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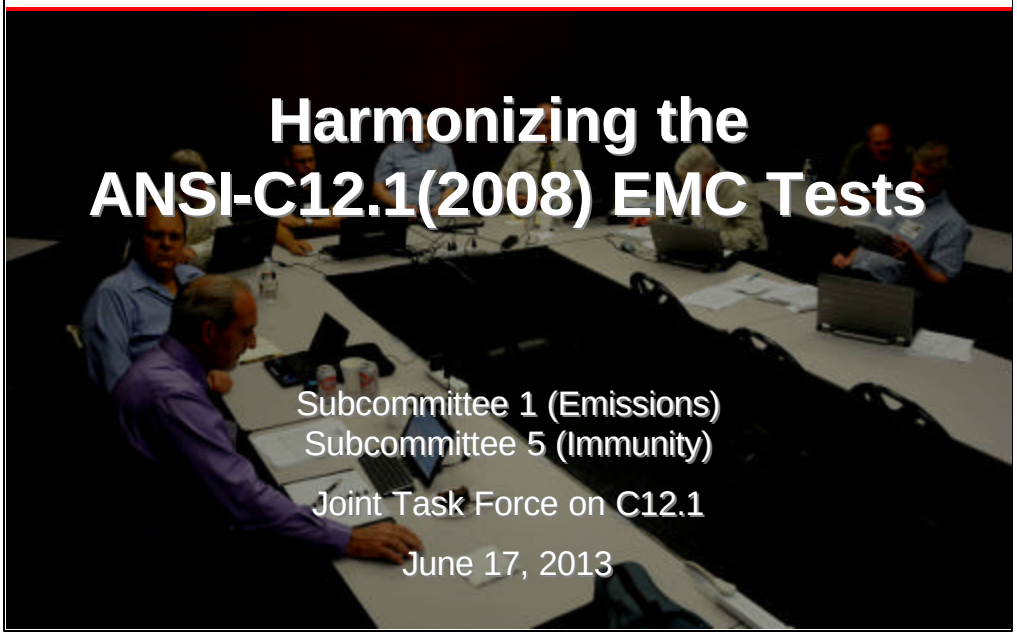
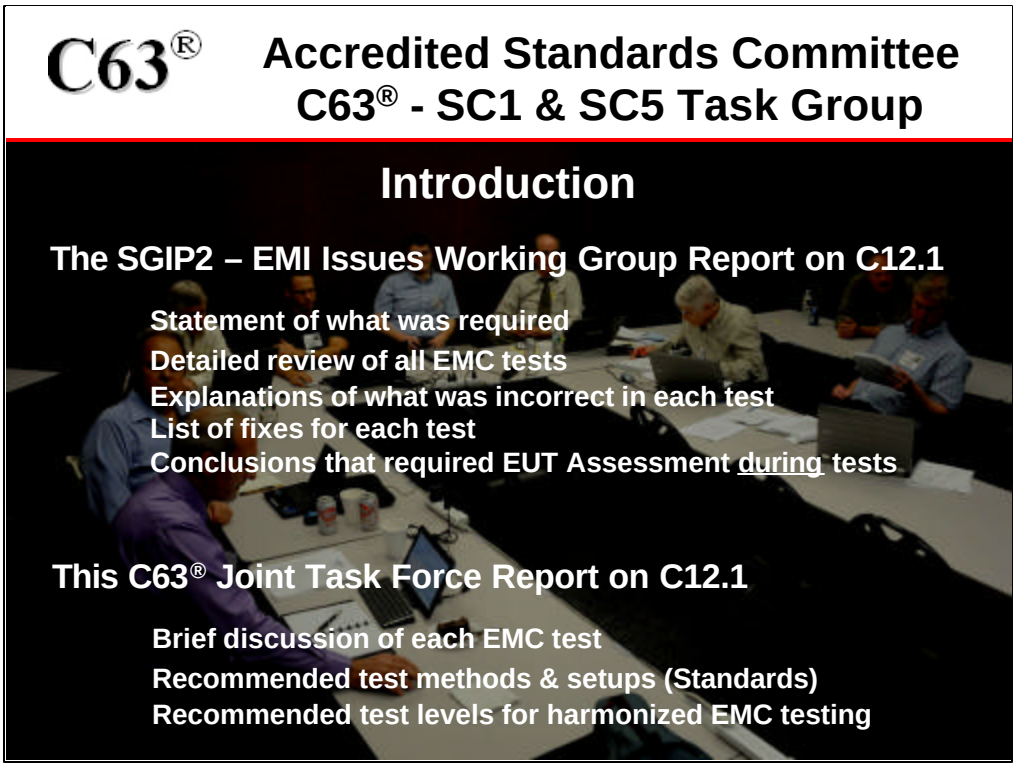


The Accredited Standards Committee C63®
presents

Harmonizing the ANSI-C12.1(2008) EMC Tests

By the
Subcommittee 1 on Emissions
Subcommittee 5 on Immunity
Joint Task Force on C12.1
June 17, 2013



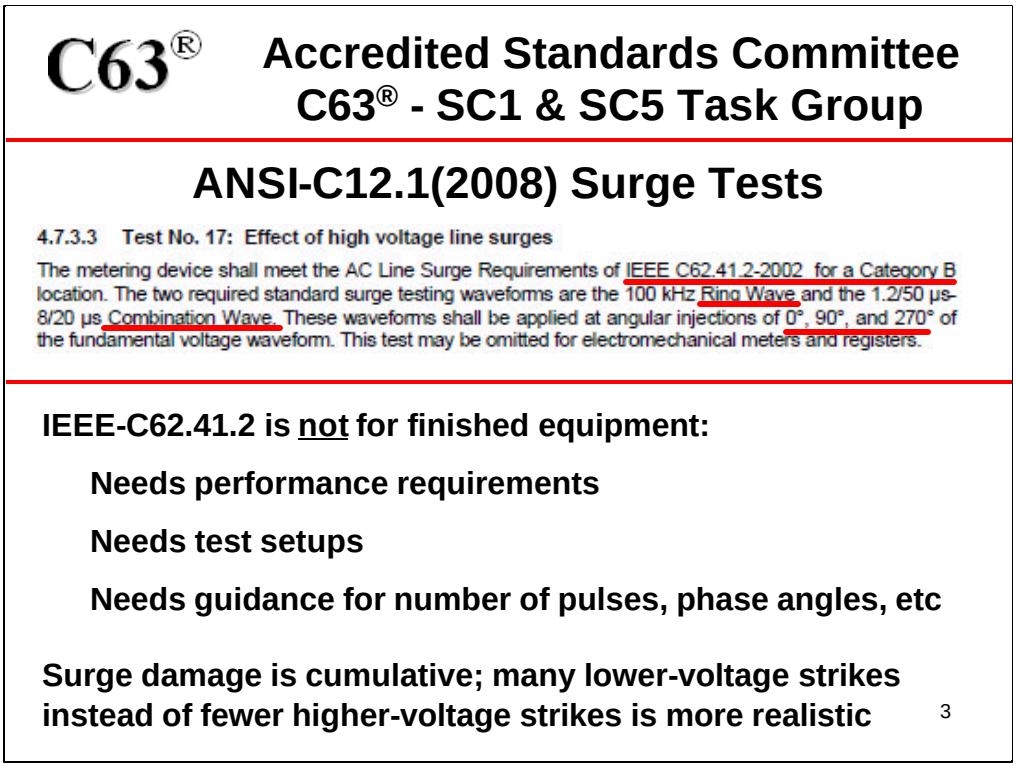
Introduction

The SGIP2 – EMI Issues Working Group Report on C12.1

Statement of what was required
Detailed review of all EMC tests
Explanations of what was incorrect in each test
List of fixes for each test
Conclusions that required EUT Assessment during tests

This C63® Joint Task Force Report on C12.1

Brief discussion of each EMC test
Recommended test methods & setups (Standards)
Recommended test levels for harmonized EMC testing



4.7.3.3 Test No. 17: Effect of high voltage line surges
IEEE C62.41.2-2002 AC line Surge for a Category B locations is cited. The purpose of the document is to offer surge testing waveforms and stress (testing) levels. There are no performance requirements. There are no test setups and no references to the number of impulses delivered nor their phase angles. The document pertains to surge protective devices, not to finished equipment.

Damage from properly-run surge tests are cumulative, that is, all the lower test levels are run first and contribute to failures of the surge protective devices within finished equipment. This mimics actual field conditions as surge protective devices sustain damage over many strikes at lower amplitudes instead of just a few strikes at higher amplitudes. Surge testing is destructive, so it is the only test appropriate for "before/after" evaluation using an accuracy check.

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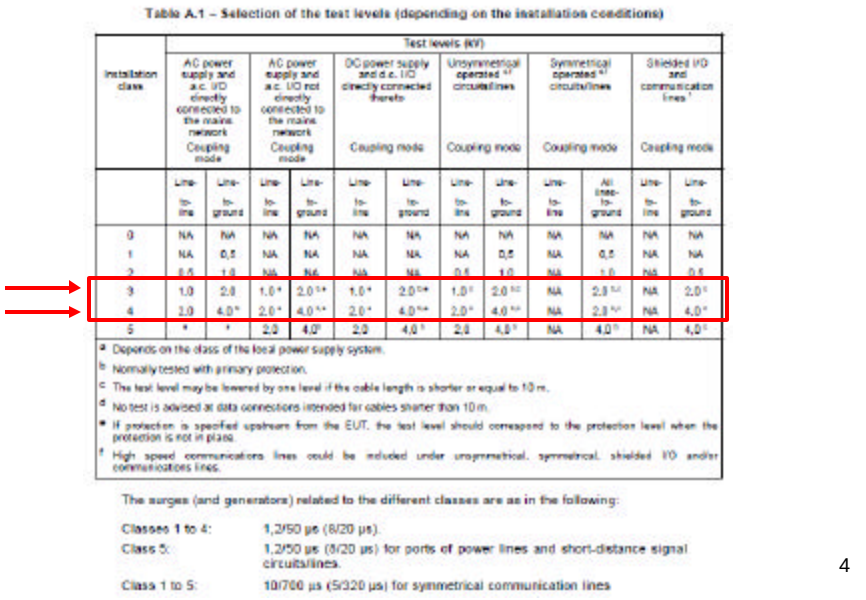

Table A.1 – Selection of the test levels (depending on the installation conditions)

Installation class	Test levels (kV)											
	AC power supply and a.c. I/O directly connected to the mains network. Coupling mode		AC power supply and a.c. I/O not directly connected to the mains network. Coupling mode		DC power supply and d.c. I/O directly connected thereto. Coupling mode		Unsymmetrical operated [f] circuits/lines. Coupling mode		Symmetrical operated [f] circuits/lines. Coupling mode		Shielded I/O and communication lines [f]. Coupling mode	
	Line-to-line	Line-to-ground	Line-to-line	Line-to-ground	Line-to-line	Line-to-ground	Line-to-line	Line-to-ground	Line-to-line	All lines-to-ground	Line-to-line	Line-to-ground
0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1	NA	0,5	NA	NA	NA	NA	NA	0,5	NA	0,5	NA	NA
2	0,5	1,0	NA	NA	NA	NA	0,5	1,0	NA	1,0	NA	0,5
3	1,0	2,0	1,0 [e]	2,0 [b e]	1,0 [e]	2,0 [b e]	1,0 [c]	2,0 [b c]	NA	2,0 [b c]	NA	2,0 [c]
4	2,0	4,0 [e]	2,0 [e]	4,0 [b e]	2,0 [e]	4,0 [b e]	2,0 [e]	4,0 [b c]	NA	2,0 [b c]	NA	4,0 [c]
5	*	*	2,0	4,0 [b]	2,0	4,0 [b]	2,0	4,0 [b]	NA	4,0 [b]	NA	4,0 [c]

[a] Depends on the class of the local power supply system.
[b] Normally tested with primary protection.
[c] The test level may be lowered by one level if the cable length is shorter or equal to 10 m.
[d] No test is advised at data connections intended for cables shorter than 10 m.
[e] If protection is specified upstream from the EUT, the test level should correspond to the protection level when the protection is not in place.
[f] High speed communications lines could be included under unsymmetrical, symmetrical, shielded I/O and/or communications lines.

The surges (and generators) related to the different classes are as in the following:

Classes 1 to 4: 1,2/50 µs (8/20 µs).
Class 5: 1,2/50 µs (8/20 µs) for ports of power lines and short-distance signal circuits/lines.
Class 1 to 5: 10/700 µs (5/320 µs) for symmetrical communication lines

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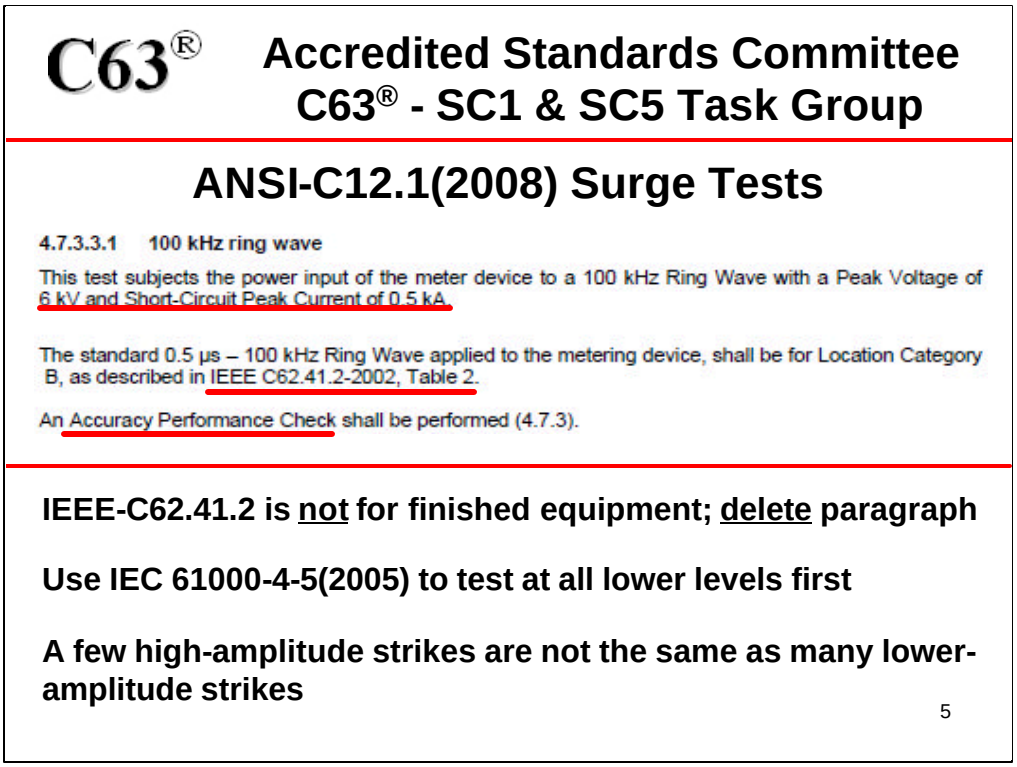
4.7.3.3 Test No. 17: Effect of high voltage line surges

A different surge Standard should be considered, such as IEC61000-4-5(2005), identified as appropriate for utility equipment in the NIST-SGIP-EMI Issues White Paper. Test levels could be taken from the draft of IEEE-P1613.1 for utility communications devices:

IEC 61000-4-5 (Surge)

Zone A: Inside the substation fence: Installation Class 4
Zone B: Outside the substation fence: Installation Class 3

Consider lowering the test levels (from 6kV down to 4kV) and increasing the number of strikes to comply with IEC61000-4-5, starting at the lowest levels and not skipping the number of impulses, their angles of application nor any of the test levels. That is, five positive and five negative impulses at four phase angles of 0, 90, 180 & 270 degrees for each test level delivered once per minute. That's 40 impulses at 0.5kV, 40 impulses at 1kV, 40 impulses at 2kV and 40 impulses at 4kV for a total of 160 impulses to achieve 4kV level testing.



4.7.3.3.1 100kHz ring wave

As before, the cited Standard (IEEE-C62.41.2-2002) is not a finished equipment testing Standard. Consider deleting this paragraph and the 100kHz ring-wave requirement and using IEC 61000-4-5 instead, which requires all test levels be satisfied, not just the highest level. A greater number of pulses will be delivered in such correctly-run tests, which will be a more realistic test scenario. As currently written, only a few strikes are administered at the highest test level. This will result in high test levels being stated on data sheets while still under-testing the meter. A few high-amplitude strikes are not the same as many lower-amplitude strikes.

Testing at only the highest level might lead customers to think that a higher voltage is a more robust test, which is not the case here. Customers cannot make comparisons of products that were type-tested so differently. Correctly tested products will be more resistant to surge damage in the field.

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ANSI-C12.1(2008) 60Hz Magnetic Fields

4.7.3.4 Test No. 18: Effect of external magnetic field

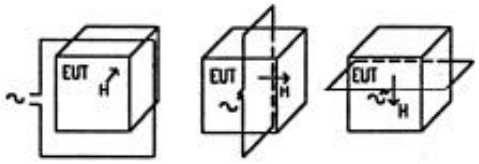
The test shall be applied to one metering device of each class. The external alternating magnetic field of the same frequency as that of the testing current shall be produced by a straight conductor 6 ft. (1.83 m) long with return leads arranged to form a 6 ft (1.83 m)square. A current in phase with the voltage applied to the meter device shall be passed through this conductor. The return leads of the conductor shall be so arranged that the loop that they form does not surround or include the meter device. The straight 6 ft. (1.83 m) conductor shall be placed in each of the following positions:

IEC 61000-4-8 (2001)

"Immersion method" for table-top products

Test Levels:

Zone A (inside fence): Level 5
Zone B (outside fence): Level 4



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4.7.3.4 Test No. 18: Effect of external magnetic field

Delete this paragraph. We agree with the SGIP report that found this unique loop size and proximity test method were not harmonized with other parts of the World. We also concur that IEC 61000-4-8 (2001-03) is suitable for utility equipment. Table-top products are tested using the "immersion" method to deliver a magnetic field measured in Amperes/meter. Testing is repeated in each of the three orthogonal orientations while the EUT is assessed for its Acceptance during the tests. Consider using its test methods.

The test levels for this stimulus from the recent draft of IEEE-1613.1 are:

IEC 61000-4-8 (2009) 60Hz magnetic fields

Zone A Inside the substation fence (Level 5): 100A/m (continuous) + 1,000A/m (short term)
Zone B Outside the substation fence (Level 4): 30A/m (continuous) + 300A/m (short term)

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ANSI-C12.1(2008) EFT Tests

4.7.3.11 Test No. 25: Effect of electrical fast transient/burst test

The metering device shall meet the Fast Transient ~~Surge~~ Test requirements of IEC 61000-4-4. This test subjects the power inputs and the I/O circuits of the metering device to repetitive bursts of 5 ns rise time, 50 ns duration electrical fast transients.

The test shall be conducted utilizing the test equipment configurations provided in Figures 4 and 5. The test shall be carried out according to IEC 61000-4-4, under the following conditions:

1) test severity level: 4
2) test voltages on the voltage and current circuits: 4 kV
3) test voltage on I/O signal, data and control lines: 2 kV
4) repetition rate 5 kHz
5) duration of the test: minimum 60 seconds
6) voltage and auxiliary circuits energized with reference voltage
7) without any current in the current circuits and the current terminals shall be open circuit

IEEE 1613.1 (draft)

Zone A (inside fence): 4kV power; 2kV I/O-signal
Zone B (outside fence): 2kV power; 1kV I/O-signal

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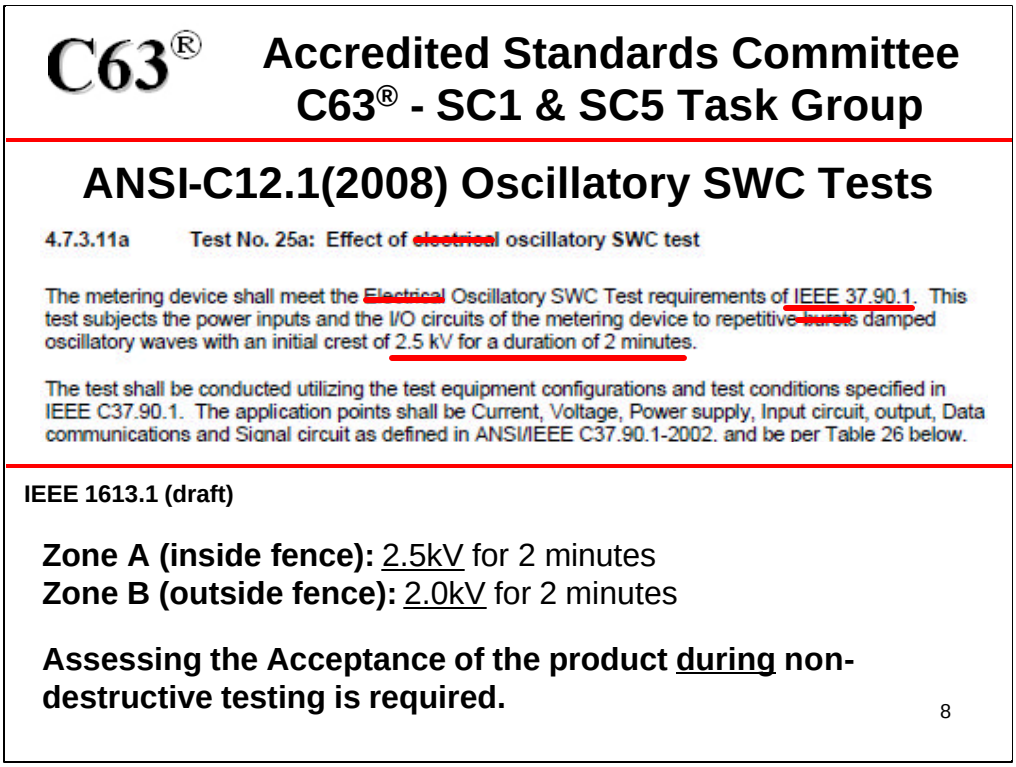
Correct Figs. 4&5 per the EMII working group report. Using IEEE-1613 and its draft extension, IEEE-P1613.1 as a guide, we suggest test levels as shown for Zone A (inside the substation fence) and for Zone B (outside the substation fence).

IEC61000-4-4 (or IEEE-C37.90.1) EFT testing as referenced in IEEE-1613.1:
Zone A (inside the substation fence): 4kV / voltage/current circuits, 2kV I/O or signal

Zone B (outside the substation fence): 2kV / voltage/current circuits, 1kV I/O or signal

While we are cautious about lowering the test level for residential meters or those used in the Distribution network, this 2008 version of C12.1 did not require communications to be taking place during these tests. This test is a high-impedance 50-ohm “voltage withstand” test not likely to damage the product. It is quite likely to disrupt communications or internal operations which must be monitored during the test as indicated in the SGIP report.

We also agree that repetition rates of both 5kHz and 100kHz are appropriate. Of course, the EUT should be configured and running with all options installed and communications operational. Figures 4 and 5 should be re-drawn per the SGIP2-C12.1 report to show this.



4.7.3.11a Test No. 25a: Effect of electrical oscillatory SWC test

We agree with the findings of the SGIP-EMII working group to load and operate the meter as typically installed. Assessing relative "error shift" during the test is appropriate as revenue metering is the critical function of a power meter.

The test level called out (2.5kV for two minutes) is appropriate for Zone A, inside the substation fence as defined in the draft of IEEE-1613.1. Consider adherence to the level called out for Zone B (outside the substation fence) in that document as well, summarized as:

IEEE-C37.90.1 Oscillatory SWC test levels:

Zone A (inside the substation fence): 2.5kV / 2 min.

Zone B (outside the substation fence): 2.0kV / 2 min.

While we are cautious about lowering the test level for testing Zone B distribution and residential meters, the active monitoring of the communications and metering capabilities that may be impacted by this 200-ohm "voltage withstand" test should ensure that the original intent of this testing Standard is met. (The test stimulus causes disruption, which must be monitored during the test, but rarely causes permanent damage) Assessing the Acceptance of the product to established Criteria during non-destructive tests like this one is required.

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ANSI-C12.1(2008) Radiated RF Immunity

4.7.3.12 Test No. 26: Effect of radio frequency interference

This test shall be conducted with all cables connected, with all options and accessories specified, in a configuration closely resembling typical field in-service connections. Typical in-service configurations are provided in Figures 6, 7, 8, and 9. These figures shall be followed as closely as possible, appropriate to type of meter tested and test chamber utilized for the test.

Re-draw figures 6-9 to show typical in-service connections

Radiated Immunity test levels from IEEE-1613.1:

Zone A (inside fence): 35V/m from 80-1,000MHz, 10V/m from 1-3.8GHz, 8.5V/m keyed pulse-mod at five frequencies from 1-6GHz

Zone B (outside fence): 15V/m from 80-1,000MHz, 10V/m from 1-3.8GHz, 8.5V/m keyed pulse-mod at five frequencies from 1-6GHz

4.7.3.12 Test No. 26: Effect of radio frequency interference
Re-draw Figures 6, 7, 8 and 9 to show typical in-service connections. Using IEC 61000-4-3 or IEEEC37.90.2 as a guide, the EUT should be functioning and assessed for its Acceptance during the testing using an established Acceptance Criteria. Show Auxiliary Equipment (AE) that verifies the accuracy of the meters (their critical function) during the tests.

Use Radiated Immunity test levels from IEEE-P1613.1 for utility communications devices:

Zone A (inside substation fence): 35V/m (-0 to +6dB) with 80% AM @ 1kHz in 1% steps from 80-1,000MHz, 10V/m with 80% AM @ 1kHz in 1% steps from 1-3.8GHZ, and 8.5V/m at five frequencies from 1-6GHz with square-wave pulse modulation @ 200Hz rate.

Zone B (outside substation fence: 15V/m (-0 to +6dB) with 80% AM @ 1kHz in 1% steps from 80-1,000MHz, 10V/m with 80% AM @ 1kHz in 1% steps from 1-3.8GHZ, and 8.5V/m at five frequencies from 1-6GHz with square-wave pulse modulation @ 200Hz rate.

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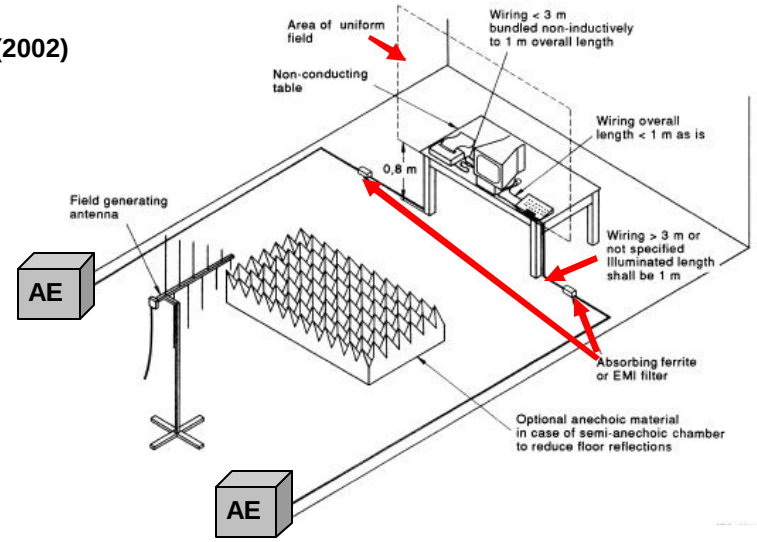
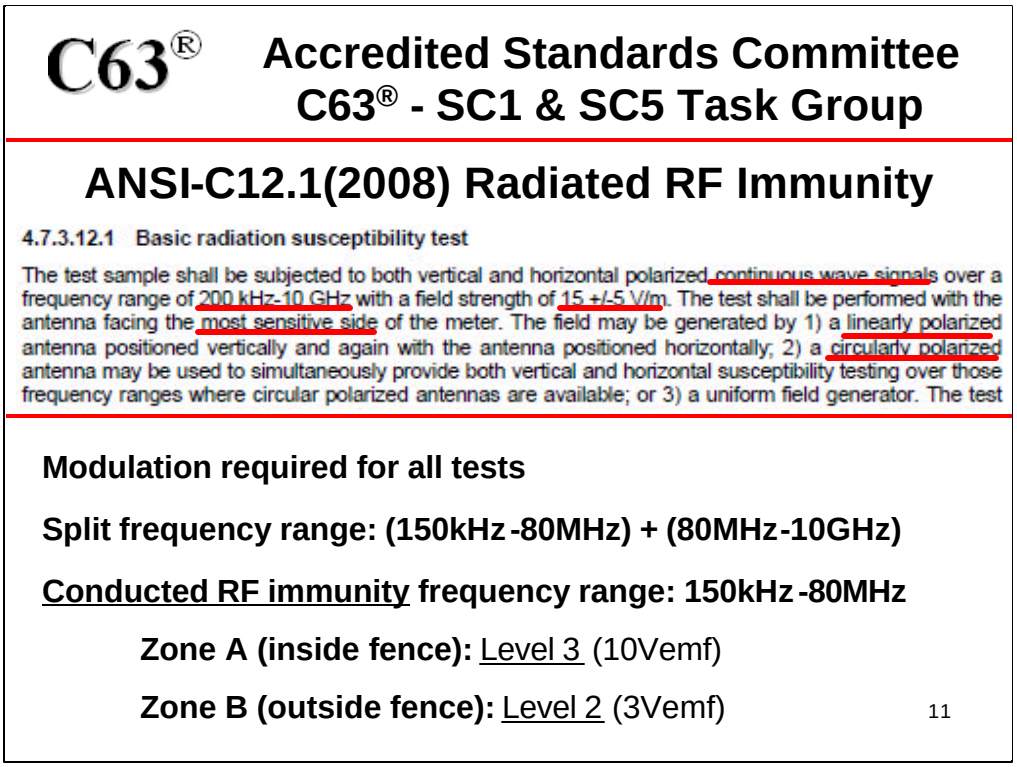
ANSI-C12.1(2008) Radiated RF Immunity

IEC 61000-4-3 (2002)
Fig. 6



Use **IEC 61000-4-3(2002)** as a guide. Figure 6 shows the area of uniform field as a "window pane" at the front face of the table that holds the EUT. The field uniformity is required to be -0 to +6dB over this area. The frequency range for this method is 80MHz to 10GHz or higher. Power and I/O lines needed to exercise the functions of the EUT are shown along the floor being decoupled from the field with absorbing ferrites or run through appropriate EMI filters (or decoupling networks) back to Auxiliary Equipment that exercises or powers those functions. The wiring is bundled up to expose about 1 meter of each type of wire to the radio fields being generated.

For testing a small item such as a meter, the input and output power wires, the I/O lines and any communications wiring would also need to be routed similarly. As noted earlier, the EUT is exercised by Auxiliary Equipment (AE) usually located outside the chamber or shielded from the fields in order to interrogate all critical device modes during the test. If the communications media is wireless, that connection should still be established so the EUT "error shift" can be monitored for its Acceptance during the test.



4.7.3.12.1 Basic radiation susceptibility test

Use modulation on all tests according to the draft of IEEE-P1613.1

Split frequency range to Conducted RF and Radiated RF Immunity ranges

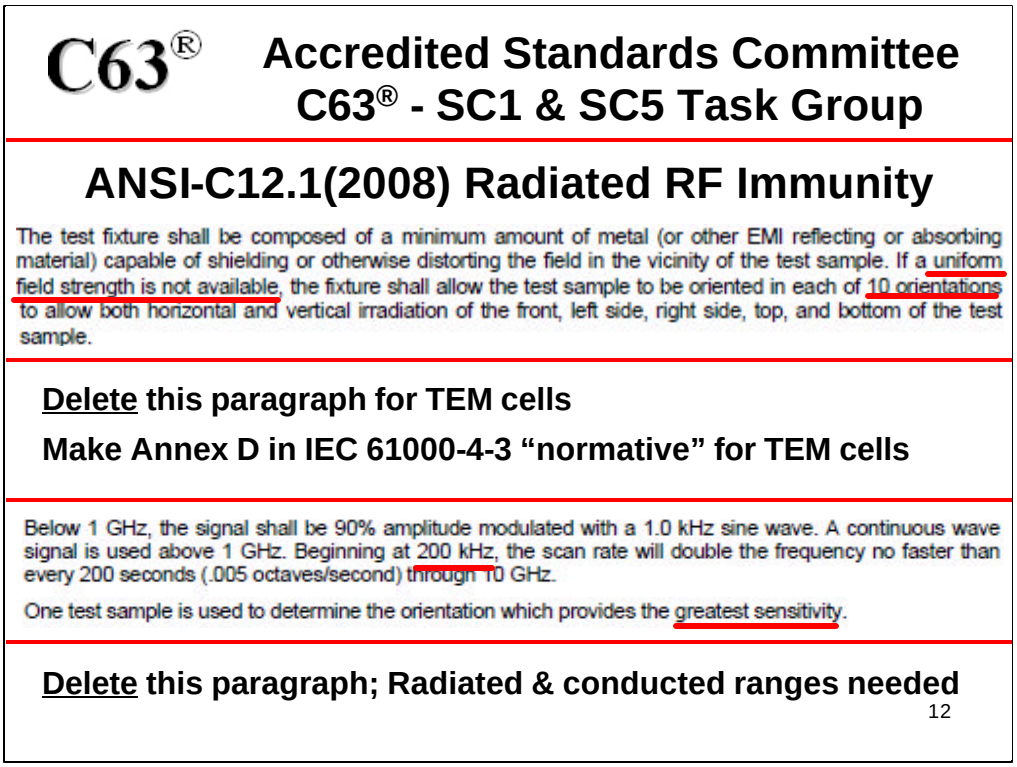
Conducted RF immunity is run from 150kHz to 80Mhz (keyed carrier) in 1% steps with 2 second dwell time at two levels:

Zone A (inside the substation fence): Level 3 (10V open circuit)

Zone B (outside the substation fence): Level 2 (3V open circuit)

Use linearly-polarized antennas as specified in C37.90.2 and IEC 61000-4-3.

Load the meter with resistors and install all optional I/O and communications hardware to note any EUT responses.
Call out Acceptance Criteria that verifies the accuracy of the meter as a critical function during the test (OIML-R46 clause 3.3.6.2)



Delete this paragraph discussing "fixtures" and make Annex D of IEC 61000-4-3 "Normative" for TEM devices.

Use harmonized frequency ranges and modulation schemes with IEEE-1613.1.

Delete this paragraph, radiated and conducted immunity frequency ranges are needed.

No single orientation will provide the "greatest sensitivity" at all frequencies.

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ANSI-C12.1(2008) Radiated RF Immunity

With a field strength set to 15 +/- 5 V/m, test the test samples over a frequency range in the most sensitive orientation.

In each orientation above, the fixture shall place the test sample in a test volume in which the field strength remains within acceptable test limits.

GTEM guidance

When using GTEM testing, power and I/O leads should be only as long as needed to make connection from the GTEM shielded I/O connectors to the test sample. Leads shall not exceed 5 meters in length. Excess leads shall be coiled in a 0.4 meter diameter coil and supported 0.02 to 0.1 meter off the floor and other metal surfaces of the GTEM.

Delete both upper paragraphs (refers to 10 orientations)

Delete third paragraph and make IEC 61000-4-3 normative

Delete Fig. 9 showing incorrectly mounted product in GTEM

Paragraphs 5 & 6 under 4.7.3.12.1

Delete both upper paragraphs, referring to ten "orientations" The test level is set elsewhere.

Delete third paragraph offering "GTEM guidance" and use IEC 61000-4-3 Annex D for requirements to be met with TEM devices.

(field uniformity should not be relaxed and the EUT with its associated power, I/O and communications wiring must not take up more than one-third of the dimension from the septum to the floor) One meter of the power & I/O leads needs to be exposed to the field, not as short as possible.

Delete Figure 9 showing an incorrectly-mounted EUT in a GTEM structure. (The current Standard IEC 61000-4-20 for TEM devices calls for battery-operated products only and is not suitable for meters.)

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ANSI-C12.1(2008) RF Emissions

4.7.3.13 Test No. 27: Radio frequency conducted and radiated emission test

The metering device shall conform to all applicable requirements of the Code of Federal Regulations (CFR) 47, Part 15—Radio Frequency Devices, Subparts A—General and B—Unintentional Radiators issued by the Federal Communications Commission for Class "B" digital devices.

The test shall be conducted with all cables connected, with all options and accessories specified, in a configuration closely resembling typical field in-service connections. Typical in-service configurations are provided in Figures 6, 7, 8, and 9. These figures shall be followed as closely as possible, appropriate to the type of meter tested and test chamber utilized for the test. The LISN can be optionally located on the floor. For all other aspects of this test not covered by CFR 47, Part 15 A and B, and this standard, refer to ANSI C63.4.

Mount LISN on the floor

Re-draw Fig. 6-9 to show typical

Show resistors as simulated loads

Exercise all functions, use conditions of greatest emission[14]

4.7.3.13 Test No. 27: Radio frequency conducted and radiated emission test

The first paragraph sets the Radiated & Conducted Emissions limits to 47CFR15 – Class B (residential)

Per IEEE-C63.4,

A) the LISN must be mounted on the floor for table-top equipment as shown in C63.4 Fig. 7

B) Re-draw Figures 6- 9 to show typical in-service configurations

C) Show resistors as simulated loads for the meter under test.

D) Exercise all functions offered in the meter during the testing, use the conditions that result in greatest emissions as the measurement case

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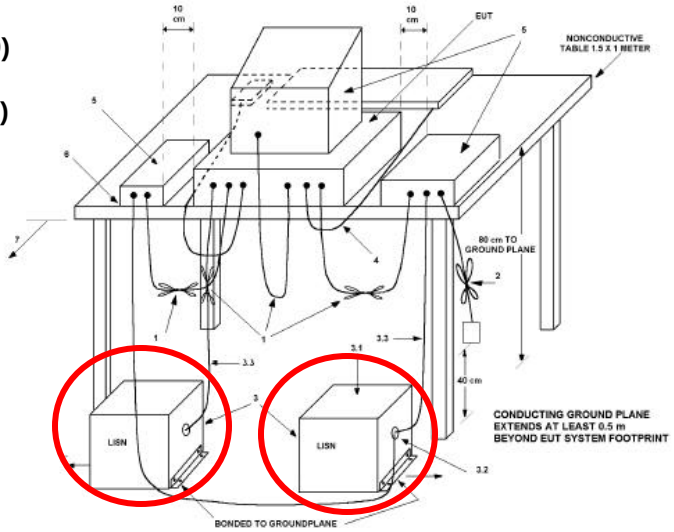
ANSI-C12.1(2008) RF Emissions

C63.4 (2009) Fig. 7 (conducted)



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C63.4(2009)

Figure 7 shows the Line Impedance Stabilization Networks (LISN) for powering the EUT and associated equipment being bonded to the ground plane on the floor behind the table for running **Conducted Emissions**. They can be left in place during radiated emissions testing as well. This setup could be used for Radiated Immunity also. See IEC 61000-4-3 for additional guidance.

The EUT needs to be hooked up and running as it would be when installed. Functions are exercised during the test so that any radio emanations from the cabling will be measured. One LISN is used to power the EUT, the other to power peripherals normally used with the EUT, if applicable. Exercised conditions that create the greatest (loudest) emissions should be used as the measurement case.

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ANSI-C12.1(2008) ESD

4.7.3.14 Test No. 28: Effect of electrostatic discharge (ESD)

This test shall be carried out according to IEC 61000 Part 4-2 (1995), under the following conditions:

- test severity level: 4
- test voltage: 15 kV; (through air)
- number of discharges: 10
- voltage and auxiliary circuits energized with reference voltage
- without any current in the current circuits and the current terminals should be open circuit

Discharges shall be applied only to such points and surfaces of the metering device that are normally accessible with the cover on. Discharges shall not be applied to any point that is accessible only for maintenance purposes.

This test shall be conducted on all metering devices containing solid-state components excluding voltage indicators.

IEEE P1613.1 (draft)

Zone A (inside fence): 15kV(air) + 8kV(contact)

Zone B (outside fence): 8kV(air) + 6kV(contact)

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4.7.3.14 Test No. 28: Effect of Electrostatic Discharge (ESD)

Specify the newer version of IEC 61000-4-2.

Specify all lower levels of testing, not just the highest level.

Consider using the draft of IEEE-P1613.1 to set these test levels:

Zone A (inside the substation fence): 15kV(air) + 8kV(contact)

Zone B (outside the substation fence): 8kV(air) + 6kV(contact)

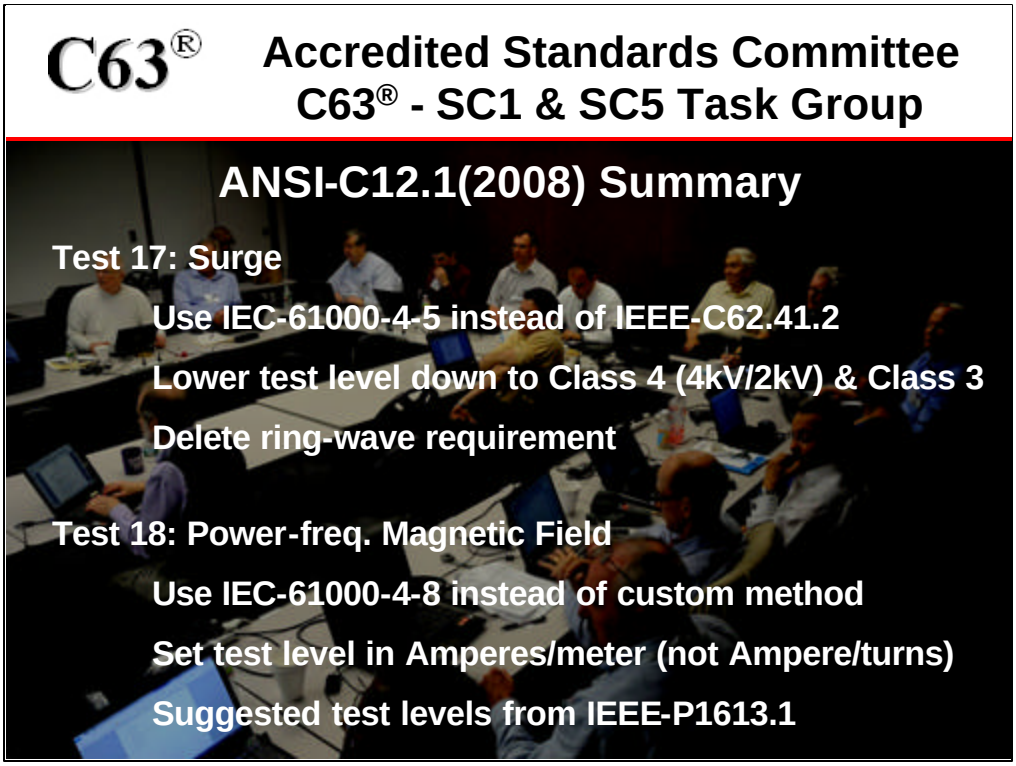
Specify that current be drawn at typical installed levels (IEC 61000-4-2 (1995) Paragraph 7) and the meter be exercised in all normal modes of operation during the tests. (five positive and five negative impulses per test point and level)

Test points should be selected in accordance with Annex A.5

Specify testing at all levels below and including that specified, in both air and contact mode with ten discharges per point and test level.

Delete the exemption for meters with voltage indicators

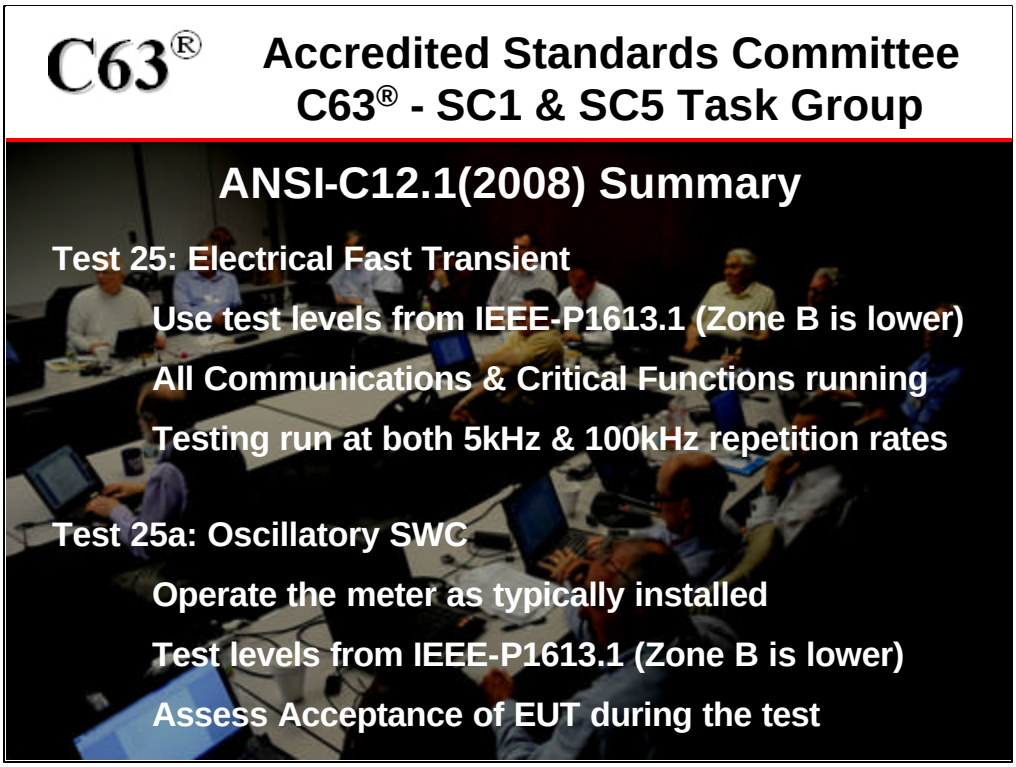
Call out Acceptance Criteria that verifies the accuracy of the meter as a critical function during the test (OIML-R46 clause 3.3.6.2)



Summary

Test 17: Surge
Use IEC-61000-4-5 instead of IEEE-C62.41.2
Lower highest test level down to Installation Class 4 (4kV) & Class 3 (2kV)
Delete ring-wave requirement

Test 18: Power-frequency Magnetic Field
Use IEC-61000-4-8 instead of existing custom method
Set test level in Amperes/meter (not Ampere-turns)
Suggested test levels from IEEE-P1613.1



Summary

Test 25: Electrical Fast Transient
Use test levels from IEEE-P1613.1 for Zones A & B (Zone B is lower than current Standard)

All communications & critical functions (metering of power) are running during the test

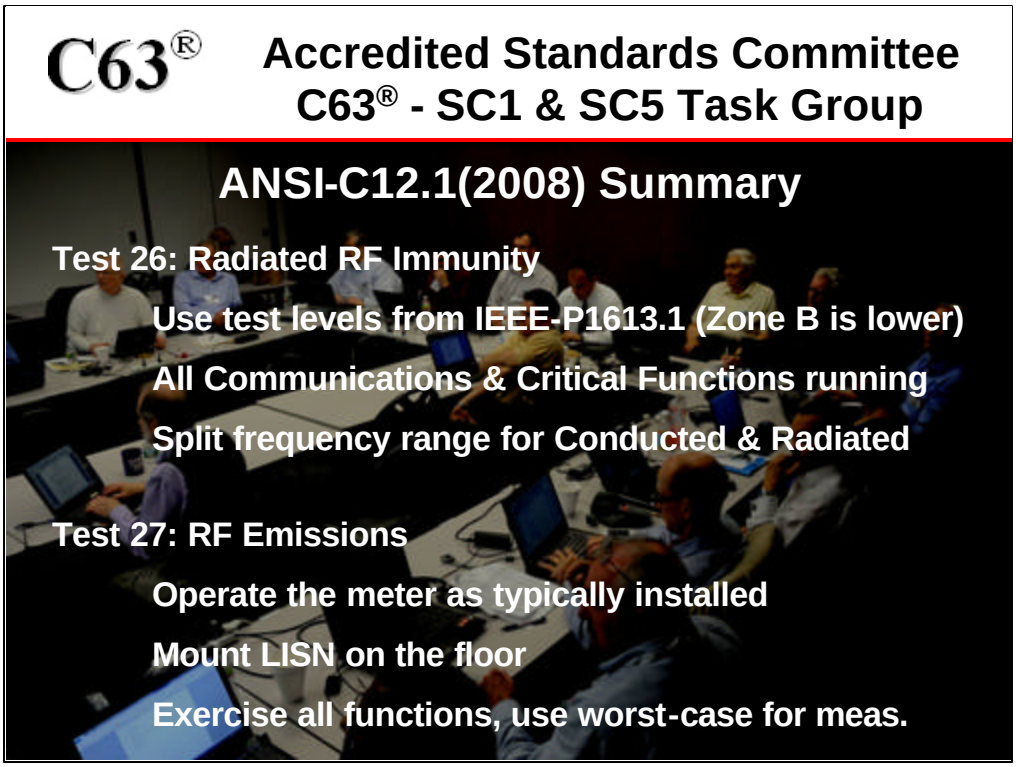
Testing is run at both 5kHz & 100kHz repetition rates

Test 25a: Oscillatory SWC

Operate the meter as typically installed

Suggested test levels from IEEE-P1613.1 (Zone B is lower than current Standard)

Assess Acceptance of EUT during the test



Summary

Test 26: Radiated RF Immunity
Use test levels from IEEE-P1613.1 for Zones A & B (Zone B is lower than current Standard)

All communications & critical functions (metering of power) are running during the test

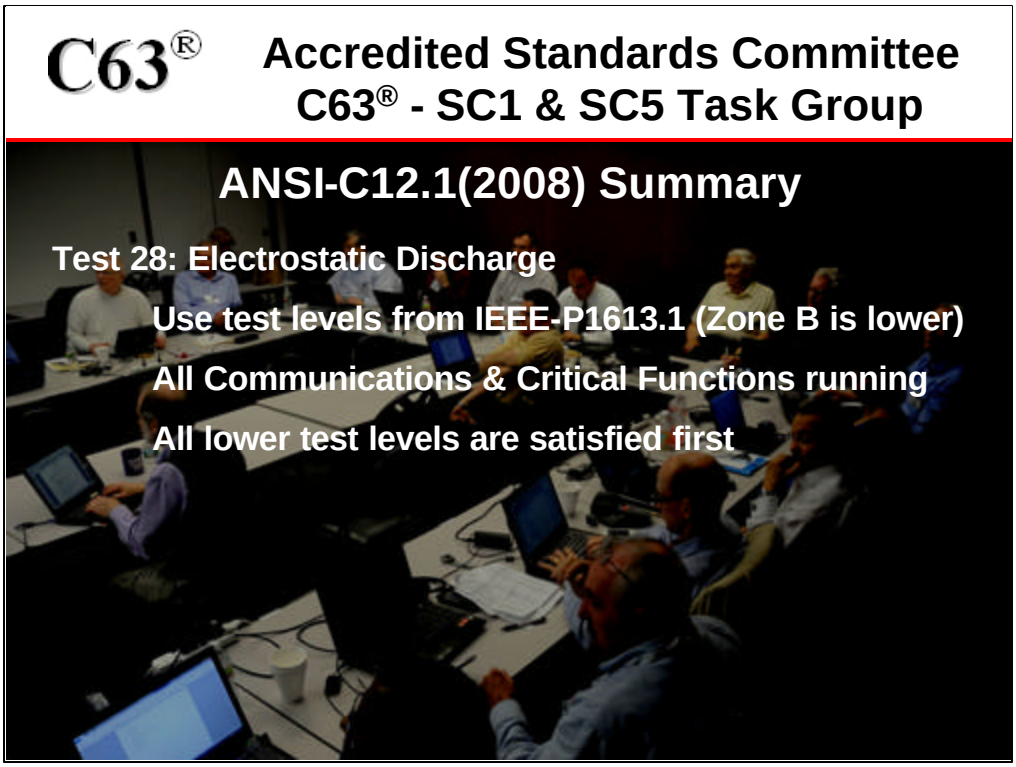
Split frequency range: Conducted (150kHz-80MHz) Radiated (80-6000MHz)

Test 27: RF Emissions

Operate the meter as typically installed

Mount LISN on the floor

Exercise all functions, use worst-case for measurements

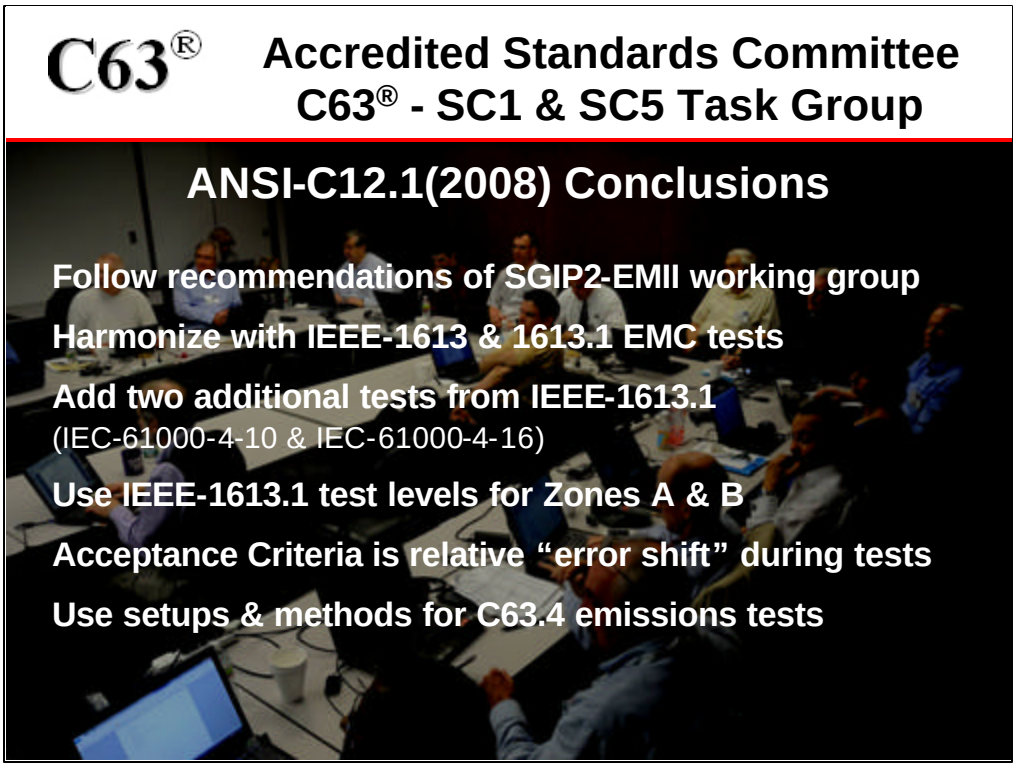


Summary

Test 28: Electrostatic Discharge
Use test levels from IEEE-P1613.1 for Zones A & B (Zone B is lower than current Standard)

All communications & critical functions (metering of power) are running during the test

All lower test levels are satisfied first



The ASC-C63® SC1 & SC5 Joint Task Force on ANSI-C12.1 concludes:

Follow the recommendations of the EMII Working Group in amending C12.1

Harmonize with IEEE-1613 and its extension IEEE-1613.1 for a list of tests to run

Add two tests from IEEE-1613.1 (IEC-61000-4-10 & IEC-61000-4-16)

Use IEEE-1613.1 test levels for Zones A & B (substation boundary being the divider)

Use a relative "error shift" between perturbed and un-perturbed meters to assess acceptance to established criteria during tests
(with the exception of destructive surge testing, which may need the "before/after" or "survivability" test method)

Use the setups and methods cited in C63.4 for emissions testing (Figure 7 for example)

References

IEEE-P1613.1/D47 – 2013, Draft Standard Environmental and Testing Requirements for Communications Networking Devices Installed in Transmission and Distribution Facilities

IEEE Std 1613™ - 2009, Standard Environmental and Testing Requirements For Communication Networking Devices Installed In Electric Power Substations

IEEE Std 1613™ - 2011 Amendment 1, Standard Environmental and Testing Requirements For Communication Networking Devices Installed In Electric Power Substations

IEC 61000-4-2 – 2008, Testing and measurement techniques – Electrostatic discharge immunity test

IEC 61000-4-3 – 2007, Testing and measurement techniques – Radiated Radio-Frequency, Electromagnetic Field Immunity Test

IEC 61000-4-4 – 2006, Testing and measurement techniques – Electrical fast transient/burst immunity test

IEC 61000-4-5 - 2009, Electromagnetic Compatibility part 4-5 Testing and measurement techniques – Section 5: Surge Immunity Tests

IEC 61000-4-6 - 2008, Electromagnetic Compatibility part 4-6 Testing and measurement techniques – Section 6: Immunity to conducted disturbances induced by radio-frequency fields

IEC 61000-4-8 - 2006, Electromagnetic Compatibility part 4-8 Testing and measurement techniques – Section 8: Power frequency magnetic field immunity test

IEC 61000-4-10 – 2001, Testing and measurement techniques – Section 10: Damped Oscillatory Magnetic Field Immunity Test

IEC 61000-4-16 – 2010, Testing and measurement techniques - TEST FOR IMMUNITY TO CONDUCTED, COMMON MODE DISTURBANCES IN THE FREQUENCY RANGE 0 HZ TO 150 KHZ

IEEE-C63.4 – 2009, American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz