Accuracy Tests for Substation and Generation Watthour Metering

1. Scope

This work practice covers the required accuracy tests for substation, generation, interchange electric watthour meters, and associated equipment. This standard applies to all Seattle City Light (SCL) substation and generation facilities.

2. Application

This work practice is for SCL Stations Meter Electricians who perform watthour meter accuracy tests. This standard will be used to determine the accuracy tests to be performed on all new watthour metering equipment as well on existing equipment as part of a maintenance program.

3. Introduction

All applicable SCL watthour meters shall be required to have the accuracy tests performed as stated in the tables in Section 4. Not all tests are required for each meter. The set of tests that are to be performed are dependent upon the meter construction type, system being measured, and the programmed functions of the meter. These accuracy tests are based on ANSI C12.1 and ANSI C12.20 requirements.

For acceptable accuracy requirements and limits of these tests, See SCL 2505.14; Accuracy Limits for Substation and Generation Watthour Meters."

For the purposes of this work practice, "watthour meter" and "revenue meter" are equivalent terms.

4. Test Sequences

The test sequence(s) to be used when performing accuracy tests shall be determined by the Stations Meter Electrician Crew Chief and be based on the functionality of the metering as designed/programmed. The following tables outline the test sequences to be performed for each metering application or function.

Test sequences are categorized by meter construction type, metering elements, measurement quantities, and programming. These customized test sequences help ensure that each meter is tested in a manner that emulates its functionality as installed, and will maintain accuracy, reliability, and repeatability of test results. Each test sequence is identified by a Station Meter Testing Programs (SMTP) unique identifier.

SMTPs are categorized into three types:

- Revenue Meter Tests (RMT): Test sequences used for meter accuracy tests performed against a meter disk or front panel LED calibration pulses.
- Pulse Meter Tests (PMT): Test sequences used for testing KYZ outputs.
- Transducer Meter Tests (TMT): Test sequences used for testing analog outputs.

All tests shall be performed singe phase at 60 Hz.

Test voltages and amperes are obtained from the meter nameplate.

Table 4. Accuracy Test Table Reference

Table	Test Type	Accuracy Test Description
4.1	Electro-Mechanical Meter	3 wire watthour meters; delivered watthours only
4.2	"	3 wire watthour meters; bi-directional watthours
4.3	"	4 wire watthour meters; delivered watthours only
4.4	"	4 wire watthour meters; bi-directional watthours
4.5	Electronic Meter	3 wire watt/varhour meters; delivered watthours, bi-directional varhours
4.6	"	3 wire watt/varhour meters; delivered watthours only
4.7	"	3 wire watt/varhour meters; 4 quadrant metering
4.8	"	4 wire watt/varhour meters; delivered watthours, bi-directional varhours
4.9	"	4 wire watt/varhour meters; delivered watthours only
4.10	"	4 wire watt/varhour meters; 4 quadrant metering
4.11	Pulse	watts; bi-directional
4.12	"	watts; delivered only
4.13	"	vars; bi-directional
4.14	"	vars; delivered only
4.15	Analog	watts; bi-directional
4.16	"	watts; delivered only
4.17	"	vars; bi-directional
4.18	"	vars; delivered only
4.19	EIM Electronic Meter	3 and 4 wire watt/varhour meters; 4 quadrant series only

Table 4.1. Accuracy Test for 3-Wire Electromechanical Watthour Meters

Test sequence SMTP-RMTM3: Revenue meter test mechanical 3-wire
Purpose: To test mechanical, 2-element meters with delivered active power flow, watthours only

Step	Element	Test	Test Revs	% Test Volts	% Test Amps	Phase Angle (degrees)	Measured Quantity
1	S	AO	5	100	100	0	Watthours
2	S	FL	10	"	100	0	"
3	S	LL	2	"	10	0	"
4	S	LL	2	"	10	0	"
5	S	PF	10	"	100	60	"
6	S	PF	10	"	100	300	"
7	A	FL	10	"	100	0	"
8	A	PF	10	"	100	60	"
9	A	PF	10	"	100	300	"
10	C	FL	10	"	100	0	"
11	C	PF	10	"	100	60	"
12	C	PF	10	"	100	300	"

Table 4.2. Accuracy Test for 3-Wire Electromechanical Watthour Meters

Test sequence SMTP-RMTM4Q3: Revenue meter test mechanical 4-quadrant 3-wire
Purpose: For testing mechanical 2-element meters w/ delivered and received active power flow, watthours only

Step	Element	Test	Test Revs	% Test Volts	% Test Amps	Phase Angle (degrees)	Measured Quantity
1	S	AO	5	100	100	0	Watthours
2	S	FL	10	"	100	0	"
3	S	LL	2	"	10	0	"
4	S	LL	2	"	10	0	"
5	S	PF	10	"	100	60	"
6	S	PF	10	"	100	300	"
7	A	FL	10	"	100	0	"
8	A	PF	10	"	100	60	"
9	A	PF	10	"	100	300	"
10	C	FL	10	"	100	0	"
11	C	PF	10	"	100	60	"
12	C	PF	10	"	100	300	"
13	S	AO	5	"	100	180	"
14	S	FL	10	"	100	180	"
15	S	LL	2	"	10	180	"
16	S	LL	2	"	10	180	"
17	S	PF	10	"	100	240	"
18	S	PF	10	"	100	120	"
19	A	FL	10	"	100	180	"
20	A	PF	10	"	100	240	"
21	A	PF	10	"	100	120	"
22	C	FL	10	"	100	180	"
23	C	PF	10	"	100	240	"
24	C	PF	10	"	100	120	"

Table 4.3. Accuracy Test for 4-Wire Electromechanical Watthour Meters

Test sequence SMTP-RMTM4: Revenue meter test mechanical 4-wire
Purpose: For testing mechanical 2.5- and 3-element meters w/ delivered active power flow, watthours only

Step	Element	Test	Test Revs	% Test Volts	% Test Amperes	Phase Angle (degrees)	Measured Quantity
1	S	AO	5	100	100	0	Watthours
2	S	FL	10	"	100	0	"
3	S	LL	2	"	10	0	"
4	S	LL	2	"	10	0	"
5	S	PF	10	"	100	60	"
6	S	PF	10	"	100	300	"
7	A	FL	10	"	100	0	"
8	A	PF	10	"	100	60	"
9	A	PF	10	"	100	300	"
10	B	FL	10	"	100	0	"
11	B	PF	10	"	100	60	"
12	B	PF	10	"	100	300	"
13	C	FL	10	"	100	0	"
14	C	PF	10	"	100	60	"
15	C	PF	10	"	100	300	"

Table 4.4. Accuracy Test for 4-Wire Electromechanical Watthour Meters

Test sequence SMTP-RMTM4Q4: Revenue meter test, mechanical, 4-quadrant, 4-wire
Purpose: For testing mechanical 2.5- and 3-element meters w/ delivered & received active power flow, watthours only

Step	Element	Test	Test Revs	% Test Volts	% Test Amperes	Phase Angle (degrees)	Measured Quantity
1	S	AO	5	100	100	0	Watthours
2	S	FL	10	"	100	0	"
3	S	LL	2	"	10	0	"
4	S	LL	2	"	10	0	"
5	S	PF	10	"	100	60	"
6	S	PF	10	"	100	300	"
7	A	FL	10	"	100	0	"
8	A	PF	10	"	100	60	"
9	A	PF	10	"	100	300	"
10	B	FL	10	"	100	0	"
11	B	PF	10	"	100	60	"
12	B	PF	10	"	100	300	"
13	C	FL	10	"	100	0	"
14	C	PF	10	"	100	60	"
15	C	PF	10	"	100	300	"
16	S	AO	5	"	100	180	"
17	S	FL	10	"	100	180	"
18	S	LL	2	"	10	180	"
19	S	LL	2	"	10	180	"
20	S	PF	10	"	100	240	"
21	S	PF	10	"	100	120	"
22	A	FL	10	"	100	180	"
23	A	PF	10	"	100	240	"
24	A	PF	10	"	100	120	"
25	B	FL	10	"	100	180	"
26	B	PF	10	"	100	240	"
27	B	PF	10	"	100	120	"
28	C	FL	10	"	100	180	"
29	C	PF	10	"	100	240	"
30	C	PF	10	"	100	120	"

Table 4.5. Accuracy Test for 3-Wire Electronic Watthour and Varhour Meters

Test sequence SMTP-RMTE3: Revenue meter test, electronic 3-wire
Purpose: For testing electronic 2-element meters w/ delivered, active, and reactive power flow, watthours and varhours

Step	Element	Test	Test Revs	% Test Volts	% Test Amperes	Phase Angle (degrees)	Measured Quantity
1	S	AO	5	100	100	0	Watthours
2	S	FL	10	"	100	0	"
3	S	PF	10	"	100	60	"
4	S	PF	10	"	100	300	"
5	S	LL	2	"	10	0	"
6	A	FL	10	"	100	0	"
7	A	PF	10	"	100	60	"
8	A	PF	10	"	100	300	"
9	C	FL	10	"	100	0	"
10	C	PF	10	"	100	60	"
11	C	PF	10	"	100	300	"
12	S	AO	5	"	100	270	Varhours
13	S	FL	10	"	100	90	"
14	S	FL	10	"	100	270	"
15	S	PF	10	"	100	30	"
16	S	PF	10	"	100	330	"
17	S	LL	2	"	10	90	"
18	S	LL	2	"	10	270	"
19	A	FL	10	"	100	90	"
20	A	FL	10	"	100	270	"
21	A	PF	10	"	100	30	"
22	A	PF	10	"	100	330	"
23	C	FL	10	"	100	90	"
24	C	FL	10	"	100	270	"
25	C	PF	10	"	100	30	"
26	C	PF	10	"	100	330	"

Table 4.6. Accuracy Test for 3-Wire Electronic Watthour and Varhour Meters

Test sequence SMTP-RMTE3B: Revenue meter test electronic 3-wire basic
Purpose: For testing electronic 2-element meters w/ delivered, active power flow, watthours only

Step	Element	Test	Test Revs	% Test Volts	% Test Amperes	Phase Angle (degrees)	Measured Quantity
1	S	AO	5	100	100	0	Watthours
2	S	FL	10	"	100	0	"
3	S	LL	2	"	10	0	"
4	S	PF	10	"	100	60	"
5	S	PF	10	"	100	300	"
6	A	FL	10	"	100	0	"
7	A	PF	10	"	100	60	"
8	A	PF	10	"	100	300	"
9	C	FL	10	"	100	0	"
10	C	PF	10	"	100	60	"
11	C	PF	10	"	100	300	"

Table 4.7. Accuracy Test for 3-Wire Electronic Watthour and Varhour Meters

Test sequence SMTP-RMTE4Q3: Revenue meter test, electronic, 4-quadrant, 3-wire
Purpose: For testing electronic, 2-element meters w/ delivered and received, active and reactive power flow, watthours and varhours

Step	Element	Test	Test Revs	% Test Volts	% Test Amperes	Phase Angle (degrees)	Measured Quantity
1	S	AO	5	100	100	0	Watthours
2	S	FL	10	"	100	0	"
3	S	PF	10	"	100	60	"
4	S	PF	10	"	100	300	"
5	S	LL	2	"	10	0	"
6	A	FL	10	"	100	0	"
7	A	PF	10	"	100	60	"
8	A	PF	10	"	100	300	"
9	C	FL	10	"	100	0	"
10	C	PF	10	"	100	60	"
11	C	PF	10	"	100	300	"
12	S	AO	5	"	100	270	Varhours
13	S	FL	10	"	100	90	"
14	S	FL	10	"	100	270	"
15	S	PF	10	"	100	30	"
16	S	PF	10	"	100	330	"
17	S	LL	2	"	10	90	"
18	S	LL	2	"	10	270	"
19	A	FL	10	"	100	90	"
20	A	FL	10	"	100	270	"
21	A	PF	10	"	100	30	"
22	A	PF	10	"	100	330	"
23	C	FL	10	"	100	90	"
24	C	FL	10	"	100	270	"
25	C	PF	10	"	100	30	"
26	C	PF	10	"	100	330	"
27	S	AO	5	"	100	180	Watthours
28	S	FL	10	"	100	180	"
29	S	PF	10	"	100	240	"
30	S	PF	10	"	100	120	"
31	S	LL	10	"	10	180	"
32	A	FL	10	"	100	180	"
33	A	PF	10	"	100	240	"
34	A	PF	10	"	100	120	"
35	C	FL	10	"	100	180	"
36	C	PF	10	"	100	240	"
37	C	PF	10	"	100	120	"
38	S	AO	5	"	100	270	Varhours
39	S	PF	10	"	100	150	"
40	S	PF	10	"	100	210	"
41	A	PF	10	"	100	150	"
42	A	PF	10	"	100	210	"
43	C	PF	10	"	100	150	"
44	C	PF	10	"	100	210	"

Table 4.8. Accuracy Test for 4-Wire Electronic Watthour and Varhour Meters

Test sequence SMTP-RMTE4: Revenue meter test, electronic, 4-wire
Purpose: For testing electronic 2.5 and 3-element meters w/ delivered, active, and reactive power flow, watthours and varhours

Step	Element	Test	Test Revs	% Test Volts	% Test Amperes	Phase Angle (degrees)	Measured Quantity
1	S	AO	5	100	100	0	Watthours
2	S	FL	10	"	100	0	"
3	S	PF	10	"	100	60	"
4	S	PF	10	"	100	300	"
5	S	LL	2	"	10	0	"
6	A	FL	10	"	100	0	"
7	A	PF	10	"	100	60	"
8	A	PF	10	"	100	300	"
9	B	FL	10	"	100	0	"
10	B	PF	10	"	100	60	"
11	B	PF	10	"	100	300	"
12	C	FL	10	"	100	0	"
13	C	PF	10	"	100	60	"
14	C	PF	10	"	100	300	"
15	S	AO	5	"	100	270	Varhours
16	S	FL	10	"	100	90	"
17	S	FL	10	"	100	270	"
18	S	PF	10	"	100	30	"
19	S	PF	10	"	100	330	"
20	S	LL	2	"	10	90	"
21	S	LL	2	"	10	270	"
22	A	FL	10	"	100	90	"
23	A	FL	10	"	100	270	"
24	A	PF	10	"	100	30	"
25	A	PF	10	"	100	330	"
26	B	FL	10	"	100	90	"
27	B	FL	10	"	100	270	"
28	B	PF	10	"	100	30	"
29	B	PF	10	"	100	330	"
30	C	FL	10	"	100	90	"
31	C	FL	10	"	100	270	"
32	C	PF	10	"	100	30	"
33	C	PF	10	"	100	330	"

Table 4.9. Accuracy Test for 4-Wire Electronic Watthour and Varhour Meters

Test sequence SMTP-RMTE4B: Revenue meter test, electronic, 4-wire basic
Purpose: For testing electronic 2.5- and 3-element meters w/ delivered, active power flow, watthours only

Step	Element	Test	Test Revs	% Test Volts	% Test Amperes	Phase Angle (degrees)	Measured Quantity
1	S	AO	5	100	100	0	Watthours
2	S	FL	10	"	100	0	"
3	S	LL	2	"	10	0	"
4	S	PF	10	"	100	60	"
5	S	PF	10	"	100	300	"
6	A	FL	10	"	100	0	"
7	A	PF	10	"	100	60	"
8	A	PF	10	"	100	300	"
9	B	FL	10	"	100	0	"
10	B	PF	10	"	100	60	"
11	B	PF	10	"	100	300	"
12	C	FL	10	"	100	0	"
13	C	PF	10	"	100	60	"
14	C	PF	10	"	100	300	"

Table 4.10. Accuracy Test for 4-Wire Electronic Watthour and Varhour Meters

Test sequence SMTP-RMTE4Q4: Revenue meter test, electronic, 4-quadrant, 4-wire
Purpose: For testing electronic 2.5- & 3-element meters w/ delivered and received, active and reactive power flow, watt and varhours

Step	Element	Test	Test Revs	% Test Volts	% Test Amperes	Phase Angle (degrees)	Measured Quantity
1	S	AO	5	100	100	0	Watthours
2	S	FL	10	"	100	0	"
3	S	PF	10	"	100	60	"
4	S	PF	10	"	100	300	"
5	S	LL	2	"	10	0	"
6	A	FL	10	"	100	0	"
7	A	PF	10	"	100	60	"
8	A	PF	10	"	100	300	"
9	B	FL	10	"	100	0	"
10	B	PF	10	"	100	60	"
11	B	PF	10	"	100	300	"
12	C	FL	10	"	100	0	"
13	C	PF	10	"	100	60	"
14	C	PF	10	"	100	300	"
15	S	AO	5	"	100	270	Varhours
16	S	FL	10	"	100	90	"
17	S	FL	10	"	100	270	"
18	S	PF	10	"	100	30	"
19	S	PF	10	"	100	330	"
20	S	LL	2	"	10	90	"
21	S	LL	2	"	10	270	"
22	A	FL	10	"	100	90	"
23	A	FL	10	"	100	270	"
24	A	PF	10	"	100	30	"
25	A	PF	10	"	100	330	"
26	B	FL	10	"	100	90	"
27	B	FL	10	"	100	270	"
28	B	PF	10	"	100	30	"
29	B	PF	10	"	100	330	"
30	C	FL	10	"	100	90	"
31	C	FL	10	"	100	270	"
32	C	PF	10	"	100	30	"
33	C	PF	10	"	100	330	"
34	S	AO	5	"	100	180	Watthours
35	S	FL	10	"	100	180	"
36	S	PF	10	"	100	240	"
37	S	PF	10	"	100	120	"
38	S	LL	10	"	10	180	"
39	A	FL	10	"	100	180	"
40	A	PF	10	"	100	240	"
41	A	PF	10	"	100	120	"
42	B	FL	10	"	100	180	"
43	B	PF	10	"	100	240	"
44	B	PF	10	"	100	120	"
45	C	FL	10	"	100	180	"
46	C	PF	10	"	100	240	"
47	C	PF	10	"	100	120	"
48	S	AO	5	"	100	270	Varhours
49	S	PF	10	"	100	150	Varhours
50	S	PF	10	"	100	210	"
51	A	PF	10	"	100	150	"
52	A	PF	10	"	100	210	"
53	B	PF	10	"	100	150	"
54	B	PF	10	"	100	210	"
55	C	PF	10	"	100	150	"
56	C	PF	10	"	100	210	"

Table 4.11. Pulse Test, Watts, Bi-Directional

Test sequence SMTP-PMTWPN: Pulse meter test, watthours
Purpose: For testing KYZ output delivered and received, active power flow, watthours.

Step	Element	Test	Test Revs	% Test Volts	% Test Amperes	Phase Angle (degrees)	Measured Quantity
1	S	FL	10	100	100	0	Watthours
2	S	FL	10	100	100	180	Watthours

Table 4.12. Pulse Test, Watts, Delivered Only

Test sequence SMTP-PMTWP: Pulse meter test, watthours
Purpose: For testing KYZ output delivered, active power flow, watthours

Step	Element	Test	Test Revs	% Test Volts	% Test Amperes	Phase Angle (degrees)	Measured Quantity
1	S	FL	10	100	100	0	Watthours

Table 4.13. Pulse Test, Vars, Bi-Directional

Test sequence SMTP-PMTVPN: Pulse meter test, varhours
Purpose: For testing KYZ output delivered & received, reactive power flow, varhours

Step	Element	Test	Test Revs	% Test Volts	% Test Amperes	Phase Angle (degrees)	Measured Quantity
1	S	FL	10	100	100	90	Varhours
2	S	FL	10	100	100	270	Varhours

Table 4.14. Pulse Test, Vars, Delivered Only

Test sequence SMTP-PMTVP: Pulse meter test, varhours
Purpose: For testing KYZ output delivered, reactive power flow, varhours

Step	Element	Test	Test Revs	% Test Volts	% Test Amperes	Phase Angle (degrees)	Measured Quantity
1	S	FL	10	100	100	90	Varhours

Table 4.15. Analog Test Watts, Delivered Only

Test sequence SMTP-TMTWP: transducer meter test watthours
Purpose: For testing analog output delivered, active power flow, watthours

Step	Element	Test Voltage	Test Amperes	Phase Angle (degrees)
1	S	120	4.167	0
2	S	120	3.333	0
3	S	120	2.5	0
4	S	120	1.667	0
5	S	120	0.833	0

Table 4.16. Analog Test, Watts, Bi-Directional

Test sequence SMTP-TMTWPN: transducer meter test, watthours
Purpose: For testing analog output delivered & received, active power flow, watthours

Step	Element	Test Voltage	Test Amperes	Phase Angle (degrees)
1	S	120	4.167	0
2	S	120	3.333	0
3	S	120	2.5	0
4	S	120	1.667	0
5	S	120	0.833	0
6	S	120	4.167	180
7	S	120	3.333	180
8	S	120	2.5	180
9	S	120	1.667	180
10	S	120	0.833	180

Table 4.17. Analog Test, Vars, Delivered Only

Test sequence SMTP-TMTVP: Transducer meter test, varhours
Purpose: For testing analog output delivered, reactive power flow, varhours

Step	Element	Test Voltage	Test Amperes	Phase Angle (degrees)
1	S	120	4.167	90
2	S	120	3.333	90
3	S	120	2.5	90
4	S	120	1.667	90
5	S	120	0.833	90

Table 4.18. Analog Test, Vars, Bi-Directional

Test sequence SMTP-TMTVPN: Transducer meter test varhours
Purpose: For testing analog output delivered and received, reactive power flow, varhours

Step	Element	Test Voltage	Test Amperes	Phase Angle (degrees)
1	S	120	4.167	90
2	S	120	3.333	90
3	S	120	2.5	90
4	S	120	1.667	90
5	S	120	0.833	90
6	S	120	4.167	270
7	S	120	3.333	270
8	S	120	2.5	270
9	S	120	1.667	270
10	S	120	0.833	270

Table 4.19. Accuracy Test for 3 and 4-Wire EIM Electronic Watthour and Varhour Meters

Test sequence SMTP-RMTEIME: Revenue meter test, EIM electronic
Purpose: For testing EIM electronic 2, 2.5, and 3 element meters w/ delivered and received, active and reactive power flow, watt and varhours

Step	Element	Test	Test Revs	% Test Volts	% Test Amperes	Phase Angle (degrees)	Measured Quantity
1	S	AO	5	100	100	0	Watthours
2	S	FL	10	"	100	0	"
3	S	PF	10	"	100	60	"
4	S	PF	10	"	100	300	"
5	S	LL	2	"	10	0	"
6	S	FL	10	"	100	180	"
7	S	PF	10	"	100	240	"
8	S	PF	10	"	100	120	"
9	S	LL	2	"	10	180	"
10	S	AO	5	"	100	90	Varhours
11	S	FL	10	"	100	90	"
12	S	PF	10	"	100	30	"
13	S	PF	10	"	100	150	"
14	S	LL	2	"	10	90	"
15	S	FL	10	"	100	270	"
16	S	PF	10	"	100	210	"
17	S	PF	10	"	100	330	"
18	S	LL	2	"	10	270	"

5. References

SCL Work Practice 2505.14; "Accuracy Limits for Substation and Generation Watthour Metering"

ANSI C12.1-2008; Electric Meters Code for Electricity Metering

ANSI C12.20-2010; Electricity Meters - 0.2 and 0.5 Accuracy Classes

6. Sources

Eltrich, Patrick; Station Meter Electrician and subject matter expert for 2505.15 (patrick.eltrich@seattle.gov)

Everist, Arlen; Station Meter Electrician, subject matter expert, and originator of 2505.15 (arlen.everist@seattle.gov)