5	4 6	7 9	10 12	14 17	21 23	31 33													
	Seventh	500	3500								2 3	4 5	6 7	9 10	13 14	18 19	25 26	37 38													

- ↓ = Use first sampling plan below arrow. If sample size equals or exceeds lot or batch size, do 100 percent inspection.
- ↑ = Use first sampling plan above arrow (refer to preceding page, when necessary).
- * = Use corresponding single sample plan (or alternatively, use multiple plan below, where available).
- # = Acceptance not permitted at this sample size
- Ac = Acceptance number.
- Re = Rejection number.

ANSI/ASQC Z1.4

Acceptable Quality Level (AQL's)

- AQL is the maximum percent nonconforming (or maximum number of nonconformities per hundred units) that, for purposes of sampling inspection, can be considered satisfactory as a process average.
- For ANSI/ASQC Z1.4, AQL's vary from 0.010 to 1000 with 26 pre-defined AQL values.
- For use with electric meter testing, either in-service testing or receipt inspection, AQL's of 0.25 to 2.5 are normally utilized.

ANSI/ASQC Z1.4

Applications for Electric Meter Testing

- Receipt inspection for new meters
- Monitoring of nonperformance-related parameters (broken glass, damaged base, etc.) for in-service testing or receipt inspection
- Simple in-service testing plans

ANSI/ASQC Z1.9-1993

Sampling Procedures and Tables for Inspection by Variables for Percent Nonconforming

- Based on MIL-STD-414
- Use variables (a measured parameter or characteristic) as the basis for its analysis. This is normally weighted average for electric meters.
- Variety of special and general inspection levels
- Selection of Acceptable Quality Levels (AQL's)

ANSI/ASQC Z1.9-1993

Sampling Procedures and Tables for Inspection by Variables for Percent Nonconforming

- Various methods (Variability Unknown - Standard Deviation Method, Variability Unknown - Range Method, and Variability Known Method)
- All methods can be used with single or double specification limits.
- For electric meters, the Variability Unknown - Standard Deviation Method with Double Specification Limits is normally used.

ANSI/ASQC Z1.9

Inspection Levels

Inspection Levels:

- Special Levels S-3 and S-4
 - Used for quick sampling and testing in certain circumstances
 - Small sample sizes
 - Not used for meter testing
- General Inspection Levels I, II, and III
 - Level I is reduced inspection
 - Level II is normal inspection (This level is the one that is normally used.)
 - Level III is tightened inspection
- Inspection level is used in conjunction with group size in Table A-2 to determine sample size code letters. 24

ANSI/ASQC Z1.9 - Table A-2

TABLE A-2²
Sample Size Code Letters¹

Lot Size	Inspection Levels		
	Special		General
	S3	S4	I II III
2 to 8	B	B	B B C
9 to 15	B	B	B B D
16 to 25	B	B	B C E
26 to 50	B	B	C D F
51 to 90	B	B	D E G
91 to 150	B	C	E F H
151 to 280	B	D	F G I
281 to 400	C	E	G H J
401 to 500	C	E	G I J
501 to 1,200	D	F	H J K
1,201 to 3,200	E	G	I K L
3,201 to 10,000	F	H	J L M
10,001 to 35,000	G	I	K M N
35,001 to 150,000	H	J	L N P
150,001 to 500,000	H	K	M P P
500,001 and over	H	K	N P P

¹Sample size code letters given in body of table are applicable when the indicated inspection levels are to be used.

²The theory governing inspection by variables depends on the properties of the normal distribution and, therefore, this method of inspection is only applicable when there is reason to believe that the frequency distribution is normal.

ANSI/ASQC Z1.9 - Table B-3

Table B-3

Standard Deviation Method

Master Table for Normal and Tightened Inspection for Plans Based on Variability Unknown
(Double Specification Limit and Form 2—Single Specification Limit)

Sample size code letter	Sample size	Acceptable Quality Levels (normal inspection)											
		T	.10	.15	.25	.40	.65	1.00	1.50	2.50	4.00	6.50	10.00
		M	M	M	M	M	M	M	M	M	M	M	M
B	3	↓	↓	↓	↓	↓	↓	↓	↓	7.59	18.86	26.94	33.69
C	4	↓	↓	↓	↓	↓	↓	1.49	5.46	10.88	16.41	22.84	29.43
D	5	↓	↓	↓	↓	0.041	1.34	3.33	5.82	9.80	14.37	20.19	26.55
E	7	↓	0.005	0.087	0.421	1.05	2.13	3.54	5.34	8.40	12.19	17.34	23.30
F	10	0.077	0.179	0.349	0.714	1.27	2.14	3.27	4.72	7.26	10.53	15.17	20.73
G	15	0.186	0.311	0.491	0.839	1.33	2.09	3.06	4.32	6.55	9.48	13.74	18.97
H	20	0.228	0.356	0.531	0.864	1.33	2.03	2.93	4.10	6.18	8.95	13.01	18.07
I	25	0.250	0.378	0.551	0.874	1.32	2.00	2.86	3.97	5.98	8.65	12.60	17.55
J	35	0.253	0.373	0.534	0.833	1.24	1.87	2.66	3.70	5.58	8.11	11.89	16.67
K	50	0.243	0.355	0.503	0.778	1.16	1.73	2.47	3.44	5.21	7.61	11.23	15.87
L	75	0.225	0.326	0.461	0.711	1.06	1.59	2.27	3.17	4.83	7.10	10.58	15.07
M	100	0.218	0.315	0.444	0.684	1.02	1.52	2.18	3.06	4.67	6.88	10.29	14.71
N	150	0.202	0.292	0.412	0.636	0.946	1.42	2.05	2.88	4.42	6.56	9.86	14.18
P	200	0.204	0.294	0.414	0.637	0.945	1.42	2.04	2.86	4.39	6.52	9.80	14.11
		.10	.15	.25	.40	.65	1.00	1.50	2.50	4.00	6.50	10.00	
Acceptable Quality Levels (tightened inspection)													

ANSI/ASQC Z1.9 - Table B-4

Table B-4 Standard Deviation Method
Master Table for Reduced Inspection for Plans Based on Variability Unknown
(Double Specification Limit and Form 2—Single Specification Limit)

Sample size code letter	Sample size	Acceptable Quality Levels										
		.10	.15	.25	.40	.65	1.00	1.50	2.50	4.00	6.50	10.00
		M	M	M	M	M	M	M	M	M	M	M
B	3	↓	↓	↓	↓	↓	↓	7.59	18.86	26.94	33.69	40.47
C	3	↓	↓	↓	↓	↓	↓	7.59	18.86	26.94	33.69	40.47
D	3	↓	↓	↓	↓	↓	↓	7.59	18.86	26.94	33.69	40.47
E	3	↓	↓	↓	↓	↓	↓	7.59	18.86	26.94	33.69	40.47
F	4	↓	↓	↓	↓	1.49	5.46	10.88	16.41	22.84	29.43	36.79
G	5	↓	↓	0.041	1.34	3.33	5.82	9.80	14.37	20.19	26.55	33.94
H	7	0.087	0.421	1.06	2.13	3.54	5.34	8.40	12.19	17.34	23.30	30.50
I	10	0.349	0.714	1.27	2.14	3.27	4.72	7.26	10.53	15.17	20.73	27.65
J	15	0.491	0.839	1.33	2.09	3.06	4.32	6.55	9.48	13.74	18.97	25.63
K	20	0.531	0.864	1.33	2.03	2.93	4.10	6.18	8.95	13.01	18.07	24.58
L	25	0.551	0.874	1.32	2.00	2.86	3.97	5.98	8.65	12.60	17.55	23.97
M	30	0.567	0.885	1.32	1.98	2.82	3.91	5.87	8.48	12.37	17.25	23.61
N	50	0.503	0.778	1.16	1.73	2.47	3.44	5.21	7.61	11.23	15.87	21.99
P	75	0.461	0.711	1.06	1.59	2.27	3.17	4.83	7.10	10.58	15.07	21.05

ANSI/ASQC Z1.9

Calculations For Standard Deviation Method

- Determine the mean and the standard deviation for the sample results.
- Determine Quality Indexes
 - $Q_u = (\text{Upper Limit} - \text{mean}) / \text{standard deviation}$
 - $Q_l = (\text{mean} - \text{Lower Limit}) / \text{standard deviation}$
 - Upper Limit is normally 102, and Lower Limit is normally 98.
- Use Q_u and Q_l to determine estimate of percent nonconformance above the Upper Limit (P_u) and below the Lower Limit (P_l) using Table B-5.

ANSI/ASQC Z1.9 - Table B-5 (portion)

Table B-5—Continued

Table for Estimating the Lot Percent Nonconforming Using Standard Deviation Method¹

$\frac{Q_U}{\text{or}} \frac{Q_L}{Q_L}$	Sample Size														
	3	4	5	7	10	15	20	25	30	35	50	75	100	150	200
.70	29.27	26.67	25.74	25.03	24.67	24.46	24.38	24.33	24.31	24.29	24.26	24.24	24.23	24.22	24.21
.71	28.92	26.33	25.41	24.71	24.35	24.15	24.06	24.02	23.99	23.98	23.95	23.92	23.91	23.90	23.90
.72	28.57	26.00	25.09	24.39	24.03	23.83	23.75	23.71	23.68	23.67	23.64	23.61	23.60	23.59	23.59
.73	28.22	25.67	24.76	24.07	23.72	23.52	23.44	23.40	23.37	23.36	23.33	23.31	23.30	23.29	23.28
.74	27.86	25.33	24.44	23.75	23.41	23.21	23.13	23.09	23.07	23.05	23.02	23.00	22.99	22.98	22.98
.75	27.50	25.00	24.11	23.44	23.10	22.90	22.83	22.79	22.76	22.75	22.72	22.70	22.69	22.68	22.68
.76	27.13	24.67	23.79	23.12	22.79	22.60	22.52	22.48	22.46	22.44	22.42	22.40	22.39	22.38	22.38
.77	26.76	24.33	23.47	22.81	22.48	22.30	22.22	22.18	22.16	22.14	22.12	22.10	22.09	22.08	22.08
.78	26.39	24.00	23.15	22.50	22.18	21.99	21.92	21.89	21.86	21.85	21.82	21.80	21.78	21.79	21.78
.79	26.02	23.67	22.83	22.19	21.87	21.70	21.63	21.59	21.57	21.55	21.53	21.51	21.50	21.49	21.49
.80	25.64	23.33	22.51	21.88	21.57	21.40	21.33	21.29	21.27	21.26	21.23	21.22	21.21	21.20	21.20
.81	25.25	23.00	22.19	21.58	21.27	21.10	21.04	21.00	20.98	20.97	20.94	20.93	20.92	20.91	20.91
.82	24.86	22.67	21.87	21.27	20.98	20.81	20.75	20.71	20.69	20.68	20.65	20.64	20.63	20.62	20.62
.83	24.47	22.33	21.56	20.97	20.68	20.52	20.46	20.42	20.40	20.39	20.37	20.35	20.35	20.34	20.34
.84	24.07	22.00	21.24	20.67	20.39	20.23	20.17	20.14	20.12	20.11	20.09	20.07	20.06	20.06	20.05
.85	23.67	21.67	20.93	20.37	20.10	19.94	19.89	19.86	19.84	19.82	19.80	19.79	19.78	19.78	19.77
.86	23.26	21.33	20.62	20.07	19.81	19.66	19.60	19.57	19.56	19.54	19.53	19.51	19.51	19.50	19.50
.87	22.84	21.00	20.31	19.78	19.52	19.38	19.32	19.30	19.28	19.27	19.25	19.24	19.23	19.23	19.22
.88	22.42	20.67	20.00	19.48	19.23	19.10	19.05	19.02	19.00	18.99	18.98	18.96	18.96	18.95	18.95
.89	21.99	20.33	19.69	19.19	18.95	18.82	18.77	18.74	18.73	18.72	18.70	18.69	18.69	18.68	18.68

ANSI/ASQC Z1.9

Calculations For Standard Deviation Method

- With the values of P_u and P_l determined from Table B-5 using Q_u and Q_l , estimated percent nonconformance equals to P_u plus P_l .
(% ncf = $P_u + P_l$)
- Acceptance is based on whether the estimated percent nonconformance is below the allowed percent nonconformance given in Table B-3.

ANSI/ASQC Z1.9

Acceptable Quality Level (AQL's)

- AQL is the maximum percent nonconforming that, for purposes of sampling inspection, can be considered satisfactory as a process average.
- For ANSI/ASQC Z1.9, AQL's vary from 0.10 to 10.00 with 11 pre-defined AQL values.
- For use with electric meter testing, either in-service testing or receipt inspection, AQL's of 0.25 to 2.50 are normally utilized.

ANSI/ASQC Z1.9

Applications for Electric Meter Testing

- In-service testing of meters
- Receipt inspection of new meters

ANSI/ASQC Z1.4 & ANSI/ASQC Z1.9 Comparison

- ANSI/ASQC Z1.4:
 - Simpler and quicker analysis
 - Analysis can be done manually
 - Limited data on actual meter performance
- ANSI/ASQC Z1.9:
 - Much more complicated analysis
 - Best done with automated data gathering and analysis
 - Provides good feedback on meter performance
 - Much smaller sample sizes

State Regulation Requirements - North Carolina

- Periodic Testing of In-Service Meters:
 - Commutating type and mercury type two and three wire meters - every 12 or 18 months depending Ampere rating
 - Single-phase induction meters - every 96 months
 - Self-contained polyphase meters - every 72 months
 - Transformer-rated polyphase meters - every 48 months

State Regulation Requirements - North Carolina

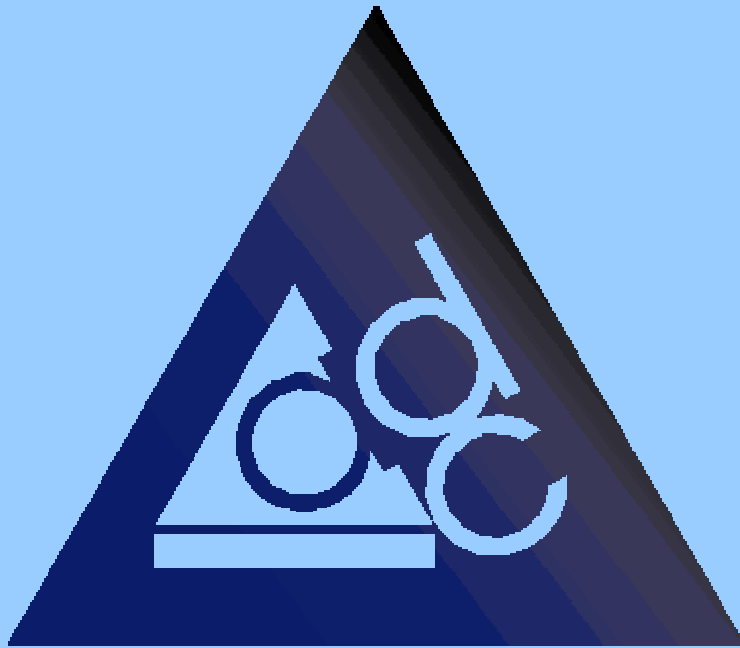
- A statistical sampling program for self-contained single-phase watt-hour meters may be used by any utility in lieu of the periodic testing program specified above provided the utility files with the Commission a statistical sampling plan which is approved by the Commission. (Rule R8-13, Para. (9))
- Plan must meet nine criteria listed in Rule R8-13 which are obviously based in part on ANSI/ASQC Z1.4 and ANSI/ASQC Z1.9.

State Regulation Requirements - South Carolina

- Periodic Testing of In-Service Meters:
 - Transformer-rated polyphase meters - every 4 years
 - Transformer-rated single-phase meters - every 8 years
 - Self-contained polyphase meters - every 6 years
 - Self-contained single-phase meters - every 8 years
- Single-phase meters may be tested and calibrated in accordance with “Sample Meter Testing Plans” approved by the Commission. (Chapter 103, Article 3, Subarticle 6, Para. 103-370.2.d)

State Regulation Requirements - Virginia

- Unable to locate regulations for in-service meter testing.
- Submetering rules have specific requirements:
 - “Each owner shall have a testing program for the primary purpose of which is to maintain an acceptable degree of accuracy during the service life of the equipment. All submetering equipment shall be tested in accordance with the provisions of the latest edition of ANSI C12 or ANSI B109.”
(20VAC5-305-70 Periodic test and checks)



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