

NECA 303



Standard for Installing and

6 ***Maintaining***~~***Closed-Circuit Television***~~
7 ~~***(CCTV)***~~

8 ***Video Surveillance Systems***

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(This ~~foreword~~Foreword is not a part of the ~~standard~~Standard)

Foreword

~~Foreword~~

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

~~Closed-circuit television (CCTV)~~Video surveillance systems and digital imaging systems shall be installed and maintained in accordance with NECA 303-2XXX, *Standard for Installing and Maintaining ~~Closed-Circuit Television (CCTV)~~Video Surveillance Systems* (ANSI).

Use of ~~NEIS~~NEISTM is voluntary, and the National Electrical Contractors Association (NECA) assumes no obligation or liability to users of this publication. ~~Existence~~The existence of a ~~standard~~Standard shall not preclude any member or non-member of NECA from specifying or using alternate ~~construction~~installation methods permitted by applicable regulations.

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

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

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1. Scope

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

1.1 Products and Applications Included

This Standard applies to the following:

- Video Analog and digital video surveillance cameras, controls, enclosures, and accessories, including pan-tilt-zoom and fixed-mounted cameras
- Monochrome Analog and digital video surveillance system electronic hardware components, such as monochrome or color monitors, video controllers, video switches, remote switchers, quad switchers, signal processing equipment, combiners, amplifiers, control stations, video multiplexers, recording devices (tape or DVR), distribution components, and power supplies, and related accessories
- Electronic hardware components
- Conduiter Raceway, conductor, and cable installation for video surveillance systems

1.2 Products and Applications Excluded

This Standard does not apply to:

- One- and two-family dwellings
- Design Lighting design or the installation of lighting light fixtures or security lighting
- Branch circuit wiring methods
- Security of data, software, or computer systems
- Transmission of video images to remote locations
- Remote supervising locations that receive signals from premises CCTV-video surveillance Systems
- Commercial Monitoring Stations
- Alternate or back-up sources of power

1.3 Regulatory and Other Requirements

All information in this publication is intended to conform to the NEC National Electrical Code (ANSI/NFPA 70™70). Installers shall follow the NEC, applicable state State and local codes Codes, manufacturer instructions, and contract documents when installing CCTV-video surveillance systems.

Only qualified persons as defined in the NEC familiar with the construction and installation of CCTV-video surveillance systems shall perform the technical work described in this publication. Administrative functions such as receiving, handling, and storing CCTV-video surveillance system parts, components, and equipment and other tasks may shall be performed under the supervision of a qualified

person. All work shall be performed in accordance with NFPA 70E, *Standard for Electrical Safety in the Workplace*.

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

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

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

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

Quality and performance instructions identify actions that are recommended or not recommended to improve the overall quality or performance of the installation and are characterized in this Standard by the use of the terms “should” or “should not.”

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

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

2. Definitions

NOTE: The following terms are used in this Standard. The definitions below apply only to the context in which the terms are used in this Standard.

Approved. Acceptable to the Authority Having Jurisdiction.

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

Bandwidth. The amount of data, measured in bytes, that a digital video will require on the network in order to transmit the video.

Blanking. ~~Electrical~~An electrical signal produced at the end of each scanning line.

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

Closed-Circuit Television (CCTV). A video system in which an analog or digital video signal travels from the camera to video monitoring stations at the protected premises. Also see Video Surveillance System.

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

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

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

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

CS-Mount. Newer standard lens mounting format.

Depth of Field. Front-to-back area that is focused in the camera view. ~~The better the~~NOTE: Improving lighting, the greater quality can increase the depth of field that is possible.

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

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

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

Fiber Optics. Flexible glass fibers used to conduct signals.

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

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

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

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

Incident Light. ~~Amount~~The amount of light directly over an object.

Internet Protocol (IP) Surveillance System. A type of digital video camera system that receives control data and sends image data over an IP network.

Labeled. Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the AHJ and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

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

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

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

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

Network Video Recorder (NVR). A digital device and software within an internet protocol (IP) video surveillance system that receives live images/video streams and records them in a digital format to a disk drive or other mass storage device. *NOTE: Many NVRs permit real-time video monitoring in addition to recording; and ~~allows~~allow remote access for one or more personnel ~~ea~~to view cameras simultaneously using secure logins.*

Open Network Video Interface Forum (ONVIF). Open standard protocol that allows compliant network video devices to communicate regardless of manufacturer.

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

Power Over Ethernet (POE). Standard that allows data (Ethernet) cables to simultaneously transmit data and power using a single network cable. POE permits powering electronic devices via Ethernet ~~eab~~ling~~cables~~ without the need for a separate power source.

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

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

Resolution. Measure of the ability of a CCTV-video surveillance system, or one of its components, to produce detail.

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

Strain Relief. Cable termination that provides structural rigidity of conductors under conditions of flexure.

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

Video Surveillance System. A video system in which an analog or digital video signal travels from the camera to video monitoring stations at the protected premises.

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

3. Delivery, Handling, and Storage

3.1 Delivery

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

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

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

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

3.2 Handling

Handle CCTV-video surveillance equipment and accessories in accordance with manufacturer instructions. Avoid impact, jolting, jarring, and rough handling.

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

3.3 Storage

Store ~~CCTV~~video surveillance equipment and accessories in accordance with manufacturer instructions.

Store in a clean, dry, environmentally controlled space.

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

4. Pre-Installation Considerations

4.1 General

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

Consider the areas to be covered by the ~~CCTV~~video surveillance system, such as, ~~but not limited to,~~ entrances, exits, entrance ramps, elevators, stairwells, walkways, and parking areas. Select equipment and components suitable for the physical and environmental conditions that the site may present. Verify that lighting levels are suitable with video cameras. Use low-light cameras or increase light levels as needed for proper operation of ~~CCTV~~video surveillance systems.

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

4.2 Documentation

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

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

- Installed in accordance with all applicable specifications, and
- Tested in accordance with the manufacturer's specifications and appropriate NFPA™ requirements.

4.3 Compatibility and Integration

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

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

Where integrated with other systems, arrange systems to function as a single system. ~~CCTV~~Video surveillance systems may share control equipment with other systems, or be able to operate as stand-alone subsystems arranged to function as a single system. Ensure that the simultaneous operation of all system components does not degrade overall system operation and performance. IP surveillance systems ~~should~~shall be compliant with ONVIF protocol.

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

When ~~CCTV~~video surveillance systems are integrated with central station ~~premise~~premises security systems, comply with applicable codes and requirements for central station ~~premise~~premises security systems.

4.4 Voltage Considerations

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

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

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

Power Over Ethernet (POE) systems should conform to ~~the following Standards;~~ IEEE 802.3AF, from 44VDC- ~~to~~ 57VDC ~~and,~~ 15 Watts maximum, and IEEE 802.3 from 44VDC- ~~to~~ 57VDC ~~and,~~ 30 Watts maximum.

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.

Where used, IP cameras must meet IEEE standards for IP cameras, must have Dynamic Host Configuration Protocol (HCP)/static IP addressing, and must require username and password access for cameras.

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

Use cameras that are appropriately designed, selected, 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 the 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, where installed.

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.

Select dome-mounted or pan/tilt/zoom cameras where the area to be protected has an unobstructed line of sight with no hidden alcoves.

Select dome-mounted cameras for 360-degree coverage.

Position and mount cameras to discourage vandalism.

5. ~~Cabling and Conductors~~

4.6 Bandwidth

For IP systems, consult the IP camera and NVR manufacturers to determine the approximate bandwidth required for the IP video surveillance system. Verify that the conductors and cables are suitable for the minimum required bandwidth of the system.

5. Conductors and Cables

Provide suitable wiring methods for video surveillance systems and equipment in accordance with the NEC.

Guidelines for installing ~~cabling~~raceways, conductors, and ~~conduits~~cables are contained in various *National Electrical Installation Standards*. The following requirements modify or supplement those requirements with respect to ~~conduits, cabling, and raceways~~, conductors, and cables installed for ~~CCTV~~video surveillance systems.

5.1 General

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

Ensure that ~~CCTV~~video surveillance system wiring, conductors and cables, are of the appropriate gauge, strands, insulation, and electrical properties as specified by the ~~manufacturer~~manufacturer of the device to be connected. Provide conductors and cables with jackets that are appropriate for the installed environment.

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

Solder and heat shrink wrap electrical connections to device ~~manufacturer~~manufacturer supplied leads, or use high-quality insulating crimp connectors.

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

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

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

Provide strain relief for all connections, including connections to device manufacturer supplied leads, to ensure that tension is not transmitted to joints or terminals and will not damage or break connections. Provide strain relief for ~~wiring leaving~~ conductors and cables that enter or leave control panels and junction boxes not utilizing raceways.

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

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

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

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

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

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

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

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

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

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

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

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

5.2 Video Cable and Conductors

Use standard coaxial video cables with a solid copper center conductor and a braided copper shield with 95 percent coverage, or mini-coaxial video cables with a stranded copper center conductor and a braided copper shield with 89 percent coverage. Use coaxial cable with a nominal impedance of 75 ohms. Do not use coaxial cable rated for any other nominal impedance.

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

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

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

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

Do not use MATV (Master Antenna TeleVision) cable for ~~CCTV~~video surveillance applications.

For digital, IP, and POE applications, use manufacturer recommended conductors, cables, and wiring methods.

5.3 Control Wiring

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

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

5.4 Data CablingCables

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

Provide data cable in accordance with manufacturer instructions.

5.5 Fiber Optic CablingCables

Fiber optic transmission of both video and data presents distinct advantages over standard copper-based cablingcables, including higher quality and longer distance transmission characteristics, inherent noise resistance, greater flexibility for usage, and reduced cablingcable diameters. Installation and design of fiber optic systems are subject to the requirements and demands of both the application and the manufacturer specifications. Fiber optic cable installations should be completed by an approved and certified fiber optics installer.

Install fiber optic cables in accordance with the NEC and manufacturer instructions, and in accordance with NECA 301, Standard for Installing and Testing Fiber Optic Cables.

Protect fiber optic cables against physical damage in accordance with NEC Article 770.

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

5.6 Coaxial Connectors, Splices, and Terminations

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

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

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

5.7 Grounding and Bonding

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

Bond metallic raceways to ground. Bond all metallic components together. ~~The~~NOTE: While the NEC does not require pullboxes to be bonded if the highest voltage in the pullbox is 50 volts or less. However, it is recommended that equipment and conduit raceway systems be bonded together.

5.8 Conduits and Raceways

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

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

NEC. Size raceways to protect field wiring, conductors and cables, and any device manufacturer-provided leads and connectors, ~~along with any conductors from the wires or cables~~where installed.

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

Install bushings to protect conductors from abrasion at all raceway connections to junction boxes and at all open ends of raceways or flexible conduits. Secure and support raceways and flexible conduits. Position raceways to provide physical protection for the wires or cables to the device.

Where raceways are not connected to an appropriate back box, limit the distance between devices and raceways or flexible conduits to no more than 75 mm (3 inches).

6. Installation

6.1 General

If required, notify the AHJ prior to the installation or alteration of ~~CCTV~~video surveillance systems, equipment, or wiring. Obtain AHJ approval of system design prior to installation.

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

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

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

~~Construct~~Install all conductors, cables, and signal transmission methods for cameras with the proper connections, splices, and amplification to ensure that the image resolution is maintained at the maximum capability of the system design.

Where required, construct pole and tower foundations and install poles and towers in accordance with drawings, specifications, ~~and~~ manufacturer instructions, and applicable codes and standards. Ensure that cameras mounted on poles or towers are accessible for maintenance using vehicles or bucket trucks, or provide a camera lowering system with dome enclosures.

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

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

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

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

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

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

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

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, external weight, such as ice and snow, 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~~rotated 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, consult the AHJ, owner, general contractor, or designer of record for approval to change the type of mounting to provide adequate headroom below.

6.3 Camera Installation

Prior to installation, check the ~~dimension~~dimensions 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~~Ensure that there is no bright light source behind the objects being viewed. Provide cameras and accessories having electronic compensation, such as high dynamic range or backlight compensation, where cameras look directly into a light source; or ~~has~~have a relatively high contrast between the 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~~locations with the building owner, general contractor, and ~~engineer~~designer 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 any~~ distortion.

Provide individual fusing for each camera.

6.3.1 External Cameras

Install external cameras such that icing, sunlight angles, extreme temperatures, wind loading, ice, snow, 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~~video surveillance equipment and components that are vandal and tamper resistant.

Install ~~sun-shield~~sunshields 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~~video surveillance 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~~video surveillance systems are installed as part of a premises security system, use software provided with the ~~premise~~premises 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~~premises security system.

Protect software from unauthorized changes.

6.6 Power Supplies

Connect power supplies for ~~CCTV~~video surveillance equipment to NEC-compliant branch circuiting. Connect power supplies to a dedicated branch circuit or the unswitched portion of a branch circuit.

Provide and install listed power supplies with performance characteristics compatible with the unique requirements of the equipment being supplied.

Size power supplies in accordance with manufacturer instructions and with the application. Ensure that loads connected to power supplies do not exceed 80 percent of the power output rating of the power supply. Keep in mind that additional devices and accessories may necessitate increasing the size of power supplies and associated conductors.

Consider power source redundancy with at least two independent and reliable power supplies ~~connected to separate sources~~, one primary source and one secondary, or standby, source, each with adequate capacity for the application.

Install surge protection devices at the primary power supply for ~~CCTV~~video surveillance equipment and for all microprocessor-based control units and equipment.

Provide a power supply disconnecting means with a distinctive marking that is accessible only to authorized personnel and identified as "PREMISES SECURITY CIRCUIT." The location of the circuit disconnecting means shall be permanently identified at the premises security control unit.

Primary power supplies to equipment that include Class 2 or Class 3 plug-in transformers utilizing receptacles shall be mechanically secured to prevent inadvertent disconnection.

6.7 Storage Batteries

When installing batteries as a secondary source for ~~CCTV~~video surveillance systems, locate storage batteries such that the ~~premise~~premises security equipment, including overcurrent devices, are not adversely affected by battery gases. Conform to NEC requirements.

Use battery racks that are suitably protected against deterioration.

Permanently identify the location of remote batteries and battery ~~charger~~chargers at the premises security control panel.

Secure storage batteries from unauthorized access.

Provide automatic battery charging in accordance with manufacturer instructions that is capable of maintaining the battery fully charged under normal operating conditions and ~~to recharger~~recharging batteries after fully charged batteries have been subject to a single discharge cycle.

Ensure that batteries are protected from excessive charging current by overcurrent devices or by automatic current-limiting design of the charging source.

Use battery charging equipment with voltage and charging current metering either by integral meters or by readily accessible terminals for the connection of portable meters.

Provide supervision of the battery charger to detect a failure of the battery charger and initiate a trouble signal.

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 any required signage for buildings and areas under ~~CCTV~~video surveillance, unless covert ~~CCTV~~video surveillance is used.

7. Commissioning

7.1 Field Adjustments

Some ~~CCTV~~ video surveillance 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. Set stops for pan-tilt-zoom cameras to suit the final position, mounting, and required field of view.

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.

For IP cameras, adjust the frame rate as needed to provide the required video quality and to minimize the video storage requirements.

7.2 Testing ~~Cables and Conductors~~ and Cables

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~~ in accordance with the installed equipment manufacturer's specifications, the maximum

allowable stray voltages shall not exceed 1 Volt AC/DC. Investigate and correct sources of excessive stray voltage.

Test conductors other than those intentionally and permanently grounded for isolation from ground ~~perin~~ accordance with the installed equipment manufacturer's specifications. Investigate and correct any defective wiring.

Test conductors other than those intentionally connected together for conductor-to-conductor isolation ~~perin accordance with~~ the installed equipment manufacturer's specifications. ~~The Test same circuits also shall be tested~~ conductors from conductor-to-ground. Investigate and correct any defective wiring.

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 ~~instructionsspecifications~~, 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. Investigate and correct any defective wiring.

7.3 Acceptance Testing

Test ~~CCTV~~ video surveillance 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- where installed.

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

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

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

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

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

Protect documentation that may compromise the CCTVvideo surveillance system to prevent the unauthorized release of critical system locations, operations, and functions.

Provide documentation of all inspections~~and~~, testing, repairs, and corrections completed during installation in accordance with NFPA 731.

7.5 Training

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

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

Document user training. ~~Maintain a record of the training for a minimum of one year. Make documentation of training available to the AHJ upon request, and include it with the owner's and user's manuals.~~ Include the names of attendees, the date(s) of ~~the~~ training, the scope of ~~the~~ training, and the lesson plan ~~of the training~~ in the documentation. Make documentation of training available to the AHJ upon request and include it with the owner's and user's manuals. ~~Maintain a record of the training for a minimum of one year.~~

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~~video surveillance 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, testing, and 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, Inspections, Testing, and Maintenance, and Testing~~

Inspect, test, and maintain, ~~and test~~ ~~CCTV~~ video surveillance 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, test, and maintain, ~~and test~~ ~~CCTV~~ video surveillance 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.

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

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

~~misoperation~~mis-operation.

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

Measure the temperature of rooms containing CCTV-video surveillance equipment and components.

Ensure that ~~equipment~~ ambient temperatures are within operational limitations of equipment. Notify the owner or responsible party when ambient temperatures exceed equipment operating limits.

Perform Acceptance Testing in accordance with Section 7.3.

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

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

8.3 Making Repairs or Modifications to an Existing System

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

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

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

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

Complete routine system maintenance in accordance with Section 8.2.

Perform Acceptance Testing in accordance with Section 7.3.

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

Annex A: Reference Standards

(This ~~annex~~Annex is not part of the ~~standard~~Standard)

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

National Fire Protection Association

1 Batterymarch Park

Quincy, MA 02169-7471

(617) 770-3000 tel

(617) 770-3500 fax

www.nfpa.org

ANSI/NFPA 70-~~2017~~, *National Electrical Code* (ANSI)

NFPA 731-~~2~~, *Standard for the Installation of Electronic Premises Security Systems*

Underwriters Laboratories

333 Pfingsten Road

Northbrook: Illinois, 60062

847-272-8800

www.ul.com

ANSI/UL 2044, *Standard for Commercial Closed-Circuit Television Equipment*, ~~2016~~.

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

(Insert Current List of NEIS Here)