Division 27 Compliant Wording for
Low Voltage Test and Measurement Specifications

CERTIFICATION, TESTING, IDENTIFICATION AND DOCUMENTATION OF COPPER AND FIBER INFRASTRUCTURE IN SUPPORT OF SMART BUILDING DEPLOYMENTS

1. **OVERVIEW**
   a. This section includes the minimum requirements for inspection, testing, and documentation of copper and fiber optic infrastructure.

   b. This document includes minimum requirements for:
      i. Copper cabling test instruments
      ii. Copper cabling testing
      iii. Fiber optic cabling test instruments
      iv. Fiber optic cabling tests
      v. Power Over Ethernet (PoE) test instruments
      vi. PoE tests
      vii. Multi-Gig test instruments
      viii. Multi-Gig tests
      ix. Test results documentation

   c. All testing shall be conducted in compliance with this document.

   d. All outlets, cables, patch cords, patch panels and associated components shall be fully assembled and labeled prior to field-testing.

   e. 100% of the links shall be tested.

   f. All tests shall be documented.

   g. All tests shall be performed by Supplier-Authorized representatives

   h. Testers shall operate with the latest firmware updates.

   i. Cable placement/routing, cable termination, grounding and bonding, outlet covers, patch panels, equipment, patch cords, and labeling of all components shall be visually inspected for defects and workmanship prior to testing.

   j. The Owner or Owner's Representative shall be invited to witness and/or review field testing. The Owner or Owner's representative shall have the option to select up to 5% of the installed links, and retest a random sampling. If more than 2% of the results from these tests differ with respect to overall pass/fail determination from the documented results, the installation

contractor shall repeat 100% testing at no additional cost to the Owner.

2. **GENERAL REQUIREMENTS FOR TESTERS**
   a. Calibration. The tester shall be within a 12-month calibration period.
   b. Approvals. Tester must be approved by the cabling supplier in support of their warranty programs
   c. Accuracy. Tester must have independent ETL/Intertek verification of ANSI/TIA-1152-A (Levels IIIe and 2G), IEC 61935-1 Ed. 4 (Levels IIIe, IV and V) and IEC 61935-1 Ed. 5 Draft 46/595/CD (Levels VI Class I and II). Each tester platform must come with a Certificate of Calibration traceable to NIST.
   d. Bandwidth. Tester must be able to perform up to 3GHz frequency range.
   e. Display. Tester must supply a full color display at both ends of the tested link, each of which can independently display all test results.
   f. Adapters. Any adapters used (example: copper or fiber certification) must be hot-swappable while the main device is powered on.
   g. Portability. Each Tester must be handheld. Total weight of each device, including battery and any adapter, must weight a maximum of 1 kg (< 36 oz).
   h. Warranty. Tester must have a 2-year warranty.

3. REQUIRED TESTS FOR COPPER CABLING PERFORMANCE CERTIFICATION
   i. Copper Cable Certification Testing shall support from Category 5e to Category 8
   ii. Tester shall support both Channel and Permanent Link testing requirements, and include all relevant adapters
   iii. Permanent link adapter RJ45 plugs shall meet the requirements for NEXT, FEXT, and Return Loss in accordance with ANSI/TIA-568-C.2 Annex C.
   iv. Measurements. The Tester shall support the following measurements, performed in compliance with ANSI/TIA-568-C:
      1. Wiremap
      2. Length
      3. Propagation delay
      4. Delay skew
      5. Loop resistance
      6. DC Resistance Unbalance for both Pair to Pair and Wire to Wire
      7. Return Loss
      8. Impedance
      9. Insertion Loss
      10. NEXT
      11. PSNEXT
      12. ACRF
      13. PSACRF
      14. TCL
      15. ELTCTL

v. Tester shall perform an Autotest to the Category 6A standard within six seconds for both Channel and Permanent Link, performing all Measurements indicated in the previous paragraph.
vi. Tester shall support real time live wiremap features to facilitate rapid cable continuity testing with automatic display of result the moment the cable is attached.
vii. Tester shall support fault location for Return Loss and NEXT aiding in problem identification.
viii. At the completion of the Autotest, the tester shall provide a highly visible Pass or Fail indication, and test results can be automatically saved with a customizable labeling scheme.
ix. Tester's internal memory capacity must be able to store over 10,000 results with full graphs. All test results shall be saved.
x. Documentation of test results shall include:
    1. Overall pass/fail evaluation
    2. Date and time of the test
    3. Wiring configuration (T568A vs T568B)
    4. Results of all tests with individual pass/fail
    5. Cabling link identifier
    6. Test limit used
    7. Test type (Permanent Link vs Channel)
    8. Supported network types based on test results i.e. (10GBASE-T, etc.)
    9. Tester manufacturer, model, and serial number of tester (both main and remote)
    10. Identification of which type of adapter(s) were used
    11. Calibration date for the tester
    12. Firmware version of the tester
    13. Operator name

4. **REQUIRED TESTS FOR OPTICAL FIBER CABLING PERFORMANCE CERTIFICATION**
    i. Tester must support Fiber Optic Testing for both multimode (850 and 1300nm) and single mode (1310 and 1550nm) fiber optic cabling
    ii. Tester must support the ability to perform Fiber Optic End Face Inspection
    iii. Fiber optic measurements must provide Tier-1 certification in compliance with IEEE 802.3 series, TIA-568.3-E, IEC-14763-3, as well as customizable limits for both Multimode and Singlemode Fiber Optic premise cabling.
    iv. Tester must provide a Visual Fault Locator (VFL) to provide a quick indication of a break in the fiber or to aid in fiber identification.
    v. The Fiber adapters must include an integrated connection port for measuring electrical voltage and resistance for hybrid powered fiber applications in support of smart building initiatives. If voltage or resistance measurements for hybrid powered fiber are performed, the simultaneous measurement of either voltage or resistance must be part of the Tier 1 Optical Loss Test and be part of the saved test results in documentation.
    vi. Multimode testing output ports must be Encircled Flux (EF) compliant sources for 50/125 micron testing applications. This means there must be no special requirements for test cabling to include a mandrel wrap or special Encircled Flux (EF) compliant reference cable when testing 50/125 micron fiber.
    vii. Fiber optic adapters must have Interchangeable connectors.

viii. At the completion of the Autotest, the tester must provide a highly visible Pass or Fail indication, and test results automatically saved with a customizable labeling scheme. Ability to save only "Passed" results automatically must be supported.

ix. Documentation of test results shall include:
    1. Overall pass/fail evaluation
    2. Date and time of the test
    3. Project name
    4. Detailed test results
        a. For Multimode
            i. Single Direction Loss for two fibers at 850 and 1300nm and individual pass/fail indications
            ii. Bi-Directional Loss for two fibers at 850 and 1300nm and individual pass/fail indications (if bi-directional testing is specified by the owner)
            iii. List of compliant networks that would operate over this fiber as tested
        b. For Single mode
            i. Single Direction Loss for two fibers at 1310 and 1550nm and individual pass/fail indications
            ii. Bi-Directional Loss from for two fibers at 1310 and 1550nm and individual pass/fail indications (if bi-directional testing is specified by the owner)
            iii. List of compliant networks that would operate over this fiber as tested
    5. Cabling link identifier
    6. Test limit used
    7. Compliant network types based on test results i.e. (1000BASE-SX, 100GBASE-LR4, 100GBASE-ER4, etc.)
    8. Number of connectors and associated connector loss budget
    9. Number of splices and associated splice loss budget
    10. Tester manufacturer, model, and serial number of tester (both main and remote)
    11. Length of the fiber
    12. Propagation delay of the fiber
    13. Calibration date for the tester
    14. Firmware version of the tester
    15. Operator name

5. REQUIRED TESTS FOR OTDR (Optical Time Domain Reflectometer) OPTICAL FIBER TROUBLESHOOTING AND TIER 2 CERTIFICATION (if applicable)

i. OTDR Test Adapters must be modular in design to permit use with the Certification tester in use for copper and fiber performance certification testing.

ii. Tester must support Fiber Optic OTDR Testing for both multimode (850 and 1300nm) and single mode (1310 and 1550nm) fiber optic cabling.

iii. Tester must support the ability to perform Fiber Optic End Face Inspection

iv. OTDR test adapters must have Interchangeable connectors.

v. OTDR settings must include user-defined adjustments of Pulse Width range from 2.5ns to 25,000ns as well as preset user-selectable Pulse Widths ranging from 250ns to 25,000ns.

vi. OTDR settings must include preset maximum length settings from 250m to 120km.

vii. OTDR settings must include Advanced Settings allowing the user to enable Pass/Fail and define limits for Total Loss, Connector Loss and Splice Loss.
viii. OTDR settings must include the ability for the user to enter Launch Cord and Tail Cord Length and enable the OTDR to hide the Launch Cord trace.
ix. OTDR settings must include the ability to enable/disable the display of both wavelength traces simultaneously.
x. OTDR must include Live Trace mode.
xi. At the completion of the OTDR Autotest, the tester must provide a Pass or Fail indication when Pass/Fail limits are enabled, and the Pass/Fail indication must show at every detected event along the fiber and include the overall Pass/Fail indication.
xii. Tester must include the ability to save the OTDR test results for management with the test results management software.
xiii. Tester must be capable of testing two wavelengths simultaneously and displaying the Loss and Reflectance of each event detected in a selected wavelength in two different viewing methods, selectable by a simple touch of the display.
    1. Event Table
    2. Event Map
xiv. OTDR Trace must show both wavelengths tested, with the selected wavelength highlighted and the other wavelength subdued. User must be able to switch between wavelengths with a simple touch of the screen to highlight the desired trace.
xv. Tester must have the ability for the user to zoom in on the OTDR trace to magnify the test trace to give the user the ability to analyze small events.
xvi. Documentation of test results shall include:
    1. Overall pass/fail evaluation.
    2. Date and time of the test
    3. Project name
    4. Detailed test results
        a. Graphical OTDR Trace image for each wavelength tested.
        b. Summary for each wavelength tested showing Length, Total Loss in dB, Total Loss Result (Pass/Fail/Info), Average Loss (dB/km), and Overall Result (Pass/Fail/Info)
        c. Event Table for each wavelength tested showing for each event: Distance, Loss (dB), Type of event (using symbol for beginning of fiber, end of fiber, reflective event or non-reflective event) and Result (Pass/Fail/Info)
    5. Cabling link identifier
    6. Wavelength(s) tested
    7. Pulse Width (ns)
    8. Averaging
    9. Launch Cord length
    10. Tester manufacturer, model, and serial number of tester
    11. Firmware version installed on tester
    12. Test Adapter type and calibration date
    13. Calibration date for the tester
    14. Connector
    15. Operator name

6. **REQUIRED TESTS FOR POWER OVER ETHERNET (PoE) CONFORMANCE (if applicable)**
   i. Tester shall support PoE conformance against 802.3af, 802.3at, and 802.3bt.
   ii. Tester shall be able to request the highest level of power load from the PSE for that standard and will perform the following tests:
      a. Load Testing for True Power at Jack
      b. Report Current, Wattage and Voltage
      c. PSE Detection
      d. PSE Type
      e. PD Class
      f. PoE Cable Pairs
      g. Sustained Power Load Monitoring
      h. DC Resistance Unbalance
   iii. Tester shall allow for sustained loading of the PSE over longer periods, through a connected external load device. This will enable user to monitor live for any power fluctuation that drops below the required level threshold as well as record this data.

7. **REQUIRED TESTS FOR MULTI-GIGABIT LINK SPEED CONFORMANCE (if applicable)**
   i. Tester shall qualify copper cabling links for 1 / 2.5 / 5 / 10Gigabit Ethernet in accordance with 802.3ab, IEEE 802.3bz, and IEEE 802.3an respectively
   ii. Tester shall report these values based on end-to-end Signal to Noise Ratio (SNR) operating margin, to provide an objective assessment of link performance under network load condition.
   iii. Tester shall include PoE Load test as part of the MultiGigabit SNR testing.
   iv. Tester shall support a link validation test at:
      a. 10/100 Mbps
      b. 1 Gbps
   v. Tester shall simulate Alien Crosstalk to derive a Quality of Service assessment by measuring Signal to Noise Ratio (SNR) at:
      a. 2.5 Gigabit
      b. 5 Gigabit
      c. 10 Gigabit
   vi. Tester shall include ability to run the MultiGigabit SNR Test with PoE Load test and save test results to provide documentation of results using test results management software.

8. **REQUIRED TESTS FOR NETWORK DISCOVERY/TROUBLESHOOTING (if applicable)**
   i. Both Main and Remote test handsets must include a built-in 1Gbps Ethernet port for network testing and connection to internet for upload of test results.
   ii. Ability to connect to a network via onboard 1Gbps Ethernet connector built into the test equipment mainframe/handset and perform the following:
      a. Discover details about connected network (Subnet/gateway/DHCP/DNS/network speed/duplex/obtained IP address)
      b. Discover switch detail including switch name, make, model, port ID/number, VLAN ID, port capabilities and MAC/IP address.

c. Blink Switch Port LED
d. Discover connected devices on the network, including MAC/IP Addresses
e. Ping
f. Traceroute
g. VLAN discovery of visible VLAN IDs and frame count by VLAN, including a selectable bar graph/pie chart display of information
h. TCP Connect/Test function
i. Ability to generate traffic in Main test unit and monitor generated traffic in Remote test unit

iii. Ability to connect to network via 10Gbps/5Gbps/2.5Gbps port built into modular test adapter and perform the following:
a. Discover details about connected network (Subnet/gateway/DHCP/DNS/network speed/duplex/obtained IP address)
b. Discover switch detail including switch name, make, model, port ID/number, VLAN ID, port capabilities and MAC/IP address
c. Discover connected devices on the network, including MAC/IP Addresses
d. Ping
e. Traceroute
f. VLAN discovery of visible VLAN IDs and frame count by VLAN, including a selectable bar graph/pie chart display of information
g. TCP Connect/Test function
h. Ability to generate traffic in Main test unit and monitor generated traffic in Remote test unit

iv. Ability to connect to a network via USB-WiFi adapter inserted into the built-in USB port and perform the following:
a. Discover WiFi networks in range and display SSID, Channel and RSSI values
b. Perform roaming Signal Strength test
c. Discover details about connected network (Subnet/gateway/DHCP/DNS/network speed/duplex/obtained IP address)
d. Discover connected devices on the network, including MAC/IP Addresses
e. Ping
f. Traceroute
g. TCP Connect/Test function

v. Ability to run Autotest in both wired and wireless network connection to save test results and provide documentation using test results management software.

9. DOCUMENTATION REQUIREMENTS

i. PC-based results management software shall come standard with all models of Tester.
ii. Results shall be transferable from Tester to PC via portable flash drive, direct USB connection or cloud via wired/wireless network connection.
iii. Test results shall be uploaded or otherwise transferred to a PC at the end of each day to provide for protection and archiving of test records.

iv. Tester's Results Management Software shall work in tandem with the tester, which allows defining projects and categorizing test results into logical groupings once uploaded into the database.
v. Software must have the ability to allow recertification of a test result
vi. The database shall provide the ability to collaborate by viewing in-depth test details within the results management software, as well as provide pdf-based printed reports.
vii. Results shall be exportable in either .csv or .pdf format.
viii. Reports shall be combinable into one pdf for the entire project, or single report pdfs for individual results.
ix. When applicable, tester shall be able to combine specific test results such as a Copper and Fiber certification tests, Multi-Gigabit and PoE test into a single Smart Building report.
x. When reports are combined into one pdf for entire project, the pdf shall include a test results summary in addition to the detailed individual test results.
xi. Tester's Results Management Software shall have the following function and capability
    a. Create New Project
    b. Import Test Results to Tester's Results Management Software
    c. View in-depth test results
    d. Generate Reports in .PDF or .CSV formats
    e. Firmware Upgrade using Tester's Results Management Software
    f. Import Custom Limit from .CSV file
    g. Create Custom Label
    h. Import Custom Label from .CSV file

10. COMPLIANT PRODUCTS

The following manufacturer's testers meet all of the above requirements and are approved. All models include wired/wireless network connectivity and test results management/documentation. Each model below specifies a focused area of certification.

AEM Multifunction Certification Test Solutions:

a. TestPro CV100-K11 or TestPro-K11E (for Tier 1 Fiber Optic Certification)
b. TestPro-K21E-MM, TestPro-K21E-SM or TestPro-K21E-QD (OTDR, part of Tier 2 certification)
c. TestPro-K41E (for Tier 1/Tier 2 Fiber Optic Certification)
d. TestPro CV100-K50 or TestPro-K50E (for Copper Certification)
e. TestPro CV100-K51 or TestPro-K51E (for Copper and Tier 1 Fiber optic Certification)

AEM Complete Smart Building Certification Test Kits:

f. TestPro CV100-K60 or TestPro-K60E (Copper Certification, PoE and Gigabit testing)
g. TestPro CV100-K61 or TestPro-K61E (Copper and Tier 1 Fiber optic Certification, PoE and Gigabit testing)
h. TestPro-K71E (Copper and Tier 1/Tier 2 Fiber optic Certification, PoE and Gigabit testing)

END OF SECTION