

NECA 303



Standard for Installing and Maintaining Closed-Circuit Television (CCTV) Systems

**ANSI Review Draft
July 2016**

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17 (This foreword is not a part of the standard)

18

19 **Foreword**

20

21 *National Electrical Installation Standards*® (*NEIS*®) are designed to improve communication among
22 specifiers, purchasers, and suppliers of electrical construction services. They define a minimum baseline
23 of quality and workmanship for installing electrical products and systems. *NEIS*® are intended to be
24 referenced in contract documents for electrical construction projects. The following language is
25 recommended:

26

27 Closed-circuit television (CCTV) systems shall be installed and maintained in accordance with
28 NECA 303-2XXX, *Standard for Installing and Maintaining Closed-Circuit Television (CCTV)*
29 *Systems* (ANSI).

30

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32 obligation or liability to users of this publication. Existence of a standard shall not preclude any member
33 or non-member of NECA from specifying or using alternate construction methods permitted by
34 applicable regulations.

35

36 This publication is intended to comply with the National Electrical Code (NEC). Because they are quality
37 standards, *NEIS* may in some instances go beyond the minimum safety requirements of the NEC. It is the
38 responsibility of users of this publication to comply with state and local electrical codes and Federal and
39 state OSHA safety regulations as well as follow manufacturer installation instructions when installing
40 electrical products and systems.

41

42 Suggestions for revisions and improvements to this standard are welcome. They should be addressed to:

43

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125 **1. Scope**

126
127 This Standard describes installation procedures for new closed-circuit television (CCTV) system
128 equipment installed for video surveillance and for protection of building interiors, building perimeter, and
129 surrounding property. This publication applies to CCTV systems, equipment, components, and
130 accessories as required for a complete and functional CCTV system for security and monitoring activities
131 in non-hazardous locations both indoors and outdoors. It also covers periodic routine maintenance
132 procedures for CCTV systems.

133
134
135 **1.1 Products and Applications Included**

136
137 This Standard applies to the following:

- 138 • Video cameras, controls, enclosures and accessories, including pan-tilt-zoom and fixed-mounted
139 cameras
- 140 • Monochrome or color monitors, video controllers, video switches, remote switchers, quad
141 switchers, signal processing equipment, combiners, amplifiers, control stations, video
142 multiplexers, recording devices (tape or DVR), distribution components, power supplies, and
143 accessories
- 144 • Electronic hardware components
- 145 • Conductor and cable installation

146
147
148 **1.2 Products and Applications Excluded**

149
150 This Standard does not apply to:

- 151 • One and two family dwellings
- 152 • Design or installation of lighting fixtures or security lighting
- 153 • Branch circuit wiring methods.
- 154 • Security of data, software, or computer systems
- 155 • Transmission of video images to remote locations
- 156 • Remote supervising locations that receive signals from premises CCTV Systems
- 157 • Commercial Monitoring Stations
- 158 • Alternate or back-up sources of power

159
160
161 **1.3 Regulatory and Other Requirements**

162
163 All information in this publication is intended to conform to the NEC (ANSI/NFPA 70). Installers shall
164 follow the NEC, applicable state and local codes, manufacturer instructions, and contract documents
165 when installing CCTV systems.

166
167 Only qualified persons as defined in the NEC familiar with the construction and installation of CCTV
168 systems shall perform the technical work described in this publication. Administrative functions such as
169 receiving, handling, and storing CCTV system parts, components, and equipment and other tasks may be
170 performed under the supervision of a qualified person. All work shall be performed in accordance with
171 NFPA 70E, *Standard for Electrical Safety in the Workplace*.

172

173 General requirements for installing electrical products and systems are described in NECA 1, *Standard*
174 *Practices for Good Workmanship in Electrical Construction (ANSI)*. Other *NEIS* provide additional
175 guidance for installing particular types of electrical products and systems. A complete list of *NEIS* is
176 provided in Annex A.

177
178

179 **1.4 Mandatory Requirements, Permissive Requirements, Quality and Performance** 180 **Instructions, Explanatory Material, and Informative Annexes**

181
182 Mandatory requirements in manufacturer instructions, or of Codes or other mandatory Standards that may
183 or not be adopted into law, are those that identify actions that are specifically required or prohibited and
184 are characterized by the use of the terms “must” or “must not,” “shall” or “shall not,” or “may not,” or
185 “are not permitted,” or “are required,” or by the use of positive phrasing of mandatory requirements.
186 Examples of mandatory requirements may equally take the form of, “equipment must be protected . . .,”
187 “equipment shall be protected . . .,” or “protect equipment . . .,” with the latter interpreted (understood) as
188 “(it is necessary to) protect equipment . . .”

189
190 Permissive requirements of manufacturer instructions, or of Codes or other mandatory Standards that may
191 or not be adopted into law, are those that identify actions that are allowed but not required, or are
192 normally used to describe options or alternative means and methods, and are characterized in this
193 Standard by the use of the terms “may,” or “are permitted,” or “are not required.”

194
195 Quality and performance instructions identify actions that are recommended or not recommended to
196 improve the overall quality or performance of the installation and are characterized by the use of the
197 terms “should” or “should not.”

198
199 Explanatory material, such as references to other Codes, Standards, or documents, references to related
200 sections of this Standard, information related to another Code, Standard, or document, and supplemental
201 application and design information and data, is included throughout this Standard to expand the
202 understanding of mandatory requirements, permissive requirements, and quality and performance
203 instructions. Such explanatory material is included for information only, and is identified by the use of
204 the term “NOTE,” or by the use of italicized text.

205
206 Non-mandatory information and other reference standards or documents relative to the application and
207 use of materials, equipment, and systems covered by this Standard are provided in informative annexes.
208 Informative annexes are not part of the enforceable requirements of this Standard, but are included for
209 information purposes only.

210
211

212 **2. Definitions**

213
214 **Approved.** Acceptable to the Authority Having Jurisdiction.

215
216 **Authority Having Jurisdiction (AHJ).** An organization, office, or individual responsible for enforcing
217 the requirements of a code or standard, or for approving equipment, materials, an installation, or a
218 procedure.

219
220 **Blanking.** Electrical signal produced at the end of each scanning line.

221

222 **C-Mount.** Former industrial standard lens mounting format. C-mounts can be adapted to CS-mounts
223 using a CSA, or a CS to C adapter, but CS-mounts cannot be adapted to C-mounts.
224

225 **Closed-Circuit Television (CCTV).** A video system in which an analog or digital video signal travels
226 from the camera to video monitoring stations at the protected premises.
227

228 **Coaxial Cable.** Cable commonly used to transmit video signals. It consists of a metallic shield with one
229 or more center conductors that are isolated from each other and from the shield.
230

231 **Combination System (as related to premises security).** A system that provides premises security as a
232 portion of a single control unit, or multiple control units that work together to provide one integrated
233 control.
234

235 **Composite Video.** Video signal that contains the picture signal, with vertical and horizontal blanking
236 and sync pulses.
237

238 **Control Unit.** A system component that monitors inputs and controls outputs through various types of
239 circuits.
240

241 **CS-Mount.** Newer standard lens mounting format.
242

243 **Depth of Field.** Front-to-back area that is focused in the camera view. The better the lighting, the greater
244 the depth of field that is possible.
245

246 **Digital Imaging System (DIS).** A video system in which a digital video signal travels from the camera
247 and can be viewed by any authorized user at or away from the protected premises.
248

249 **Digital Video Recorder (DVR).** Electronic device used to store video images on an internal hard drive
250 with a specific memory capacity.
251

252 **Dwell.** Length of time a video switcher holds a camera's scene before switching to the next camera's
253 scene.
254

255 **Fiber Optics.** Flexible glass fibers used to conduct signals.
256

257 **Field of View.** The horizontal or vertical picture size at a given distance from a camera to the subject.
258

259 **f-Stop.** Lens speed. Lower f-stop means the lens remains open longer, resulting in more light passing
260 through the lens and better low light camera performance.
261

262 **Gen-Lock.** Method used to synchronize one or more cameras by external means. Typical methods are
263 composite video, composite sync, and horizontal or vertical sync.
264

265 **Image Intensifier.** Electronic device used to provide a brighter output image than the input image.
266

267 **Incident Light.** Amount of light directly over an object.
268

269 **Labeled.** Equipment or materials to which has been attached a label, symbol, or other identifying mark
270 of an organization that is acceptable to the AHJ and concerned with product evaluation, that maintains

271 periodic inspection of production of labeled equipment or materials, and by whose labeling the
272 manufacturer indicates compliance with appropriate standards or performance in a specified manner.
273

274 **Listed.** Equipment, materials, or services included in a list published by an organization that is
275 acceptable to the AHJ and concerned with evaluation of products or services, that maintains periodic
276 inspection of production of listed equipment or materials or periodic evaluation of services, and whose
277 listing states that either the equipment, material, or service meets appropriate designated standards or has
278 been tested and found suitable for a specified purpose.
279

280 **Looping.** Term used when a high impedance device is connected in parallel to a video source.
281

282 **Matrix Switcher.** Normally used in larger camera systems, a matrix switcher allows any of the system's
283 cameras to be routed to any of the system's monitors.
284

285 **Multiplexer.** Device which allows the recording or playback of multiple cameras on a single time
286 recorder with little loss of information.
287

288 **Pinhole Lens.** Lens with a very small front, easily concealed, for use in covert applications.
289

290 **Quad.** Device that simultaneously places the scenes from four cameras onto one video monitor.
291

292 **Record of Completion.** A document that acknowledges the features of installation, operation
293 (performance), service, and equipment with representation by the property owner, system installer, system
294 supplier, service organization, and the AHJ.
295

296 **Resolution.** Measure of the ability of a CCTV system, or one of its components, to produce detail.
297

298 **Roll.** Result of the loss of vertical sync which causes the picture on a monitor to move up or down.
299

300 **Strain Relief.** Cable termination that provides structural rigidity of conductors under conditions of
301 flexure.
302

303 **Sync.** Electronic pulses inserted in a video signal for assembling picture information in the proper
304 position.
305

306 **Video Cassette Recorder (VCR).** Electronic device used to store video images on a removable cassette
307 tape. VCRs that can record for extended periods of time on a single video tape by using frequent pausing
308 of the tape. The longer the time of recording, the fewer number of frames or pictures recorded per
309 second. Each state separately defines the minimum number of frames per second for recordings to be
310 considered "real time" for law enforcement purposes.
311
312

313 **3. Delivery, Handling, and Storage**

314 **3.1 Delivery**

315
316
317 Upon delivery of equipment and accessories, visually inspect packaging for physical damage. Carefully
318 unpack equipment and accessories sufficiently to inspect for concealed damage resulting from shipping
319 and handling. If damage has occurred, notify the shipper and the manufacturer in writing immediately.
320

321 Compare equipment and accessories received with the bill of materials, to verify that the shipment is
322 complete. If the shipment is not complete, notify the manufacturer in writing immediately.

323
324 Verify that the equipment and accessories received conform with approved submittals and manufacturer
325 quotations. If they do not, notify the manufacturer in writing immediately.

326
327 If CCTV equipment and accessories are to be stored prior to installation, restore original packing
328 materials to protect from exposure to environmental conditions. When conditions permit, leave the
329 packing materials intact until equipment and accessories are ready for installation.

330

331

332 **3.2 Handling**

333

334 Handle CCTV equipment and accessories in accordance with manufacturer instructions. Avoid impact,
335 jolting, jarring, and rough handling.

336

337 Ensure that equipment and components are within the rated capacity of the handling equipment.

338

339

340 **3.3 Storage**

341

342 Store CCTV equipment and accessories in accordance with manufacturer instructions.

343

344 Store in a clean, dry, environmentally controlled space.

345

346 Store in an area to discourage vandalism and theft, and out of the way of construction traffic.

347

348

349 **4. Pre-Installation Considerations**

350

351 **4.1 General**

352

353 Survey the project site for conditions prior to installation. Inspect for seasonal and environmental
354 conditions such as average, maximum, and minimum temperatures, fog, rain, snow, ice, humidity,
355 condensing moisture, corrosion, salt water exposure, heat, cold, vibration, radio frequency interference,
356 electrical discharge, AC induction, dust, smoke, animal or insect infestation, vegetation, decorations,
357 marketing aids, hazardous or volatile atmospheres, vandalism, tampering, and theft. Survey outdoor
358 camera locations when trees and shrubs are in full foliage.

359

360 Consider the areas to be covered by the CCTV system, such as entrances, exits, entrance ramps, elevators,
361 stairwells, walkways, and parking areas. Select equipment and components suitable for the physical and
362 environmental conditions that the site may present. Verify that lighting levels are suitable with video
363 cameras. Use low-light cameras or increase light levels as needed for proper operation of CCTV systems.

364

365 The level of tamper resistance shall be determined by a security vulnerability assessment or by the
366 requirements of the AHJ.

367

368

369 **4.2 Documentation**

370
371 Upon the AHJ's request, submit documentation regarding the system or system alteration design,
372 including project drawings and specifications and battery calculations, if applicable.

373
374 If required by the AHJ and prior to requesting final approval of the installation, furnish a written
375 statement that the system has been:

- 376 • Installed in accordance with specifications, and
- 377 • Tested in accordance with the manufacturer's specifications and appropriate NFPA requirements.

378
379

380 **4.3 Compatibility and Integration**

381
382 CCTV systems can be installed as an independent, stand-alone system, or can be either integrated systems
383 combining detection, notification, and auxiliary functions in a single system or a combination of
384 component subsystems.

385
386 Ensure that CCTV system components are compatible as a system. Ensure that the CCTV system is
387 compatible with collateral systems when integrated with other systems. Systems other than electronic
388 premises security systems are permitted to share components, equipment, circuitry, and installation wiring
389 with premises security systems.

390
391 Where integrated with other systems, arrange systems to function as a single system. CCTV systems may
392 share control equipment with other systems, or be able to operate as stand-alone subsystems arranged to
393 function as a single system. Ensure that the simultaneous operation of all system components does not
394 degrade overall system operation and performance.

395
396 When a CCTV system connects to a fire alarm system or other life safety systems, the requirements of
397 other codes and standards pertaining to those systems shall be followed.

398
399 When CCTV systems are integrated with central station premise security systems, comply with applicable
400 codes and requirements for central station premise security systems.

401
402

403 **4.4 Voltage Considerations**

404
405 CCTV systems operating at 120 Volts AC typically have cameras supplied with a 1.8 m (6-foot) standard
406 power cord, which necessitates locating a suitable receptacle within 1.8 m (6 feet) of the camera location.
407 Cameras operating at 120 Volts AC are typically used for installations requiring power-intensive
408 accessories such as wiper/washers, heaters, and blowers, such as in outdoor locations.

409
410 CCTV systems typically operate at 24 Volts AC. Cameras can be powered by external, plug-in type
411 power supplies using smaller-gauge conductors at each location, or from remote or centrally-located
412 power supplies. Alternatively, Siamese cable, which contains video coax and power cable under one
413 jacket, can be used for both power and video cabling requirements.

414
415 CCTV systems operating at 12 Volts DC are typically used in vehicles or other locations where power is
416 derived from one or more batteries used to power the system. 12 Volt DC systems are supplied power in
417 the same manner as 24 Volt AC systems with the additional restriction that cable length is more limited
418 due to voltage drop.

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4.5 Camera Selection and Location

Camera lenses are typically furnished separately from the camera body. Exercise care in selecting cameras and lenses to ensure compatibility and proper performance. Camera performance depends upon several factors including area and image illumination, reflectance and glare, f-stop, and color temperature. Consequently, camera performance is somewhat subjective and may require a live demonstration or mock-up to determine suitability for a given application.

Ensure that camera selections and locations comply with manufacturer instructions, drawings, and specifications, considering access for maintenance, repairs, and future replacement.

Use color cameras in locations where color and details are important to distinguish characteristics or for object recognition.

Use cameras that are appropriately designed and adjusted for light levels and sensitivity. Supplemental lighting, including infrared or ultraviolet lighting, may be required for acceptable camera performance. Locate cameras such that light sources are either behind the camera or are perpendicular to camera field of view. Where the camera field of view has bright illumination behind the main subject, or for scenes with extreme contrast, use cameras and accessories having electronic compensation, such as backlight compensation or high dynamic range cameras.

Use cameras and lenses with the appropriate level of resolution for the intended application. In general, a higher resolution camera is more desirable than a lower resolution camera.

Select cameras and lenses considering focal length for depth of field and field of view. Consider how wide or how tall an object is in comparison to surroundings when related to recognition of that object on a system monitor. Two cameras may be required for a given application, one for an overall view, and another to view fine details.

Select cameras, lenses, enclosures, and accessories that are physically compatible with the installed location and mounting methods, such as concealed locations or dome enclosures. Size enclosures for cameras, lenses, ancillary equipment, and any other required equipment, such as connectors, other electronic devices, and transformers.

Use optically-corrected domes. Typically, clear domes are used for outdoor locations and smoked domes are used for indoor locations.

Select enclosures considering discretion, aesthetics and serviceability. Domes afford a great deal of discretion by prohibiting an observer from determining which way the camera is looking at any given time. Certain enclosures, including domes, afford greater serviceability due to built-in features, electronics or modularity. Other enclosures tend to “blend in” more with their environment for purely aesthetic reasons.

Select cameras and/or systems that allow cameras to be synchronized for roll-free video switching, using either cameras with synchronizing capabilities, or using systems with external phase adjustment features. External phase adjustment capabilities are recommended because they allow more flexibility in system set-up and do not require cameras with phase line-lock capabilities.

Select fixed cameras where focusing on one point or feature, such as doors, hallways, alcoves, and very small areas.

471
472 Select dome-mounted or pan/tilt/zoom cameras where the area to be protected has an unobstructed line of
473 sight with no hidden alcoves.
474
475 Select dome-mounted cameras for 360-degree coverage.
476
477 Position and mount cameras to discourage vandalism.
478
479

480 **5. Cabling and Conductors**

481
482 Guidelines for installing cabling, conductors, and conduits are contained in various *National Electrical*
483 *Installation Standards*. The following requirements modify or supplement those requirements with
484 respect to conduits, cabling, and conductors installed for CCTV systems.
485

486 487 **5.1 General**

488
489 Install wiring and cable in accordance with manufacturer instructions and the NEC requirements. Install
490 low-voltage cables in accordance with Federal State and local low-voltage Codes, specifications,
491 standards and practices. Install plenum-rated cable where cable is installed in an air handling plenum.
492

493 Ensure that CCTV system wiring and cables are of the appropriate gauge, strands, insulation, and
494 electrical properties as specified by the manufacture of the device to be connected.
495

496 Splice or join conductors using mechanical splicing devices approved for the purpose. Mechanically join
497 splices intended to be soldered before soldering. Cover each splice and joint with insulation equivalent to
498 that of the conductors or wrap with a minimum of two layers of electrical tape. Seal splices located in
499 damp or wet locations with an approved sealant or equivalent treatment.
500

501 Solder and heat shrink wrap electrical connections to device manufacture supplied leads, or use high-
502 quality insulating crimp connectors.
503

504 Use connection terminals that are insulated either by the manner of their construction and use, or by
505 adding heat shrink insulation over the connection for each individual connector.
506

507 Ensure that all terminations are properly made. Examples of improper connections include, but are not
508 limited to, connections that do not included all of the strands of the conductor, are bent or misshapen, and
509 do not properly fit the terminal on the device.
510

511 Use terminals for more than one conductor that are identified as suitable for that purpose. Connect only
512 conductors of the same size and composition under common terminals. Mark or color code terminals
513 where necessary to indicate the proper connections.
514

515 Provide strain relief for all connections, including connections to device manufacturer supplied leads, to
516 ensure that tension is not transmitted to joints or terminals and will not damage or break connections.
517 Provide strain relief for wiring leaving control panels and junction boxes not utilizing raceways.
518

519 Make connections to terminal parts using pressure connectors, wire binding screws or splices to flexible
520 leads.

521
522 Provide a 150 mm (6-inch) service loop at field terminations, control panels and enclosures used for
523 wiring terminations. Provide physical protection of service loops. See Section 5.5 for fiber optic service
524 loop requirements.

525
526 Provide a minimum of 50 mm (2 inches) of separation between conductors of lighting and power circuits
527 and those of Class 3 circuits, unless one of the circuits is installed in a metallic or non-metallic raceway.
528 Bond metallic raceways to ground. Size raceways in accordance with the NEC.

529
530 Install conductors and cables to provide access to equipment for maintenance and repairs. Do not block
531 access panels or removable coverplates with conductors or cables.

532
533 Prepare conductors and cables in accordance with manufacturer instructions. *NOTE: Some*
534 *manufacturers provide unique instructions for preparing their products for connection or termination.*
535 *Additionally, stripping of sheathing as described below may not be an acceptable practice with products*
536 *such as coaxial cable or category-rated network cable. Strip cables and conductors to the length*
537 *prescribed by the manufacturer of the device to which they should be connected. Do not damage or*
538 *remove any strands of stranded conductors.*

539
540 Remove the outside protective sheathing of cables a minimum of 50 mm (2 inches) from the end to
541 expose the internal insulated conductors for making connections. *NOTE: Removal of the outside*
542 *sheathing in excess of 50 mm (2 inches) to facilitate inserting the cable back into the opening is generally*
543 *acceptable. Do not damage the insulation of the internal conductors of the wires or cables while*
544 *stripping.*

545
546 Ensure that wires and cables extend at least 150 mm (6 inches) beyond the finished surface at the point of
547 device installation. Provide excess cabling at each camera installation point to allow for repositioning of
548 the camera in the future, when possible.

549
550 Use separate cables for power, control, and video, unless using one cable listed as suitable for combined
551 use, such as a Siamese cable.

552
553 Bundle, lace and neatly train wiring within enclosures to terminal points with no excess. Provide and use
554 lacing bars and distribution spools as needed.

555
556 Identify circuits within control panels, enclosures, and pull boxes. Identify circuits at field terminations
557 and all accessible locations. Ensure that identification is not visible to the public.

558
559 Do not exceed manufacturer's recommended pulling tension. Do not install bruised, kinked, scored,
560 deformed or abraded cable. Do not splice cable between termination, tap, or junction points. Remove
561 and discard cable where damaged during installation and replace with new cable.

562
563 Install exposed cable parallel and perpendicular to building lines, follow surface contours, and support as
564 recommended by the manufacturer.

565
566

567 **5.2 Video Cable and Conductors**

568

569 Use standard coaxial video cables with a solid copper center conductor and a braided copper shield with
570 95 percent coverage, or mini-coaxial video cables with a stranded copper center conductor and a braided

571 copper shield with 89 percent coverage. Use coaxial cable with a nominal impedance of 75 ohms. Do
572 not use coaxial cable rated for any other nominal impedance.

573
574 Do not use coaxial cables with an aluminum or copper-clad steel center conductor. Do not use cables
575 with an aluminum braid or foil shield. Cables with a foil shield may be used if the foil shield is combined
576 with, and in addition to, a copper braid shield.

577
578 Do not exceed manufacturer's recommended maximum cable length. Do not exceed 4.5 m (15 feet) for
579 mini-type cables. Do not exceed 230 m (750) feet for RG-59/U-type cables. Do not exceed 365 m (1,200
580 feet) for RG-6/U-type cables. Do not exceed 760 m (2,500) feet for RG-11/U-type cables. Where cables
581 exceed the manufacturer's recommended maximum length, use a larger cable, use a different mode of
582 transmission such as fiber optics, or install a video amplification system to ensure signal strength.

583
584 Use flexible cables with a stranded center conductor cable specifically manufactured for the application
585 for pan/tilt/zoom cameras between the camera and junction box to accommodate camera movement.

586
587 Use moisture proof, gel-filled direct burial type cable in raceways located outdoors.

588
589 Do not use MATV (MasterAntenna TeleVision) cable for CCTV applications.

590
591

592 **5.3 Control Wiring**

593
594 The purpose of low-voltage control cabling is to carry control signals to devices within the CCTV system.
595 Such devices include, but are not limited to, remote positioning devices, such as pan/tilt/zoom cameras,
596 scanner units, and domes, zoom lenses, and auxiliary devices such as wipers and washers, heaters,
597 blowers, and remote relays.

598
599 Size control wiring in accordance with controls manufacturer instructions. Size control wiring to deliver
600 the manufacturer's optimum operating voltage from the power supply or controller to the device being
601 driven. Size control wiring based on the current and voltage needs of the controlling system and the
602 length of the wire run, but not less than 18 AWG, stranded copper conductors.

603
604

605 **5.4 Data Cabling**

606
607 The purpose of data cable is to carry digital data communications between various devices within the
608 system. Such devices include, but are not limited to, receivers, drivers, keyboards, controllers,
609 multiplexers, and recording devices.

610
611 Provide data cable in accordance with manufacturer instructions.

612
613

614 **5.5 Fiber Optic Cabling**

615
616 Fiber optic transmission of both video and data presents distinct advantages over standard copper-based
617 cabling, including higher quality and longer distance transmission characteristics, inherent noise
618 resistance, greater flexibility for usage, and reduced cabling diameters. Installation and design of fiber
619 optic systems are subject to the requirements and demands of both the application and the manufacturer

620 specifications. Fiber optic cable installations should be completed by an approved and certified fiber
621 optics installer.

622
623 Install fiber optic cables in accordance with manufacturer instructions.

624
625 Protect fiber optic cables against physical damage.

626
627 Install a service loop at field terminations, control panels and enclosures used for terminations and at all
628 field terminations. Conform to manufacturer's specifications for the bending radius of the service loop,
629 but not less than 10 times the cable diameter. Provide physical protection of service loops.

630
631

632 **5.6 Coaxial Connectors, Splices, and Terminations**

633
634 Use three-piece BNC crimp-on style connectors for coaxial cable connections. Do not use screw-on or
635 twist-on connectors or adapters. Use suitable tools and methods for stripping coaxial cables and for
636 crimping three-piece BNC connectors.

637
638 Make direct coaxial cable connections within the CCTV system. Use appropriate connectors as dictated
639 by the equipment when terminating coaxial cable on terminals for other than BNC connectors. Do not
640 make connections using any type of in-line adapter.

641
642 Use a standard female-to-male BNC splice when splicing coaxial cable. Do not use type "F" connectors
643 or barrels. Although a female-to-female splice using a barrel adapter is generally acceptable, there is
644 more signal loss with this type of splice.

645
646

647 **5.7 Grounding and Bonding**

648
649 Ground and bond equipment and components in accordance with NEC requirements and manufacturer
650 instructions.

651
652 Bond all metallic components together. The NEC does not require pullboxes to be bonded if the highest
653 voltage in the pullbox is 50 volts or less. However, it is recommended that equipment and conduit
654 systems be bonded together.

655
656

657 **5.8 Conduits and Raceways**

658
659 Install bushings to protect conductors from abrasion at all conduit and raceway connections to junction
660 boxes and at all open ends of raceways or flexible conduits. Secure raceways and install bushings for
661 conduits and raceways that are not connected to an appropriate back box. Position conduits and raceways
662 to provide physical protection for the wires or cables to the device.

663
664 Limit the distance between devices and raceways, conduits or flexible conduits to no more than 75 mm (3
665 inches).

666
667 Size raceways to protect any device manufacturer-provided leads and connectors, along with any
668 conductors from the wires or cables.

669

670 Install raceways and conduits relative to devices to facilitate removal, reinstallation, and reconnection
671 without damaging finished surfaces or extended time fishing for wires or cables. Generally, install
672 raceways and conduits perpendicular to the device.
673
674

675 **6. Installation**

676 **6.1 General**

677 If required, notify the AHJ prior to the installation or alteration of CCTV equipment or wiring. Obtain
678 AHJ approval of system design prior to installation.
679

680 Install cameras, equipment, and accessories in accordance with the standards and specifications approved
681 by the AHJ, if required, manufacturer installation instructions, and in accordance with NFPA standards,
682 the NEC, and other applicable state and local codes. Comply with all federal, state, and local privacy
683 laws when installing CCTV systems. Notify the AHJ prior to the start of installation, if required.
684
685

686 Ensure that components are fully compatible as a system and that equipment is compatible with wiring
687 methods, and system voltage. Use equipment listed or labeled for the purpose for which it is used, where
688 applicable nationally recognized standards exist.
689

690 Integrate system components with support equipment and software into a fully operational and functional
691 video monitoring and control system.
692

693 Construct pole and tower foundations and install poles and towers in accordance with drawings,
694 specifications, and manufacturer instructions. Ensure that cameras mounted on poles or towers are
695 accessible for maintenance using vehicles or bucket trucks, or provide a camera lowering system with
696 dome enclosures.
697

698 Install, conceal, and disguise covert cameras in accordance with manufacturer instructions.
699

700 Locate equipment, components, devices, appliances, and control units so that accidental operation or
701 failure is not caused by vibration or jarring.
702

703 Ensure that equipment is suitable for the voltage, temperature, and humidity conditions in accordance
704 with manufacturer instructions.
705

706 Locate CCTV controls and system components within a secured area, such as within the area being
707 monitored by the system. When this is not possible, locate controls and components where continuously
708 under the notice of assigned personnel, in an area accessible only to authorized personnel, or supervised
709 to annunciate tampering.
710

711 Locate and install equipment and components in accessible locations for service personnel.
712

713 Install rack-mounted CCTV equipment in suitable component racks sized for the equipment and equipped
714 with accessories as needed for proper equipment operation, such as power supplies, power distribution
715 units, power conditioners, and cooling fans.
716

717 Set stops for pan-tilt-zoom cameras to suit final position, mounting, and required field of view.
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6.2 Mounting and Supports

Mount and support equipment in accordance with manufacturer instructions and in consultation with the owner. Cameras are typically mounted to provide as wide a field of view as possible, such as ceiling-mounting in the corner of a room.

Use anchoring devices that are approved for the weight of the equipment used, mounting surface, and wind-loading, where applicable.

Install tamper resistant fasteners, nuts, bolts, screws, locks or similar equipment, or install fasteners in such a fashion that they cannot be removed without the use of tools.

Torque anchors, mounting bolts, and hardware in accordance with manufacturer instructions.

Use mounts and supports that provide for adequate support and do not inhibit camera operation or field of view. Support ceiling-mounted cameras from structure.

Use parapet mounts that are designed to allow equipment to be swiveled in toward the roof for maintenance access.

Mount control units, power supplies and batteries in a vertical, upright position, unless indicated otherwise in manufacturer instructions.

Provide adequate headroom below cameras and their mountings. Where necessary, change the type of mounting to provide adequate headroom below.

6.3 Camera Installation

Prior to installation, check the dimension of all camera housing assemblies to ensure that cameras, lenses, mounting brackets, heaters, where required, blowers, where required, washer/wiper assemblies, where required, and all other required components will fit into the housing.

Install cameras in locations that avoid a direct view of sources of light. Picture quality is degraded when a camera looks directly into a light source, or has a relatively high contrast between objects being viewed and the background scene.

Ensure that proposed camera locations afford the necessary field of view of the areas to be monitored.

Verify that the field of view of ceiling-mounted cameras is not obstructed by light fixtures, fire suppression sprinklers, HVAC diffusers or return air grills, or breaks in ceiling height. If such conflicts exist, coordinate the camera location with the building owner, general contractor, and engineer of record, prior to installation.

Install spot filters for cameras with fixed lenses, where necessary. Install asymmetrical wide-angle lenses when needed to correct for distortion.

Provide individual fusing for each camera.

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6.3.1 External Cameras

Install external cameras such that icing, sunlight angles, extreme temperatures, wind loading, rain, and external moisture do not affect their operation. Keep in mind that pan/tilt/zoom cameras may be required to start up in icing conditions.

Use weather-tight housings for cameras exposed to the elements.

Install accessories for external conditions such as heaters, blowers, washers/wipers, and defrosters or defoggers, as required for proper operation.

Install external CCTV equipment and components that are vandal and tamper resistant.

Install sun-shields or hoods to reduce glare when the sun is low on the horizon, or if the camera has a direct view of the sun, where applicable.

6.4 Control Cabinets and Equipment

Install CCTV equipment, components, transmitters, receivers, matrix switchers, collectors, DVRs or VCRs, programmable logic controllers, computers, routers, monitors, and pan/tilt/zoom controls, in accordance with manufacturer instructions.

Ensure that equipment is installed and connected to function as intended, designed, and manufactured.

Ensure that transmitters and receivers are capable of transmitting and receiving video, data, and control signals for pan/tilt/zoom controls, where applicable.

Install console-mounted monitors on consoles or cabinets. Install overhead monitors mounted on steel support brackets. Use brackets capable of supporting up to 18 kg (40 pounds) that are adjustable in height and width to accommodate the required monitor dimensions.

Provide 75-ohm terminations for all unused video amplifier outputs that are not source-terminated.

6.5 Software

Provide and configure custom software, if necessary, to complete the system installation.

When CCTV systems are installed as part of a premises security system, use software provided with the premise security system that is listed for use with the equipment on which it is installed. Maintain a record of installed software version numbers at the location of the premise security system.

Protect software from unauthorized changes.

6.6 Power Supplies

819 Connect power supplies for CCTV equipment to NEC-compliant branch circuiting. Connect power
820 supplies to a dedicated branch circuit or the unswitched portion of a branch circuit.
821
822 Provide and install listed power supplies with performance characteristics compatible with the unique
823 requirements of the equipment being supplied.
824
825 Size power supplies in accordance with manufacturer instructions and with the application. Ensure that
826 loads connected to power supplies do not exceed 80 percent of the power output rating of the power
827 supply. Keep in mind that additional devices and accessories may necessitate increasing the size of
828 power supplies and associated conductors.
829
830 Consider power source redundancy with at least two independent and reliable power supplies, one
831 primary source and one secondary, or standby, source, each with adequate capacity for the application.
832
833 Install surge protection devices at the primary power supply for CCTV equipment and for all
834 microprocessor-based control units and equipment.
835
836 Provide a power supply disconnecting means with a distinctive marking that is accessible only to
837 authorized personnel and identified as "PREMISES SECURITY CIRCUIT." The location of the circuit
838 disconnecting means shall be permanently identified at the premises security control unit.
839
840 Primary power supplies to equipment that include Class 2 or Class 3 plug-in transformers utilizing
841 receptacles shall be mechanically secured to prevent inadvertent disconnection.
842
843

844 **6.7 Storage Batteries**

845
846 When installing batteries as a secondary source for CCTV systems, locate storage batteries such that the
847 premise security equipment, including overcurrent devices, are not adversely affected by battery gases.
848 Conform to NEC requirements.
849
850 Use battery racks that are suitably protected against deterioration.
851
852 Permanently identify the location of remote batteries and battery charger at the premises security control
853 panel.
854
855 Secure storage batteries from unauthorized access.
856
857 Provide automatic battery charging in accordance with manufacturer instructions that is capable of
858 maintaining the battery fully charged under normal operating conditions and to recharge batteries after
859 fully charged batteries have been subject to a single discharge cycle.
860
861 Ensure that batteries are protected from excessive charging current by overcurrent devices or by
862 automatic current-limiting design of the charging source.
863
864 Use battery charging equipment with voltage and charging current metering either by integral meters or
865 by readily accessible terminals for the connection of portable meters.
866
867 Provide supervision of the battery charger to detect a failure of the battery charger and initiate a trouble
868 signal.
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6.8 Site Cleanup

Upon completion of the work, remove excess debris, materials, equipment, apparatus, and tools, and leave the premises clean, neat, and orderly. Separate, sort, and recycle materials to the greatest extent possible.

Clean all system components, including camera housing windows, lenses and monitor screens. Use methods and materials recommended by the manufacturer.

Provide signage for buildings and areas under CCTV surveillance, unless covert CCTV is used.

7. Commissioning

7.1 Field Adjustments

Some CCTV equipment and components contain automatic controls to adjust for in-service conditions such as brightness control of video monitors, frequency control for synchronizing cameras, gain control to adjust signal strength, and light control for cameras to automatically adjust for proper light levels.

Make field adjustments to cameras to improve the field of view of the area being monitored. For cameras monitoring doors, for example, the top of the field of view should be the top of the door.

Set pan and tilt limits in accordance with manufacturer instructions and as required for the project.

Use the proper filters and tools necessary to perform step-by-step back focus and depth of field adjustments for each camera in accordance with manufacturer instructions. Set camera back-focus such that cameras remain in focus while zooming all the way out or zooming all the way in.

As applicable, set all pan/tilt/zoom cameras to automatically adjust, using set points, to view the intended target, when the camera's call-up switching signal is generated.

Synchronize all cameras to prevent rolling when switching on each monitor. Adjust cameras to optimize the presentation at the display.

Ensure that the recording speed of the multiplexer is compatible with the time-lapse speed of the recording device. Some multiplexers require the video signal to be delivered in three-hour mode to prevent lost information or picture interference.

Adjust variable focal lenses during final acceptance testing.

Perform set up procedures on dual chip technology color cameras in accordance with manufacturer instructions to provide proper color temperature during high light situations and proper Black/White (B/W) sensitivity during low light situations.

Adjust the lens iris, electronic iris, digital rendering, and all other electronic or mechanical devices so that analog camera video output is approximately 1 Volt Peak to Peak (VPP) or 140 Institute of Radio Engineers (IRE) units composite signal. The minimum acceptable video output level is 0.85 VPP with the automatic gain control engaged in lower light situations.

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7.2 Testing Cables and Conductors

Test conductors with a voltmeter to verify that there are no stray (unwanted) voltages between installation conductors or between installation conductors and ground. Unless a different threshold is specified in the system per the installed equipment manufacturer's specifications, the maximum allowable stray voltages shall not exceed 1 Volt AC/DC.

Test conductors other than those intentionally and permanently grounded for isolation from ground per the installed equipment manufacturer's specifications.

Test conductors other than those intentionally connected together for conductor-to-conductor isolation per the installed equipment manufacturer's specifications. The same circuits also shall be tested conductor-to-ground.

Test the fiber-optic transmission line in accordance with the manufacturer instructions by the use of an optical power meter or by an optical time domain reflectometer used to measure the relative power loss of the line. Record this relative figure for each fiber-optic line in the control panel. If the power level drops to below the manufacturer's instructions, repair or replace the transmission line, section thereof, or connectors to bring the line back into compliance with the accepted transmission level in accordance with manufacturer instructions.

Test supervised or monitored circuits for integrity by opening one connection for not less than 10 percent of the controlled devices. Introduction of a fault in any monitored circuit should result in a trouble indication at the control unit.

7.3 Acceptance Testing

Test CCTV systems, equipment, and components in accordance with manufacturer instructions and AHJ requirements, if applicable.

Visually inspect monitors to ensure system monitors are working properly and that cameras are properly aimed and focused. Verify that the various camera images are displayed on the appropriate monitors. Verify that the final image meets the design requirements.

Verify proper operation of remote controls, such as pan/tilt/zoom cameras.

Verify proper operation of ancillary devices, such as heaters, blowers, defrosters, and washer/wipers.

Verify proper operation of matrix switchers, multiplexers, and quads, that sequence and cycle between cameras and monitors.

Verify proper operation of recording devices such as DVRs and VCRs.

Correct system defects and malfunctions in accordance with manufacturer instructions.

7.4 Documentation

970 Deliver operation and maintenance manuals and installation instructions covering all system equipment to
971 the owner or responsible party upon final acceptance of the system. The owner or responsible parties
972 include, but are not necessarily limited to, the owner of the protected property, the leaseholder of the
973 tenant space where the system is installed, or an employee or agent of the owner or the leaseholder.
974

975 Documentation should include a general description, safety precautions, and installation procedures for
976 the system, in addition to the following:

- 977 • Detailed narrative description of the system inputs, signaling, ancillary functions, annunciation,
978 intended sequence of operation, expansion capability, and application considerations and
979 limitations.
- 980 • Detailed operating instructions covering operation under both normal and abnormal conditions.
- 981 • Operator instructions for basic system operations, including system start-up and reset, operation
982 of manual ancillary function controls such as pan/tilt/zoom cameras, and operation of recording
983 devices.
- 984 • Detailed description of routine maintenance and testing as required and as would be provided
985 under a maintenance contract.
- 986 • Listing of the individual system components that require periodic testing and maintenance.
987 Include step-by-step testing and maintenance instructions for each type of device installed, along
988 with a schedule of testing and maintenance intervals for each type of device installed.
- 989 • Detailed troubleshooting instructions for each trouble condition generated from monitored field
990 wiring such as opens, grounds and loop failures, including a list of all trouble signals annunciated
991 by the system, a description of the conditions that cause such trouble signals, and step-by-step
992 instructions describing how to isolate such problems and correct them, or how to call for service,
993 as appropriate.
- 994 • Service directory that includes a list of names and telephone numbers of those who provide
995 service for the system along with a list of spare parts and replacement components recommended
996 to be stored at the site for ready access.
997

998 Where required by code or regulation, provide a Premise Security Record of Completion form to the
999 owner or responsible party.

1000
1001 Protect documentation that may compromise the CCTV system to prevent the unauthorized release of
1002 critical system locations, operations, and functions.

1003
1004 Provide documentation of all inspections and testing completed during installation in accordance with
1005 NFPA 731.

1006
1007

1008 **7.5 Training**

1009
1010 Provide training for all systems users. Coordinate training with the owner or responsible party.

1011
1012 Base training on the level of user involvement with the system, using owner's and user's manuals as
1013 references materials.

1014
1015 Document user training. Maintain a record of the training for a minimum of one year. Make
1016 documentation of training available to the AHJ upon request, and include it with the owner's and user's
1017 manuals. Include the names of attendees, the date of the training, the scope of the training, and the lesson
1018 plan of the training in the documentation.
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8. Maintenance

8.1 General

Inspection, testing, or maintenance may be performed by a person or organization other than the owner if conducted under a written contract. Inspection, testing, and maintenance must be performed by qualified personnel.

To prevent unnecessary response, notify all persons affected by CCTV systems, including the system user, parties responsible for the protected premises, and facilities receiving alarm, supervisory, or trouble signals before proceeding with any testing or maintenance.

Notify the owner or responsible party that the system or a part of the system may not be fully functional during the testing or maintenance procedure and that appropriate safeguards should be taken, based upon the perceived risk.

Notify the owner or responsible party that information may be lost during the time the system is undergoing maintenance or testing.

Coordinate maintenance and testing to prevent interruption of critical building systems or equipment.

Review information regarding the system and system alterations, including the Record of Completion, owner's manual, and installation instructions prior to maintenance and testing, if available from the owner or responsible party.

Notify all affected parties upon the conclusion of inspections, maintenance, and testing.

If a defect or malfunction is not corrected at the conclusion of system inspection, testing, or maintenance, provide written notice to the system owner or responsible party within 24 hours. Maintain a written record for a period of one year from the date the impairment is corrected.

8.2 Routine Inspection, Maintenance, and Testing

Inspect, maintain, and test CCTV equipment and components in accordance with manufacturer instructions. Perform inspections, maintenance, and testing periodically in accordance with a security vulnerability assessment for the protected premises, and in accordance with the manufacturer's published instructions for the devices and appliances that are used. In general, inspect, maintain, and test CCTV systems, devices, and equipment not less than annually.

Use replacement components that are fully compatible with existing equipment and components. For example, do not replace a CS-mount lens with a C-mount lens. A C-mount lens requires a greater distance between the lens and the camera sensor than a CS mount lens. It would not be possible to focus the camera without the aid of a CSA, or CS-to-C adapter. Also, installing a C-mount lens on a CS-mount camera without an adapter may damage the camera sensor.

Clean equipment and components using manufacturer recommended materials and methods.

1069 Inspect equipment and components for evidence of moisture. Consult the manufacturer for instructions to
1070 protect against moisture.

1071
1072 Periodically measure the voltage of power supplies to ensure proper equipment operating voltage.
1073 Replace deficient or degraded power supplies. Voltage regulation problems can cause camera
1074 misoperation.

1075
1076 Inspect equipment with air filters. Clean or replace dirty filters as required.

1077
1078 Measure the temperature of rooms containing CCTV equipment and components. Ensure that equipment
1079 ambient temperatures are within operational limitations of equipment. Notify the owner or responsible
1080 party when ambient temperatures exceed equipment operating limits.

1081
1082 Perform Acceptance Testing in accordance with Section 7.3.

1083
1084 Provide training for all users when inspection, maintenance, or testing results in a change in system
1085 operation.

1086
1087 If a defect or malfunction is not corrected at the conclusion of system inspection, testing, or maintenance,
1088 provide written notice to the party responsible for the protected premises within 24 hours.

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1091 **8.3 Making Repairs or Modifications to an Existing System**

1092
1093 Upon notification of a CCTV system malfunction, initiate repairs within 24 hours, unless the system user
1094 or party responsible for the protected premises agrees to a delay. If the system at the protected premises
1095 is impaired for more than 24 hours from the time of the defect or malfunction is identified, notify the
1096 owner or the designated responsible party in writing so other security measures can be implemented.
1097 When it is determined that there is no risk to the protected property or occupants, repair to the system is
1098 permitted to begin more than 24 hours after notification of a malfunction, provided that the owner or
1099 responsible party is notified in writing so other security measures can be implemented, if needed.

1100
1101 Consider temporary mitigating measures during CCTV system impairments. Base temporary mitigating
1102 measures on a risk assessment of the protected property or the occupants in consultation with the AHJ, if
1103 required. Implement instructions from the risk assessment for the period that the system is impaired.

1104
1105 Inspect and test all systems upon completion of installation, adding or deleting system components, any
1106 modification, repair, or adjustment to system hardware or wiring, any change in site-specific software, or
1107 any change in the structure being protected.

1108
1109 Fully test all components, circuits, system operations, and site-specific software functions known to be
1110 affected by changes.

1111
1112 Complete routine system maintenance in accordance with Section 8.2.

1113
1114 Where required by code or regulation, provide a revised Record of Completion form reflecting any
1115 system changes to the owner or responsible party.

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1119 **Annex A: Reference Standards**

1120

1121 *(This annex is not part of the standard)*

1122

1123 This publication, when used in conjunction with the National Electrical Code and manufacturers'
1124 literature, provides sufficient information to install and maintain CCTV systems. The following
1125 publications may also provide useful information:

1126

1127 National Fire Protection Association

1128 1 Batterymarch Park

1129 Quincy, MA 02169-7471

1130 (617) 770-3000 tel

1131 (617) 770-3500 fax

1132 *www.nfpa.org*

1133

1134 ANSI/NFPA 70-2014, *National Electrical Code* (ANSI)

1135

1136 NFPA 731: Standard for the Installation of Electronic Premises Security Systems

1137

1138

1139 ANSI/UL 2044, Standard for Commercial Closed-Circuit Television Equipment, 2008, revised 2010.

1140

1141

1142 **Current *National Electrical Installation Standards*TM published by NECA:**

1143

1144 *(Insert Current List of NEIS Here)*

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1147