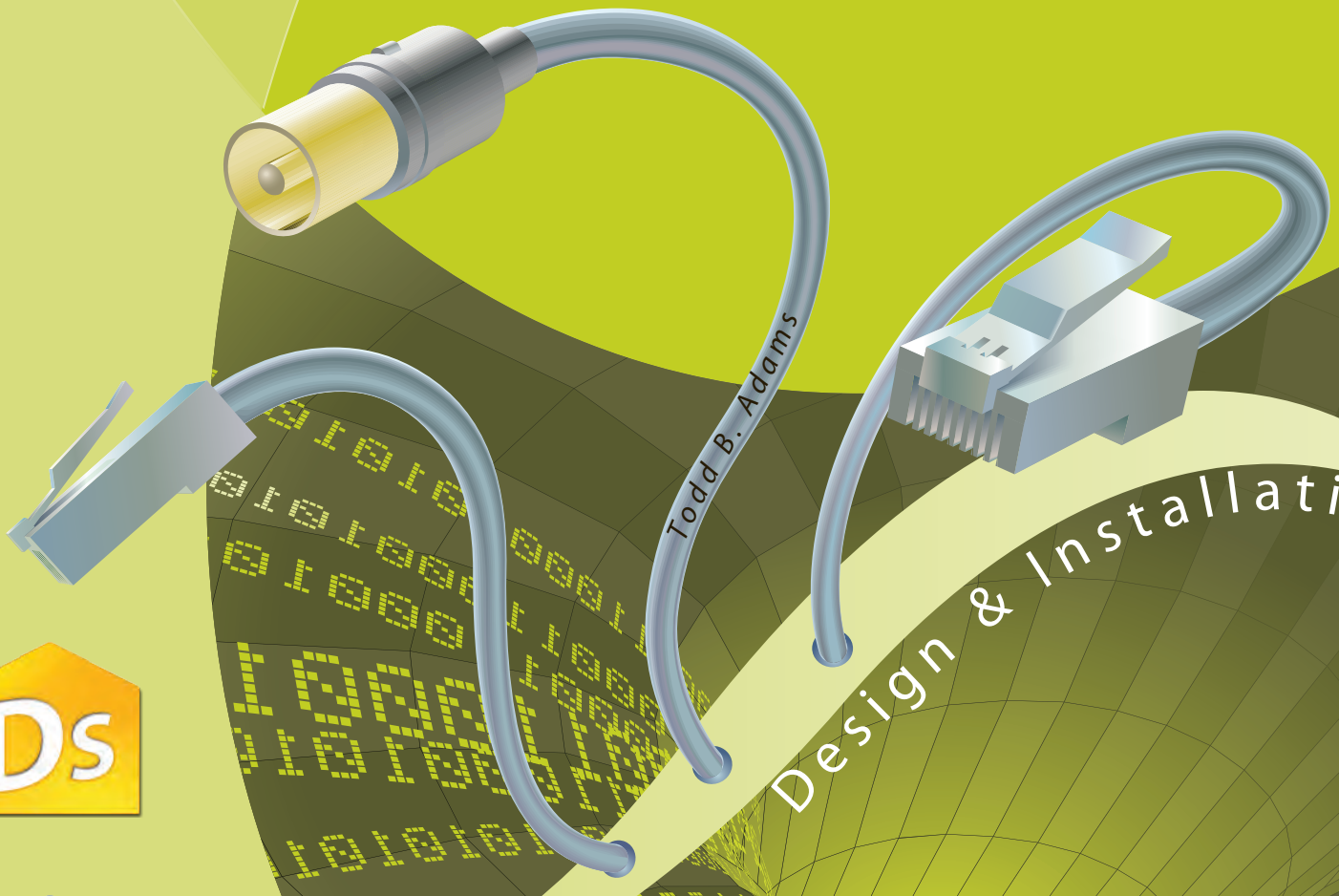
Sample Participant Workbook

PARTNER

Structured Cabling



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Design & Installation

Structured Cabling

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Contents

Preface

About this Sample

This booklet is an example of a participant guide for a design and installation class on structured cabling. It represents only a small section of our book *Structured Cabling | Design and Installation*. While the information is accurate, each section has been condensed. The purpose is to show various styles of content to include tables, figures, and written information.

In this text we show industry standards where appropriate. When no industry standard exist, a best practice is indicated by the DIpartner logo is used. These are practices that DIpartner recommends the reader adopt.

About the Author

A 15-year veteran of the industry, Todd B. Adams has a comprehensive array of experiences in home integration project management, design, engineering, installation, and sales.

Todd's work has been featured in "The Robb Report" and "Audio Video Interiors", and his articles have been published by "Dealer Scope", "Residential Systems", and "CE Pro".

He is the author of four books:

The D.I. Guide to Residential Integration

The Residential Integrator's Project Management

The Residential Integrator's Certification

Strategic Planning | Marketing | Finance

A CEDIA-certified instructor, he has taught industry seminars and workshops in design, project management, business, and other topics across the globe. Todd has BS degree in an electrical engineering, and holds CEDIA's Design certification and CEDIA's Home Theater Master Certification. He received the 2002 CEDIA Best Home Theater Level III and the CEDIA Volunteer of the Year Award for his work on the education council.

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Industry Standards

While not required by local code, industry standards provide a uniform way in which systems are designed and installed. The most important industry standard in structured cabling for the residence is TIA-570-B. This standard, developed by the Telecommunications Industry Association (TIA), allows integrators to prepare homes for current and future technologies. In addition, it gives manufacturers a framework from which products can be developed. TIA-570-B is also a standard approved by the Telecommunications Industry Association for the purpose of cabling single- and multi- dwelling residences for telephone, networking, video, and audio.

Code References

Throughout this book we refer to the National Electrical Code ® (NFPA-70), 2005 edition. The NEC® provides a guide for safe practices and procedures in the electrical field, and is published by the National Fire Protection Association (NFPA). While the NEC® is aimed at the electrical contractor, it applies equally to low-voltage contractors. The standard is updated every three years. The NEC® is part 70 of a set of codes and standards set forth by the National Fire Protection Association (NFPA). It is comprised of a set of rules that when properly applied are intended to provide safe installation of electrical wiring and equipment. This standard governs the use of electrical wire, cable, and fixtures, and electrical and optical communications cable installed in buildings in the USA.

The International Residential Code (IRC) is a residential code, which establishes minimum regulations one- and two-family dwellings of three stories or less. It brings together all building, plumbing, mechanical, fuel gas, energy and electrical provisions for one- and two-family residences.

Objectives

After studying this lesson, you should be able to:

- Understand the construction process of a typical residential dwelling
- Discuss the role of the AHJ in the construction process
- Identify the role of the NEC® in low-voltage installation
- Determine appropriate drilling and notching requirements for studs
- Determine appropriate drilling and notching requirements for joists and rafters
- Explain methods of securing low-voltage cabling
- Define pull tension for coaxial and UTP cables
- Discuss general cabling best practices

Introduction

Structured cabling provides the foundation that allows a variety of integration systems within the home. In this text, we describe the standard method of providing a structured cabling system in a single home for the purpose of voice, data, and video.

Typically structured cabling systems are integrated, and the cabling is distributed from the distribution device (distribution center) to various locations within the home. Figure 8 shows a typical home and how the voice, data, and video are distributed.

We first discuss the construction process in typical home, as well as the role of the AHJ and NEC®. Secondly we review requirements for notching and drilling, as well as other common cabling best practices.

The Construction Process

As the residential construction industry and its associated technology continues to grow, more and more home builders and their customers see the value of installing integrated systems at the time of new home construction.

In order to gain a greater understanding of this practice, we will walk through the construction of a typical new home. The following process is for a typical home with a basement and a garage. The actual construction process varies from location to location within the United States. In many southern areas such as Florida and California, most homes are built at ground level without a basement. Homes built in the northern areas frequently include a basement to help insulate against the cold. Our example home is 3,000 to 4,000 square feet with four bedrooms, an unfinished basement, and a three-car garage.

The construction process not only involves the various trades working on the home, but also includes professionals, such as the architect, engineers, financial managers, and designers. In addition, it involves the **authority having jurisdiction (AHJ)**, which utilizes local building codes that set a minimum standard for the quality of construction. While not required by law, most local building departments adopt the **National Electrical Code® (NEC®)** and the **International Residential Code (IRC).**

The AHJ issues building permits for the construction of the home. The agency issues permits for the general contractor and each of the subcontractors, which includes the low-voltage contractor. Even when a license is not required to perform the work, a permit may still be required. The AHJ performs inspections of the home at critical times, typically just prior to insulation, and just prior to the owner's taking possession. These inspections ensure the home is constructed in accordance with local building codes.

Phase 1. Preconstruction

The preconstruction phase typically lasts four to six weeks. The first step is to survey the site, which includes marking the property lines, building setbacks and locating excavation lines. Next, temporary power and water are installed and a portable toilet is brought to the site. The foundation is excavated, making way for the basement and garage. The footings are built and poured with concrete. These footings (also called the footer) act as the base that supports the building's structure.

The foundation is the part of the structure that is below grade (ground level). The foundation, which supports the building, is constructed of poured concrete and rebar, (see Figure 1). The outside of the foundation is coated with a water sealant and is then back-filled with soil. The flat piece of concrete becomes the flooring of the basement and garage.

A single trench includes connections to the city services for sewer and water. These connections are tested, capped, inspected, and then the trenches are filled. A second trench is dug and separate conduit is laid for electric, telephone, and cable television. The trench is filled and the conduit is left empty for later installations.

Figure 1 A Home Foundation

Figure 2 A Home Being Framed

Phase 2. Framing

The framing phase lasts four to six weeks. The first step is to build the basement bearing walls. These walls support the weight of the structure. They are tied to the basement slab with a power gun. The basement ceiling joists sit on the bearing walls and sill plates that are bolted to the foundation. The joists are covered with sheathing to form the flooring of the first level of the home. These walls are built, sheathed and held in place with temporary angle braces. These walls are then framed and tied to the exterior walls. The temporary angle braces are removed. The second floor is framed in the same manner as the first, and finally, the roof is framed. The home is made weather tight by applying roofing tiles, windows, doors, and siding. The home is now ready for rough in (see Figure 2).

Phase 3. Rough-In

The rough-in phase also lasts about four to six weeks. This phase includes HVAC, plumbing, electrical and low-voltage installations. Once all the rough-in work has been completed, the AHJ performs an inspection of the property. This is done just prior to insulation and drywall, allowing the inspector an opportunity to see possible code and safety issues within the walls.

HVAC

Ductwork is installed between joists, inside of soffits and walls. Air exchangers are located in the basement and attic area. The boiler is installed, and the air compressor lines are run outside and made ready for the installation of the chillers.

Since the ducts are the hardest to place in the home, they are installed prior to other systems. Framing may need to be altered to make room for the system, and soffits may need to be built around ductwork.

Plumbing

The pipes in the home move hot and cold water, and remove wastewater. These pipes are installed inside of the walls and ceilings. Toilets, sinks, showers, tubs, and the washing machine all receive plumbing connections. Since tubs are sometimes larger than doorways they of-ten are delivered to the home prior to the completion of interior framing. However, final connections to the tubs are made during a later phase.

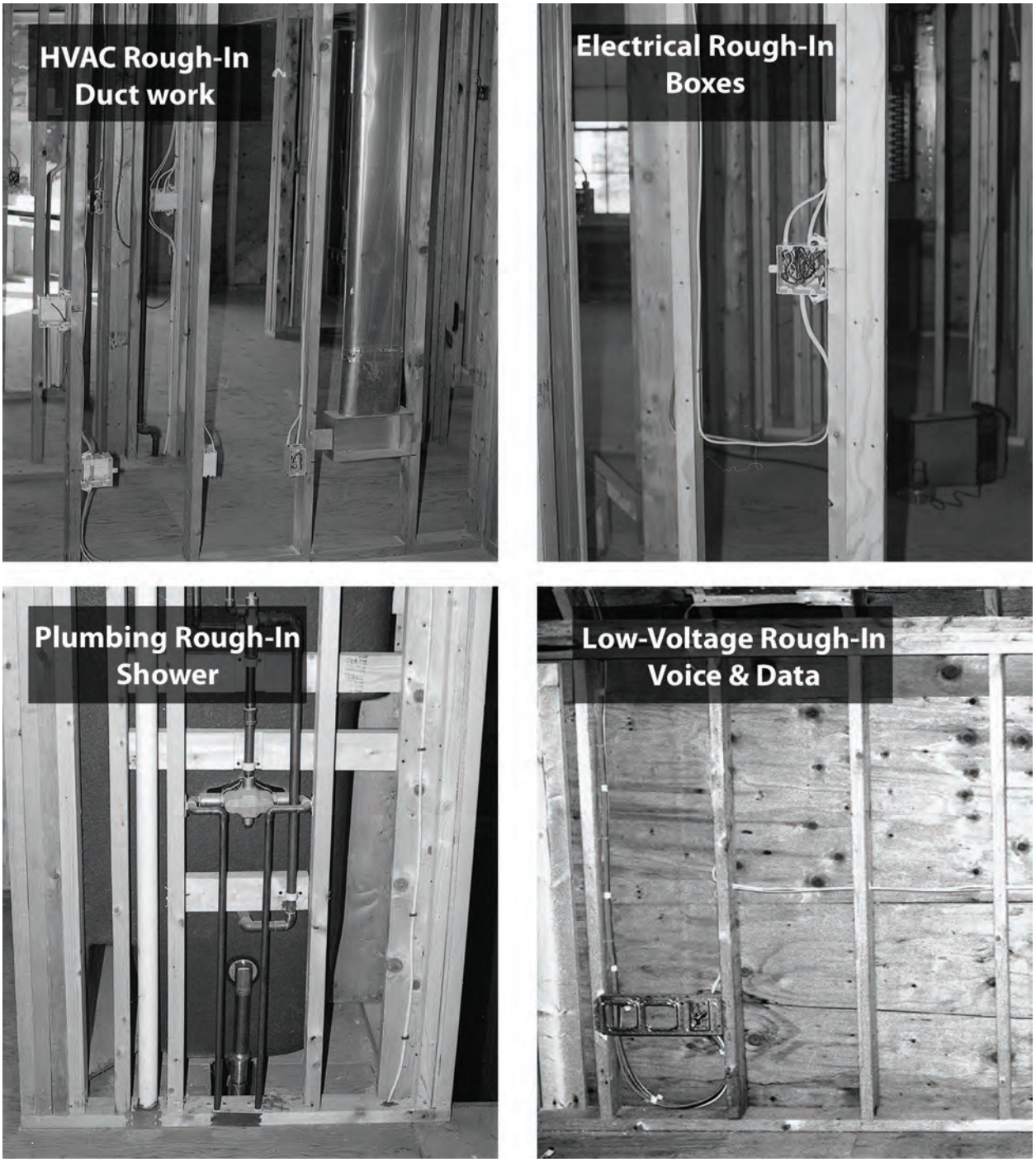
Electrical

Since wiring is small and flexible, it is installed after the HVAC and plumbing. Lights are placed and cabled to switches, and outlets are strung together and run to circuit breaker panels. Appliances such as the washing machine, dryer, and refrigerator receive special outlets. While landscape lighting is not installed at this time, the switches are located and the cabling is left hanging in the basement ready to exit the home via conduit.

Low-Voltage

The low-voltage systems can involve multiple contractors. The home security system often is installed by a separate contractor then the one installing the other systems. Low-voltage systems include doorbells, intercom, music, televisions, telephones, the computer network, and the home theater. They also include control of devices, such as draperies, lighting, skylights, and thermostats.

Figure 3 Rough-In Steps



Phase 4. Interior Finishes

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Phase 5. The Certificate of Occupancy

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Phase 6. Post Construction

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Cabling Best Practices

Drilling Wall Studs

When drilling a hole through a stud, the edge of the hole cannot be closer than 5/8" from the edge of the stud. In addition if the hole edge is within 1 1/4" from the edge of the stud a nail plate should be used. If the hole is drilled in a non-load bearing wall, then hole cannot exceed 60% of the depth of the stud, see figure 10. For a load bearing wall a hole cannot exceed 40% of the depth of a stud, see figure 11.

Notching Wall Studs

A load bearing stud can be notched to a depth of 25 percent of the stud's width and anywhere along the length of the stud, except when back to back to a drilled hole or notch, see figure 12. A non-load bearing stud can notched to a depth of 40 percent of the stud's width, see figure 13.

Drilling Joists and Rafters

Drilling joists and rafters is covered by IRC R502.8.1 and R802.7.1. Holes are not permitted within 2 in (50 mm) of the edges of the joists and rafters. In addition a hole cannot be larger than 1/3 the depth of joist or rafter. Holes can be drilled anywhere along the length of the joist or rafter. Drilling can be seen in figure 14.

Notching Joists and Rafters

Notching joists and rafters is covered by IRC R502.8.1 and R8027.1. The size (depth) of the notch varies with the span of the joist or rafter. Notches along the edge of the joist or rafter cannot exceed 1/6 the depth, and cannot be located in the middle third of the joist or rafter. Notching can be seen in figure 15.

Nail Plates

Nail plates, also known as notch plates, are installed over a notch or a hole where the cable is within 1 1/4" of the face of the stud. The plate must be at least 1/16 in (1.6mm) thick and cover the entire cable as it passes through the stud. This is covered by NEC 300.4**.** As a result of the plate, a nail or screw will not be able to penetrate the cable, as shown in figure 16.

Figure 10 Non-Load Bearing Stud Drilling Requirements

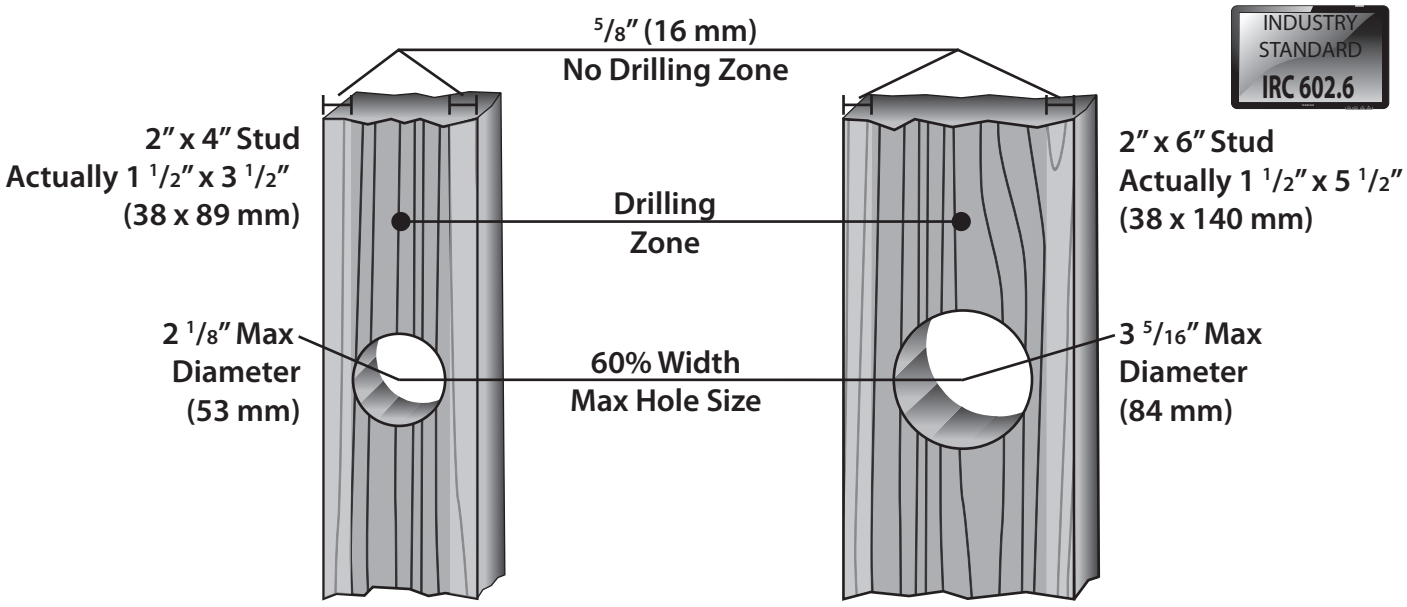


Figure 11 Load Bearing Stud Drilling Requirements

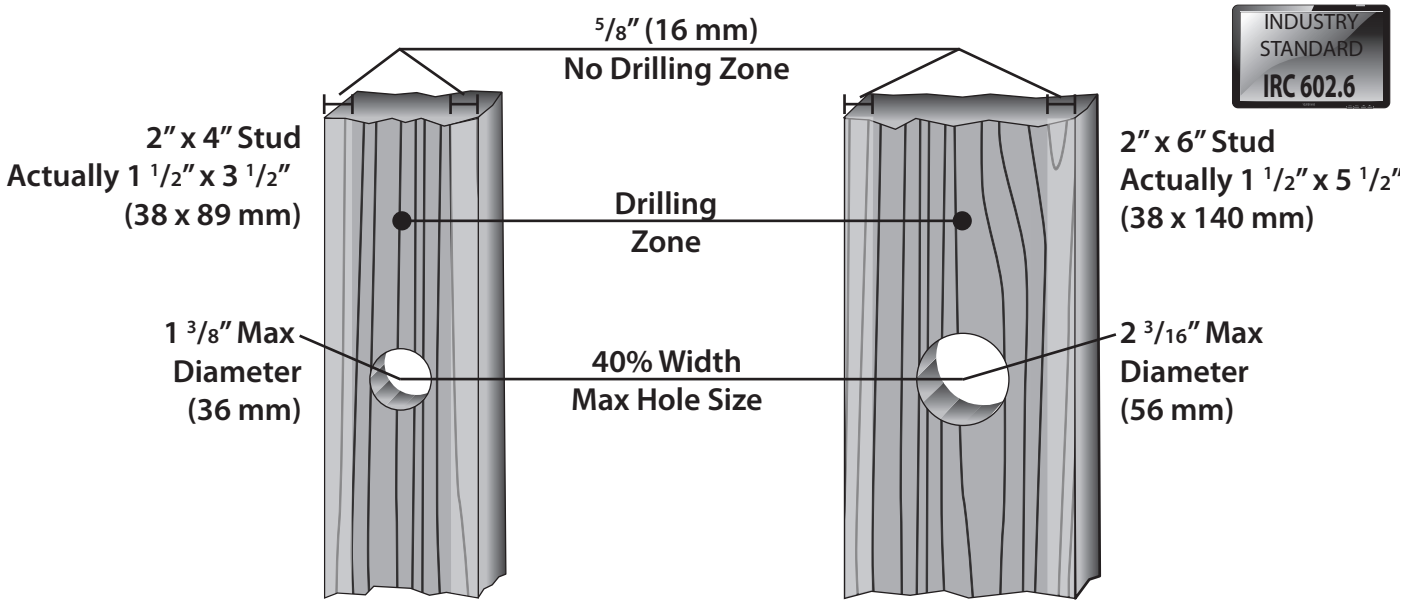


Figure 12 Load Bearing Stud Notching Requirements

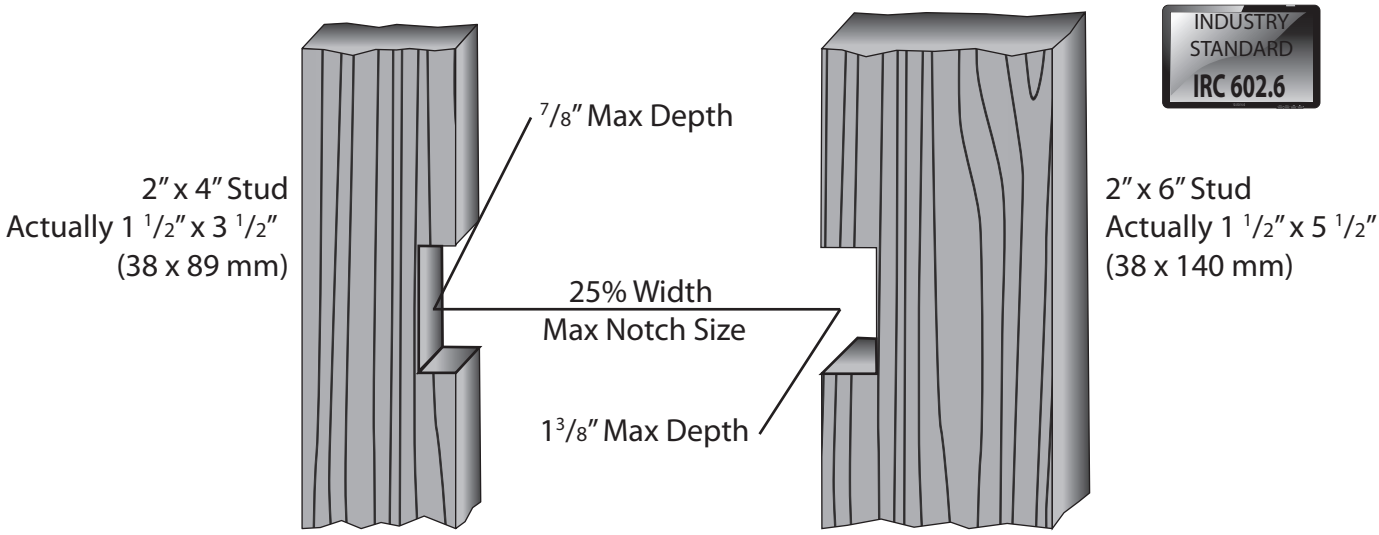


Figure 13 Non-Load Bearing Stud Notching Requirements

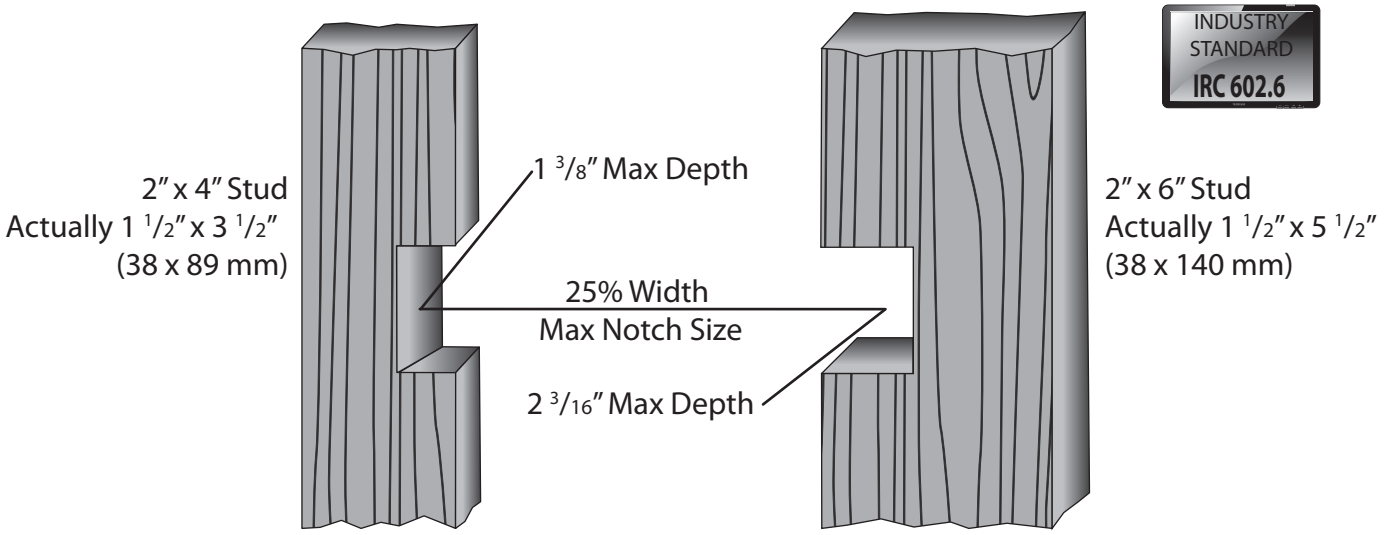


Figure 14 Joist and Rafter Drilling Requirements

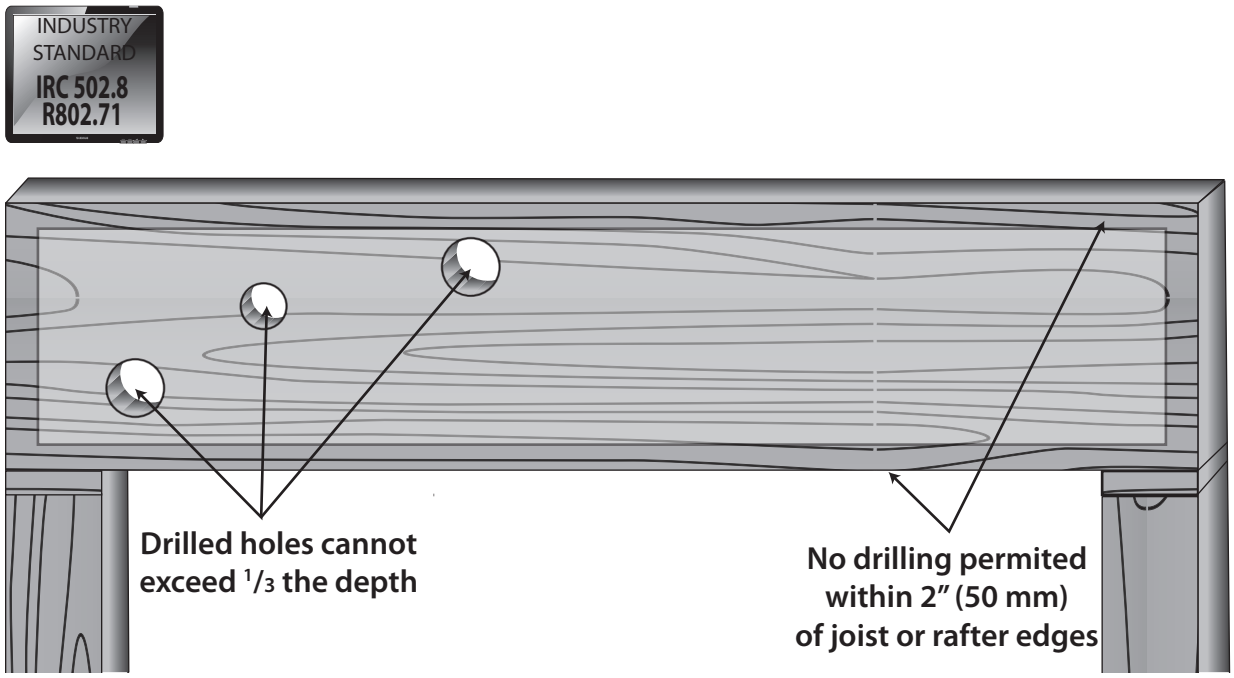


Figure 15 Joist and Rafter Notching Requirements

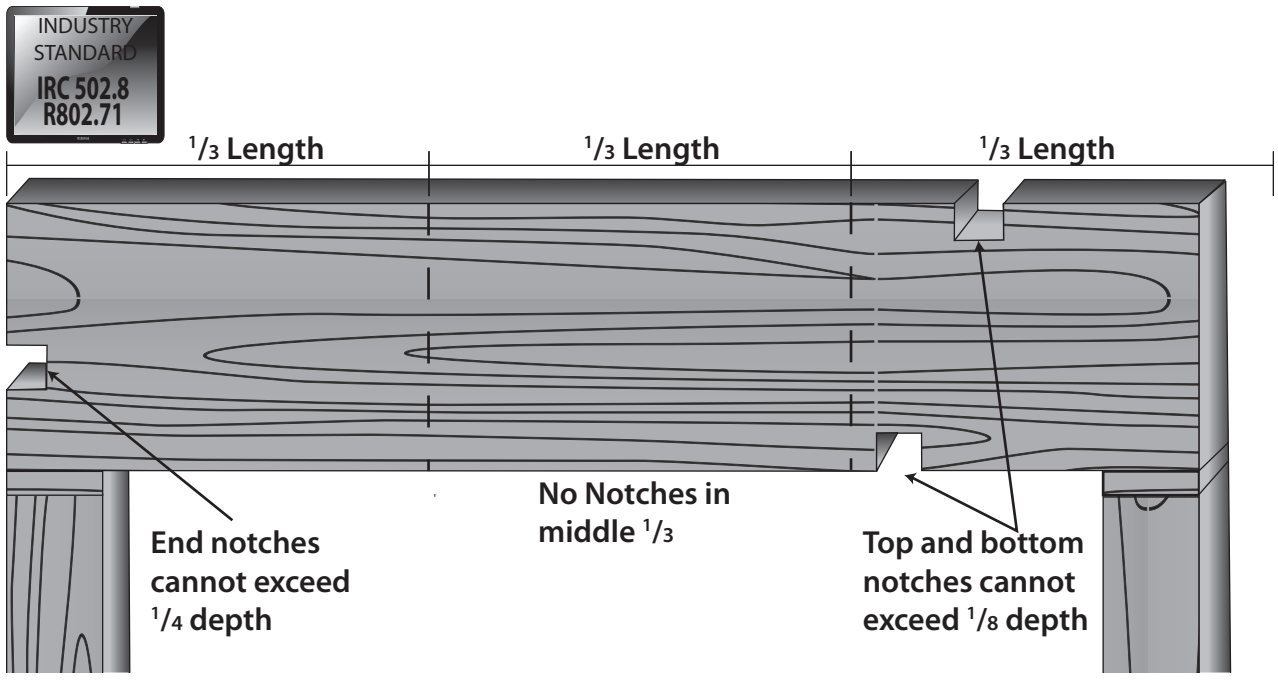
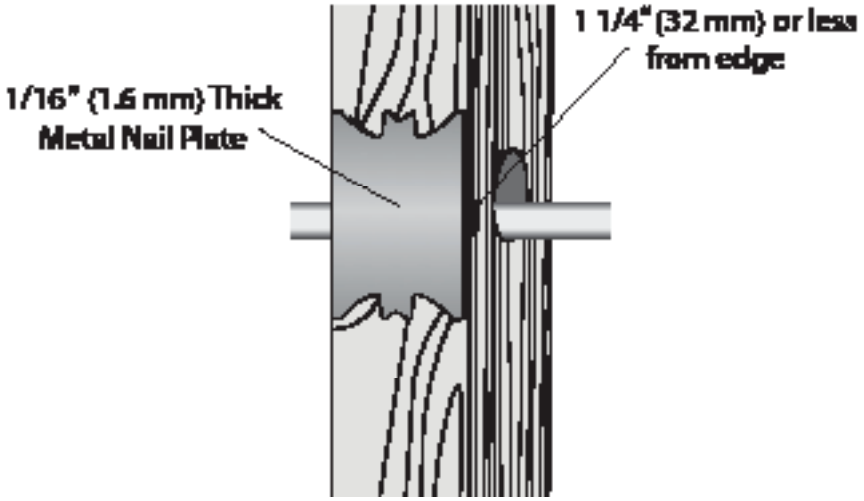


Figure 16 Nail Plate Installation

INDUSTRY STANDARD
NEC 300.4



Pull Tension

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Supporting Cables

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General Cabling Recommendations

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Summary

In this lesson, we discussed the standard installation of a structured cabling system in a single-family home. We discussed standard outlets and standard installation practices.. We also discussed the standard outlets installed in the rooms of a typical home and listed the cables used in a home theater room.

Important points in this lesson include:

- Twisted pair cable and 75-ohm coaxial cable commonly are used in residential integration projects.
- Twisted pair cable is used for telephone, home networking, and as a general communication cable for devices such as keypads, thermostats, and other integrated devices.
- Twisted pair cable is provided in two forms, UTP (unshielded twisted pair) and STP (shielded twisted pair). UTP is the choice for most residential applications - telephone, data, and control. Some manufacturers recommend STP cable for active loudspeakers, which send balanced audio signals over the cable.
- Coaxial cable is used for satellite, CATV and CCTV systems and has a characteristic impedance of 75 +/- 3 ohms.
- Attenuation over the frequency band must be considered when using 75-ohm coaxial cable.
- Coaxial cable uses structural return loss (SRL) measurements to characterize reflections due to impedance roughness as opposed to return loss (RL) that is used for twisted-pair measurements.
- Cables are divided into two grades. Grade 1 - cabling that meets the minimum requirements for basic telecommunications services, such as telephone, satellite, community antenna television (CATV) and data services. Grade 2 - cabling that meets the minimum requirements for basic and advanced telecommunications services such as high-speed Internet and in-home generated video.
- Testing is by far the most important part of the installation. You must test every cable and subsequently label each one that passes.
- While an unlimited combination of connections on the outlets can be designed, the savvy designer creates a set of standardized outlets.
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Key Terms

attenuation decrease in value in power of a signal

authority having jurisdiction (AHJ) the local governmental authority that is charged with the regulation of construction projects. The AHJ may be a city, county, or sometimes a state organization, that is usually answerable to a legislative body that assigns the authority.

Auxiliary Disconnect Outlet (ADO) is connected to the ADO, typically with one cable for each incoming service, such as telephone, cable television, satellite, etc. The ADO allows the incoming services to be quickly disconnected for the purpose of testing.

baseband video is an unmodulated analog video signal

bandwidth is the amount of data that can be transferred over the network in a fixed amount of time. On the Net, it is usually expressed in bits per second (bps) or in higher units like Mbps (millions of bits per second)

cable television (CATV) A broadband distribution network, using coaxial or fiber-optic transmission technology, which carries multiple television channels to domestic and business subscribers within a franchise area. Cable television networks can also carry telephony and information services

closed circuit television (CCTV) monitoring system of cameras that are interconnected so that remote areas can be check from one point, usually for security purposes

certificate of occupancy (C.O.) Issued by the County Building Department once the home has passed all of the required inspections by the County building department. This certificate is issued by the local municipality and is required before anyone can occupy and live within the home. It is issued only after the local municipality has made all inspections and all monies and fees have been paid.

coaxial cable 75-ohm coaxial cable; used for satellite, CATV, CCTV systems; a cable comprised of an insulated central conducting wire wrapped in another cylindrical conducting wire; usually wrapped in another insulating layer and an outer protective layer; has the capacity to carry great amounts of data

dielectric any insulating medium, which intervenes between two conductors and permits electrostatic attraction and repulsion to take place across it

diplexer combines the frequencies, yet blocks harmful DC voltages from the CATV signal path

Distribution Device (DD) is connected to the ADO via a quick disconnect cable, known as the DD cable. The DD is the heart of the structured cabling system. It brings together outlet cabling and equipment cabling. When possible, the DD is centrally located in the residence, thus minimizing cabling lengths. In addition, it is placed in a location that provides a high degree of serviceability.

International Residential Code (IRC) residential code establishes minimum regulations one- and two-family dwellings of three stories or less. It brings together all building, plumbing, mechanical, fuel gas, energy and electrical provisions for one- and two-family residences.

National Electrical Code® (NEC®) Part 70 of a set of codes and standards set forth by the National Fire Protection Association (NFPA). It is comprised of a set of rules that when properly applied are intended to provide safe installation of electrical wiring and equipment. This standard governs the use of electrical wire, cable, and fixtures, and electrical and optical communications cable installed in buildings in the USA.

Network Interface Device (NID) contains a demarcation point between the exterior and interior of the residence. This is typically the point at which the service provider has responsibility prior to the NID, and the residential integrator has responsibility after the NID.

Telecommunications Outlet (TO) connects to the DD via TO cabling. The TO cables are typically UTP, coaxial, and optionally fiber optic. The telecommunications outlet provides the interface between the structured cabling system and the consumer equipment, such as telephones, televisions, and computers.

shielded twisted pair. (STP) cable recommended for active loudspeakers, which send balanced audio signals over the cable

skin effect refers to the phenomena whereby the signal traveling through a conductor will be conducted only on the outer surface (skin) of the wire as the frequency increases.

T568A the preferred wiring pattern for four-pair UTP cable as it provides backward compatibility to both one pair and two pair USOC wiring schemes

T568B matches the older AT&T 258A color code and was the most widely used wiring scheme

TIA-570-B A standard approved by the Telecommunications Industry Association (TIA) for the purpose of cabling single and multi- dwelling residences for telephone, networking, video, and audio.

tilt compensation amplification increases as frequency increases to compensate for cabling losses

twisted pair two insulated copper wires twisted around each other to reduce induction (therefore interference); most common type of transmission media

unshielded twisted pair (UTP) commonly used cable in the residential integration industry used for telephone, home networking, and as a general communication cable for devices such as keypads, thermostats, and other integrated devices

USOC Universal Service Order Code. An old Bell system term identifying a particular service or equipment