

Module 1.1 — Commercial Tools, Materials & Blueprints

The drawings and spec book, the tools and how to run them, and step-by-step how gear gets mounted — knockouts, anchors, trapezes — plus the working-clearance rules.

Why start here. If you have wired a house, you already know the electricity. Commercial work is a different system: three-phase power, every wire inside a pipe, gear bolted to steel and concrete, and a job that runs off **drawings and a written specification** instead of a walk-through. This module makes you useful on day one in three areas: how to **read the documents**, how to run the **tools** the work demands, and, step by step, how equipment gets **mounted** to the building, with the working-clearance rules built in.

Part A — Reading the Documents

Your scope, your material, and your paycheck all come off the paper. Two documents govern, and they work together: the **drawings** (what goes where) and the **project specifications**, called the spec book (what quality, what brand, what method). The drawings show what the specs do not, and the specs say what the drawings cannot. Read both.

The drawing set, in reading order

Open a set the same way every time. The order below is the order a foreman uses on the first morning of a job.

1. **Cover sheet and sheet index.** Check that the set says "for construction" or "issued for permit," not "progress" or "bid set." Find the **revision block** (a letter or number, a date, and a short description). If your set is revision B and the office has revision C, stop and get the current one.
2. **Title block** (lower right corner of each sheet). It carries the sheet title, drawing number, the **scale**, who drew and checked it, and the revision history. The scale is only listed here, so look before you measure anything.
3. **E0 sheets: legend, abbreviations, general notes.** The legend explains every symbol used on that set. Symbols are not from a single national standard, so the legend on the set in your hand beats what you remember from the last job.
4. **E1 power, E2 lighting, E3 one-line and risers, E4 details, E5 and up for schedules.** Most offices number this way, but it is a convention, not a rule. Trust the sheet index.
5. **Keyed notes.** Numbered hexagons or circles on the plan that point to a list on the same sheet. A keyed note often carries the real instruction ("mount at 48 in. to center," "provide 1 in. spare conduit to ceiling"). General notes live in a block near the top of the sheet and apply to the whole drawing.

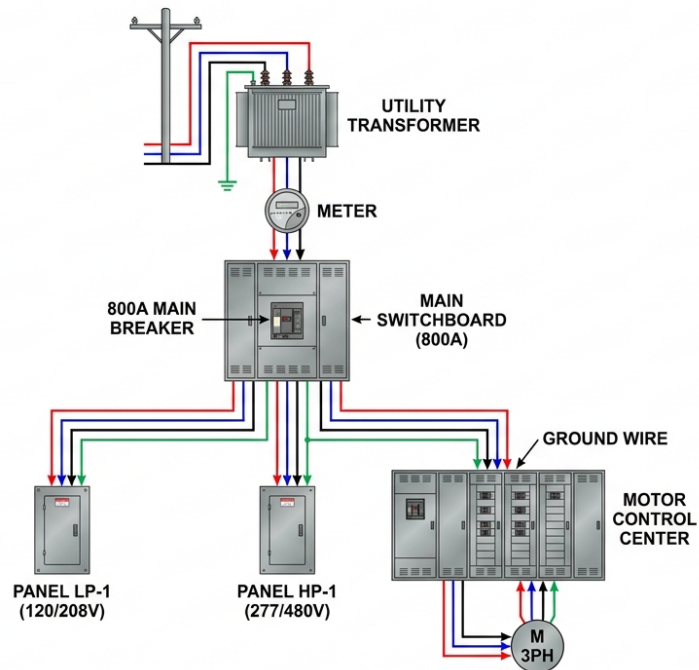
6. **Details and sections.** A detail bubble that reads **3/E4.1** means "detail 3 on sheet E4.1." A section cut marked A-A on a site plan shows what is under the slab or behind the wall. Go to the detail before you build anything the plan only shows as a symbol.
7. **The spec book, Division 26.** Specifications are written under the CSI MasterFormat numbering, which has 50 divisions. Electrical is **Division 26** (older sets say Division 16). The spec names which manufacturers are acceptable, the device grade, the conductor type, the testing you must do, and the paperwork (submittals) you must turn in. It is a legal part of the contract.
8. **When the drawings and the spec disagree.** The usual rule is that the **specifications take precedence over the drawings**. Division 01 of a given contract can change that order, so when you find a conflict, do not guess. Write it down, tell your foreman, and the office sends an RFI (a request for information) to the engineer.

Sheet	What's on it
E0	Symbol legend, abbreviations, general notes, often the schedules (panel, feeder, fixture).
E1 power	Receptacles, equipment connections, homeruns, circuit numbers.
E2 lighting	Fixtures, switching, controls, emergency and exit lighting.
E3 one-lines & risers	Service, distribution, feeders, fire-alarm risers.
E4 details	Mounting and grounding details, elevations, mounting heights.

The spec book = Division 26 (CSI MasterFormat). It dictates acceptable manufacturers, device grade (spec grade vs. hospital grade), conductor type, testing, and submittals. Price and build to the spec, not just the picture.

One-line, riser, and plan: three views of one system

COMMERCIAL SERVICE ONE-LINE



The one-line: utility → meter → main switchboard → panels/MCC. Shows how power flows and how it is protected (incl. AIC).

- The **one-line diagram** (also called a single-line) shows the whole power system as one line per feeder. It shows function and protection, not location. Read it top to bottom: utility, meter, main breaker, feeders, panels, transformers, motors. Breaker sizes, wire sizes, and the AIC (interrupting rating) of each piece of gear live here.
- The **riser diagram** shows the same feeders stacked by floor, so you can see how long each run is and where the feeders go up through the building.
- The **floor plan** (E1, E2) shows where each device sits in the room. The plan tells you where, the one-line tells you how big, and the spec tells you what brand.

NEC 2026 408.6 — field marking on the gear

Switchboards, switchgear, and panelboards must be field-marked with the available fault current, the date the calculation was made, and the short-circuit current rating of the equipment. The one-line is where the engineer's fault current numbers come from. If the gear you are setting has no marking, that is a punch-list item.

COMMERCIAL ELECTRICAL PLAN SYMBOLS

	Duplex receptacle		Ceiling luminaire		Data / phone outlet
	GFCI receptacle		Recessed downlight		
	Weatherproof recept.		2x4 lay-in troffer		
S	Single-pole switch		Junction box		
S₃	Three-way switch		Panelboard		
S₄	Four-way switch		Motor		
S_D	Dimmer switch		Disconnect switch		

Plan symbols — switches print as S / S3 / S4 / SD, not pictograms. The E0 legend governs any non-standard symbol.

The panel schedule, column by column

PANEL SCHEDULE – LP-1			
CIRCUIT #	DESCRIPTION	BREAKER (AMPS/POLES)	LOAD (KVA)
1	Lighting – Open Office	20A/1P	1.2
2	Receptacles – Breakroom	20A/1P	1.4
3	Receptacles – Conf. Room	20A/1P	0.8
4	HVAC RTU-1	30A/3P	4.5
5	Spare	20A/1P	–
6	Spare	20A/1P	–
TOTAL CONNECTED LOAD		–	7.9 KVA
PANEL RATING: 208Y/120V, 3PH, 4W, 225A MLO			

FEEDER SCHEDULE				
FEEDER TAG	CONDUCTORS	CONDUIT SIZE	FROM	TO
F1	3#3/0 THHN + 1#4G	2" EMT	MSB-1	PANEL LP-1
F2	4#500MCM XHHW + 1#1/0G	4" RMC	UTILITY TRANSFORMER	MSB-1
F3	3#2 THHN + 1#6G	1-1/2" EMT	MSB-1	HVAC RTU-1

Panel and feeder schedules — what you price and pull. Watch the A-B-C phase balance and the feeder conductor/ conduit callout.

A panel schedule is a table for one panel. Learn the header first, then the rows.

- **Header:** panel name (LP-1, HP-2A), voltage and phase (208Y/120 V 3Ø 4W, or 480Y/277 V), bus amps, main type (MCB = main circuit breaker, MLO = main lugs only), AIC or SCCR rating, mounting (surface or flush), and "fed from" (which upstream breaker feeds it).
- **Rows:** circuit number (odd numbers down the left, even down the right), the load description, number of poles and trip amps, wire size, conduit size, and the load in VA (volt-amperes) under phase A, B, or C.
- **Footer:** connected load, demand load, and the total per phase. If one phase column is far heavier than the others, the panel is unbalanced and the designer or your foreman needs to know.

NEC 2026 408.4(A) — circuit directory

Every circuit, including spare positions, must have "a legible and permanent description" that is "specific to the purpose or use of each circuit." "Lights" is not good enough. "Lights, rooms 104-108" is. The panel schedule on the drawings is the starting point for the typed directory you leave in the panel door.

The feeder schedule

A feeder schedule lists every feeder by tag: from, to, breaker amps, conductor count and size, conduit size and type, and sometimes length. Read a callout like "**3 #3/0 + 1 #4 G, 2" EMT**" as: three 3/0 AWG phase conductors, no neutral, one #4 AWG equipment grounding conductor, in a 2-inch EMT. Modules 1.2 and 1.3 teach you how to check the conduit fill and the ground size yourself.

Scales: a worked example

Measure runs with an **architect's scale** ($\frac{1}{4}" = 1'-0"$, feet-and-inches) on building plans or an **engineer's scale** ($1" = 20'$ or $1" = 50'$, decimal feet) on site plans. Never lay a tape on the paper and trust it. Copies shrink and stretch, and a reduced print throws every length off. Confirm the scale in the title block first.

- At $\frac{1}{4}" = 1'-0"$, one inch on the paper equals 4 feet in the building.
- A homerun that measures $7\frac{1}{2}$ inches on the plan is $7.5 \times 4 = \mathbf{30 \text{ feet}}$ across the floor.
- Add what the plan hides. A 12-foot ceiling with boxes at 18 inches above the floor means each end drops $12 - 1.5 = 10.5$ feet, so add $2 \times 10.5 = \mathbf{21 \text{ feet}}$ of vertical.
- Total: $30 + 21 = \mathbf{51 \text{ feet}}$, plus a small allowance for offsets around obstacles. Your foreman will tell you the shop's allowance.

Part A — mistakes to avoid

- Building from an old revision. Always check the revision block against the office set.
- Reading the symbol from memory instead of from the legend on that set.

- Skipping the keyed notes. The mounting height and the spare conduit are almost always in a keyed note.
- Buying devices off the drawing without reading Division 26. The spec may require hospital grade, a specific color, or a named manufacturer.

Part A — checklist before you start a room

- Current revision confirmed. Scale confirmed in the title block.
- Legend read. Keyed notes for this sheet read.
- Panel schedule row found for every circuit you are about to rough in.
- Conflicts written down and handed to the foreman, not solved on your own.

Part B — The Commercial Tool Kit

Tool	For	New vs. residential
Hand & mechanical benders	EMT/IMC/rigid bends	Core skill — Module 1.2B
Threader, cutter, reamer	Cut/thread/ream rigid & IMC	No threading in the Romex world
Knockout punch (manual/hydraulic)	Clean holes in steel boxes/panels	Steel enclosures
Hammer drill / rotary hammer	Drill concrete & block	Concrete, not wood
Powder-actuated tool (PAT)	Drive pins into concrete/steel	Requires operator training card
Hydraulic crimper & torque tools	Terminate large conductors	Torqued, not "snug"
Wire tugger / cable puller	Pull big feeders	Crew pulls (Module 1.3)

Naming the tool is not the same as running it. Here is the operating sequence for each one, taken from the manufacturer's manual. The code backs this up: **NEC 2026 110.3(B)** says listed equipment "shall be installed and used in accordance with any instructions included in the listing, labeling, or identification." The instruction sheet is enforceable, and that includes the sheet for the anchor and the tool.

Rotary hammer (SDS-Plus), for example a Milwaukee 1-inch SDS Plus

1. Unplug the tool or pull the battery before you change a bit or a mode.
2. Wipe the SDS shank clean and put a light film of grease on it. Push the bit in, rotate it until it lines up, and push until it clicks. Pull it back and forth about ¼ inch to confirm it is locked. A little in-and-out play is normal.
3. Set the side handle and tighten it. Set the depth rod: the drilling depth is the distance from the tip of the bit to the tip of the rod.
4. Pick the mode: rotation only (wood, steel), rotary hammer (concrete), or hammer only (chiseling, setting drop-in anchors). Stop the tool before you move the mode lever.

5. Hold both handles and let the tool do the work. On deep holes, pull the bit partway out while it is still running to clear the dust. Never add water to settle dust.
6. If the bit binds, the slip clutch stops the bit from turning. Stop, free the bit, and start again. Do not fight it.
7. Before you drill, think about what is in the wall or slab: wiring, conduit, post-tension cables. Ask the foreman.

Silica dust is regulated (OSHA 29 CFR 1926.1153, Table 1). Drilling concrete makes fine silica dust that scars lungs. For handheld drills the rule is a dust shroud with a vacuum sized to the maker's airflow, a filter of 99 percent efficiency or better with a filter-cleaning mechanism, and hole cleaning with a HEPA-filtered vacuum. No compressed air to blow holes clean. With a compliant shroud-and-vacuum system, a respirator is not required. Use carbide bits marked ANSI B212.15, which is what anchor makers specify.

Powder-actuated tool (PAT), for example a Hilti DX

A PAT is a tool that fires a pin into concrete or steel with a powder charge. OSHA 29 CFR 1926.302(e) treats it like a firearm, and so should you.

1. **Training first.** Only employees trained on that specific tool may operate it. Hilti offers free online DX operator training. Carry the card.
2. **Test the tool each day before loading,** by the manufacturer's method.
3. **Center-punch test.** Set a pin on the concrete and strike it with a hammer. If it will not mark the concrete, the base is too hard. Never fire into cast iron, glazed tile, hardened steel, glass block, face brick, hollow tile, or live rock, and never into a spalled (chipped) area.
4. **Start low.** Load the lowest power level. If it does not drive the pin fully, go up one level and try again.
5. **Edge and spacing.** Stay at least 3 inches from a masonry edge, $\frac{1}{2}$ inch from a steel edge, and 2 inches from a weld. The concrete must be at least three times as thick as the pin penetrates.
6. **Load only when you are about to fire.** Never point it at anyone. Keep your hand clear of the muzzle. Use the right shield or guard for the fastener.
7. **Two-stage firing.** Press the tool firmly to the work, then pull the trigger. It will not fire unless pressed.
8. **Misfire:** hold the tool against the work for at least five seconds, then follow the manufacturer's unloading procedure. Never leave a loaded tool unattended.
9. Store the tool unloaded. Keep loads of different power levels in separate containers.

Hydraulic knockout punch, for example a Greenlee Quick Draw

Full step-by-step is in Part C. The key manual points: every thread of the punch must be engaged, never pump after the ram stops, and never punch two layers at once. Capacity is 10-gauge steel.

Portable band saw, for example a Milwaukee deep-cut

1. Unplug. Turn the tension handle half a turn to release. Fit the blade with the teeth pointing toward the rear on the left side of the saw, seat it in the guides, and turn the handle back to tension it.
2. Pick the blade pitch (teeth per inch, TPI). Keep at least three teeth in the cut. 14 to 18 TPI is right for EMT, strut, and all-thread. 24 TPI is for thin tubing or sheet.
3. Vise the work. Rest the saw's stop against the piece, start the blade before it touches, and let the weight of the saw feed it. Never force it.
4. Wear side-shield safety glasses. The blade and the cut end are hot.
5. **Ream every cut end.** A cut leaves a sharp burr inside the pipe, and that burr slices insulation on the pull. All types of conduit must be reamed after they are cut.

Pipe threader, for example a RIDGID 700 power drive

1. Lock the pipe in a trisland chain vise. Support long pieces so they cannot swing.
2. Slide the die head into the power drive, spline end first, until the spring-loaded pawls catch.
3. Fill the oiler with thread-cutting oil and set it in front of the vise. Oil the die as you cut.
4. For pipe 1 inch and larger, use the support arm. Set it so the end of the tang lines up with the end of the pipe. The support arm takes the torque so your wrists do not.
5. No gloves and no loose clothing near the rotating die. Eye protection on. Expect a hard kick on the handle.
6. Thread until the die is flush with the end of the pipe. Pipe thread tapers $\frac{3}{4}$ inch per foot, so a thread cut too long or too short will not seal in a coupling. Reverse off, then ream the inside.

Torque tools

NEC 2026 110.14(D) — terminal connection torque

"Tightening torque values for terminal connections shall be as indicated on equipment or in installation instructions provided by the manufacturer. An approved means shall be used to achieve the indicated torque value." Approved means include a torque wrench, a torque screwdriver, or a shear bolt that breaks at the right torque. "Snug" is not a torque value. Carry an inch-pound screwdriver for devices and breakers, and a foot-pound wrench for lugs and anchors.

Part B — safety baseline

- Power tools must be double-insulated or grounded (OSHA 1926.302(a)). Never carry or hoist a tool by its cord.
- Working near energized gear: follow the NFPA 70E (2024) Article 120 process to put equipment in an electrically safe work condition. The voltage test is phase-to-phase and phase-to-ground at every point of work, and you test your meter on a known live source before and after (live-dead-live). Module 2.1 covers this in full.

- Ladders and lifts follow OSHA rules and the manufacturer's label. Three points of contact on a ladder, harness clipped in a boom lift.

Part C — STEP-BY-STEP: Punching a Knockout

A knockout (KO) is the round hole a connector or conduit fitting passes through in a box or panel. Factory KOs are pre-cut. When you need one where there is none, you punch it. The sequence below follows the Greenlee Quick Draw manual.

1. **Confirm the enclosure is de-energized.** The manual says do not use the tool near live circuits. On an existing panel that means lockout first (Module 2.1).
2. **Mark the center** of the hole on the enclosure wall. Check the inside: nothing behind the wall where the punch and slug will land. Close any panel door that sits in line with the ram.
3. **Drill the pilot hole** slightly larger than the draw stud. Small punches use a 7/16-inch stud; larger ones use a 3/4-inch stud. For a big hole, use **step-up punching**: punch the 1/2-inch-conduit hole first, then swap to the 3/4-inch stud for the larger die.
4. **Open the release knob** so the ram extends. Slide the die onto the stud, then pass the stud through the pilot hole from the inside or outside as the manual shows.
5. **Thread the punch on until it is tight.** Every thread must be engaged. If the punch is not tight, the hole may not finish and the stud can break.
6. **Close the release knob and pump** until the punch is completely through the steel. Stop when the ram stops. Never pump after the ram bottoms out.
7. **Open the knob**, back off the punch, remove the slug, and deburr the edge with a file or reamer.
8. **Plug any KO you opened but will not use.** NEC 2026 110.12(A) requires unused openings to be closed.

Conduit size	Hole diameter	Conduit size	Hole diameter
1/2 in.	0.885 in.	1 1/4 in.	1.701 in.
3/4 in.	1.115 in.	1 1/2 in.	1.951 in.
1 in.	1.362 in.	2 in.	2.416 in.

Part C — mistakes to avoid

- Punching two layers (a box and a cover) at once. The tool is rated for one layer up to 10 gauge.
- Pumping after the ram stops. That is how studs break.
- Using the wrong die for the connector. A sloppy KO will not seat the locknut flat, and a locknut that is not tight breaks the ground path through the box.

Part C — inspection

- Hole is round and clean. Locknut sits flat on the metal with no gap.
- Burr removed. Insulating bushing in place where the spec or the connector listing calls for it.

- Every unused opening plugged.

Part D — STEP-BY-STEP: Anchoring to Concrete

Every piece of gear and every trapeze hangs from an anchor. An anchor is only as strong as the hole it sits in, and the tables below show why the hole size, hole depth, cleaning, and torque are not suggestions. Torque numbers differ by brand, so **the sheet that came with the anchor in your hand governs** (NEC 2026 110.3(B)).

Wedge anchor (heavy load)

A wedge anchor is a threaded stud with an expansion clip at the bottom. Tightening the nut pulls the stud up and forces the clip against the hole wall. The steps follow the DEWALT Power-Stud+ SD1 technical sheet.

1. Drill the hole with a carbide bit (ANSI B212.15) that **matches the anchor diameter** exactly: a ½-inch anchor takes a ½-inch bit. Drill to the required depth (see table). Dust shroud and vacuum on.
2. Clean the hole: vacuum during drilling with a hollow bit or shroud, or vacuum after drilling. A dirty hole cuts the holding power.
3. Put the washer and nut on the stud with the nut flush to the top, so the hammer does not damage the threads. Drive the anchor through the fixture into the hole until it reaches the minimum embedment, called h_{nom} .
4. Tighten the nut **with a torque wrench** to the installation torque on the sheet. The stud draws up while the clip stays put. Do not keep going past the number.

Anchor dia.	Bit	Min. embedment h_{nom}	Hole depth	Torque, concrete	Torque, grouted block
¼ in.	¼ in.	1½ in.	$h_{nom} + \frac{1}{8}$	4 ft-lb	4 ft-lb
⅜ in.	⅜ in.	1⅝ in.	$h_{nom} + \frac{1}{8}$	20 ft-lb	15 ft-lb
½ in.	½ in.	2¼ in.	$h_{nom} + \frac{1}{4}$	40 ft-lb	25 ft-lb
⅝ in.	⅝ in.	2¾ in.	$h_{nom} + \frac{1}{4}$	80 ft-lb	35 ft-lb
¾ in.	¾ in.	3⅜ in.	$h_{nom} + \frac{1}{4}$	110 ft-lb	50 ft-lb

DEWALT Power-Stud+ SD1 (ICC-ES ESR-2818). Concrete must be at least $1.75 \times h_{nom}$ or 3¼ in. thick, whichever is greater. A Hilti Kwik Bolt TZ2 of the same ½-inch size calls for 50 ft-lb, not 40, and Hilti nuts only. Same job, different brand, different torque. Read the sheet.

Drop-in anchor (flush, for all-thread)

A drop-in anchor is a hollow steel shell with internal threads and a cone plug inside. You set it with a tool that drives the plug down and flares the shell. It sits flush with the concrete, which is why trapeze rods hang from it. Steps follow the Simpson Strong-Tie DIAB instructions.

1. Drill with the bit the sheet lists. The bit is **larger than the rod**: a $\frac{3}{8}$ -inch rod uses a $\frac{1}{2}$ -inch bit and a 1 $\frac{9}{16}$ -inch minimum embedment; a $\frac{1}{2}$ -inch rod uses a $\frac{5}{8}$ -inch bit and a 2-inch embedment. A fixed-depth bit stops when its shoulder touches the surface.
2. Blow or vacuum the hole clean. Overhead holes drain themselves and need not be blown out.
3. Tap the anchor in until it is flush.
4. Drive the plug with the setting tool, by hand or in an SDS rotary hammer on hammer-only mode, until the shoulder of the setting tool touches the top of the anchor. When it is set right, you will see **four indentations** on the top.
5. Thread the rod in at least one full rod diameter deep (a $\frac{3}{8}$ -inch rod goes in at least $\frac{3}{8}$ inch).

Sleeve anchor (concrete, block, brick)

1. Bit diameter equals anchor diameter. The hole in the fixture is $\frac{1}{16}$ inch larger than the anchor.
2. Drill at least $\frac{1}{2}$ inch deeper than the anchor will go.
3. Brush and vacuum the hole. Insert the anchor through the fixture and tighten with a wrench to the sheet's torque. Over-torquing makes the anchor spin in the hole, and then it holds nothing.

Powder-actuated tool is firearm-class. Hold the operator card, match the load and pin to the base material, never fire into spalled, thin, or edge concrete, and keep the muzzle guard down. Full steps in Part B.

Part D — mistakes to avoid

- Oversized or dirty holes. Both cut the load capacity, and you cannot see it until the trapeze lets go.
- Torquing by feel. Buy a ft-lb torque wrench and use it.
- Zinc-plated carbon steel anchors outdoors or in wet areas. They are listed for dry interior use only. Use stainless or hot-dip galvanized where it gets wet.
- Wood plugs in a drilled hole. NEC 2026 110.13(A) forbids wooden plugs driven into masonry or concrete as a means of securing equipment.

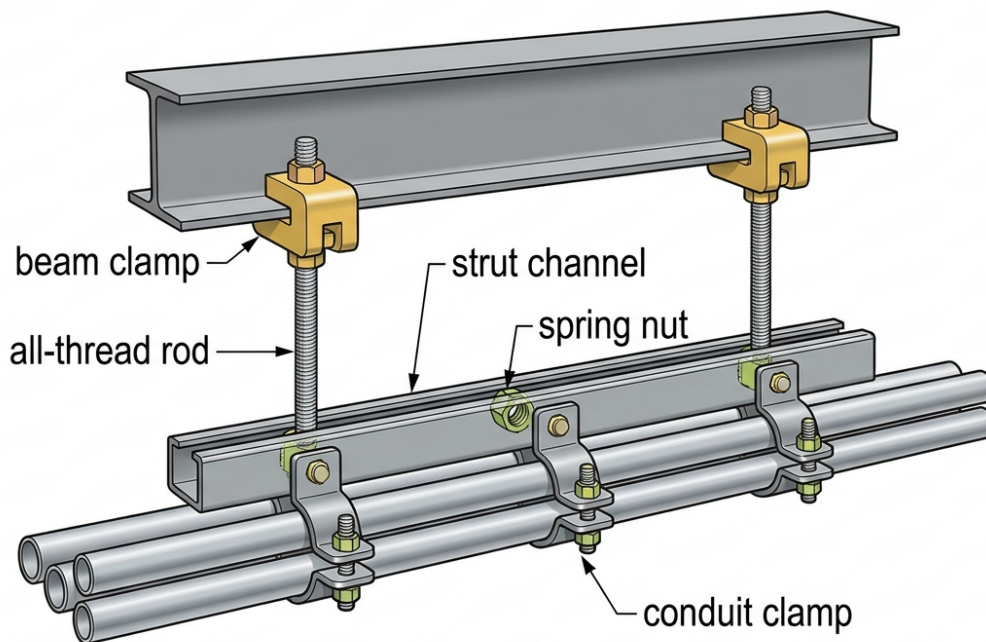
Part D — inspection

- Head of the wedge anchor shows its length-code letter; stud did not spin while torquing.
- Four set marks visible on every drop-in. Rod threaded in at least one diameter.
- Edge distance and spacing match the anchor sheet.

- Equipment is firmly secured (NEC 2026 110.13(A)) and the raceway system is "securely fastened in place" (NEC 2026 300.13(A)).

Part E — STEP-BY-STEP: Building a Trapeze Support

TRAPEZE CONDUIT SUPPORT



A trapeze: beam clamp → all-thread rod → strut channel carrying multiple conduit runs.

A trapeze is a length of strut channel hung on two threaded rods, carrying several conduits side by side. Parts and load numbers below come from the Unistrut General Engineering Catalog No. 17A. Other strut brands publish the same kind of tables.

The parts

- **Channel:** P1000 is the standard $1\frac{5}{8} \times 1\frac{5}{8}$ inch, 12-gauge channel. P1001 is two P1000s welded back to back for heavier spans. P2000 and P3000 are lighter.
- **Channel nuts:** spring nuts (P1006 to P1010 for $\frac{1}{4}$ through $\frac{1}{2}$ inch) drop in anywhere along the slot. A 90-degree clockwise turn lines the grooves in the nut up with the inturned lips of the channel. If the grooves are not engaged, the nut will slide.
- **Threaded rod:** comes in 12-foot sticks. Allowable load per rod: $\frac{3}{8}$ inch 730 lb, $\frac{1}{2}$ inch 1,350 lb, $\frac{5}{8}$ inch 2,160 lb, $\frac{3}{4}$ inch 3,230 lb.
- **Beam clamps:** P2675 takes rod up to $\frac{3}{8}$ inch and 250 lb; P2676 is a swivel for rod up to $\frac{1}{2}$ inch at 500 lb; P2784 carries 1,200 lb with its set screw torqued to 13 ft-lb. Clamp ratings carry a safety factor of 4.
- **Conduit clamps:** P1109 to P1126 for rigid conduit, the P1431 series for EMT, and universal clamps that take either.

Bolt size	Recommended torque	Max torque
1/4-20	6 ft-lb	7 ft-lb
5/16-18	11 ft-lb	15 ft-lb
3/8-16	19 ft-lb	25 ft-lb
1/2-13	50 ft-lb	70 ft-lb
5/8-11	100 ft-lb	125 ft-lb

Unistrut torque values for dry, clean threads. A lubricated bolt tightens far past these numbers at the same wrench reading and can snap.

Build sequence

1. **Layout.** Space the trapezes at or inside the support interval for the raceway you are carrying. For EMT that is every 10 feet and within 3 feet of every box or termination (NEC 2026 358.30(A)). Shoot both hanger lines with a laser or chalk line, square to the run.
2. **Overhead attachment.** On steel, a beam clamp sized for the load (P2784 set screw to 13 ft-lb). On concrete, a drop-in anchor per Part D, or a cast-in strut insert if the slab was poured with one.
3. **Rods.** Cut the two rods with the band saw, dress the cut end with a file so the nut starts, thread each rod into its clamp or anchor at least one diameter, and lock it with a jam nut.
4. **Channel.** Cut the channel square, deburr it, and put plastic end caps on.
5. **Hang it.** Nut and washer above and below the channel on each rod. Level it, then torque the nuts per the table (3/8-16 to 19 ft-lb).
6. **Load it.** Drop spring nuts in, turn each one 90 degrees so the grooves bite, set the conduits, and tighten the clamps. Space conduits so you can still land couplings and fittings, and stagger the couplings between hangers.
7. **Seismic jobs.** If the engineered detail calls for rod stiffeners and cradle clips, install them where the detail shows. Do not skip them to save time; the inspector will look.

Worked load check

Two 2-inch rigid steel conduits with conductors and two 1-inch EMTs, on P1000 trapezes with rods 24 inches apart, hung every 10 feet.

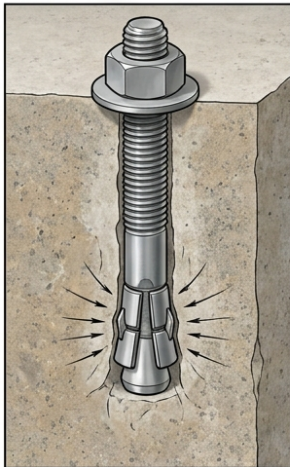
- 2-inch rigid with conductors weighs 8.50 lb per foot. 1-inch EMT with conductors is about 1.2 lb per foot.
- Load on one trapeze = $10 \text{ ft} \times (2 \times 8.50 + 2 \times 1.2) = 10 \times 19.4 = \mathbf{194 \text{ lb}}$.
- P1000 on a 24-inch span is good for 1,690 lb uniform load, so the channel is at 11 percent.
- Each 3/8-inch rod carries 97 lb against 730 lb allowable. Each P2675 clamp carries 97 lb against 250 lb.
- Now add lines. At ten 2-inch rigids per trapeze the clamp load would be over 400 lb, past the P2675's 250 lb, so you would step up to P2676 or P2784 clamps and probably 1/2-inch rod. The

channel table is for a uniform load; a single conduit in the middle counts as a point load at half the table value.

Raceway	Weight, lb/ft	Raceway	Weight, lb/ft
1 in. EMT (tubing only)	0.64	¾ in. rigid w/ conductors	1.80
1½ in. EMT	1.10	1 in. rigid w/ conductors	2.60
2 in. EMT	1.40	2 in. rigid w/ conductors	8.50
3 in. EMT	2.70	3 in. rigid w/ conductors	16.50
4 in. EMT	4.00	4 in. rigid w/ conductors	24.80

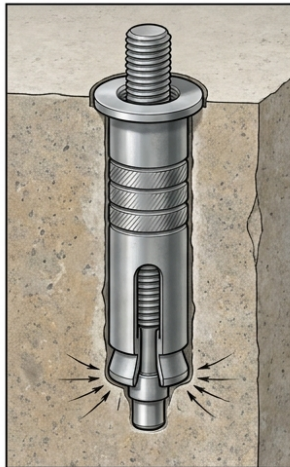
COMMERCIAL CONCRETE & STEEL ANCHORS

Wedge Anchor



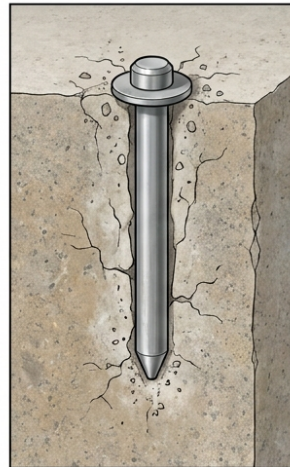
For heavy-duty loads in solid concrete.

Drop-In Anchor



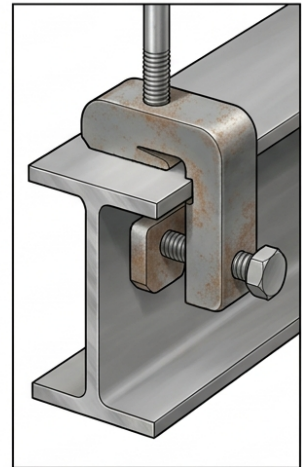
For flush mounting and internal thread applications.

Powder-Actuated Pin



For fastening to concrete, steel, or masonry.

Beam Clamp



For suspending loads from structural steel.

Pick the fastener by base material and load.

Anchor	Base	Use
Wedge	Solid concrete	Heavy/high-load
Drop-in	Concrete	Flush, all-thread hangs from it
Sleeve	Concrete/block/brick	Medium in masonry
PAT pin	Concrete/block/steel	Fast light-duty
Beam clamp	Structural steel	No drilling steel

Securing & supporting (NEC 2026 300.13): "Raceways, cable assemblies, boxes, cabinets, and fittings shall be securely fastened in place." A raceway may **not** support other raceways, cables, or equipment. **300.13(B)(1):** "Wiring shall not be secured to or supported by the ceiling grid system, including the ceiling support wires." If you hang from independent support wires above a lay-in ceiling, they must be marked by color or tag and secured at both ends. (Older lessons and older electricians call this rule 300.11. In the 2026 code 300.11 is now "Raceways in Wet Locations Above Grade.")

Part E — mistakes to avoid

- Spring nuts not turned. The grooves must engage the channel lips or the nut walks under load.
- Tie-wiring to the ceiling grid wires. Illegal and it fails inspection every time.
- One clamp carrying ten conduits. Do the load check before you hang, not after.
- Oiling the bolts. The torque table is for dry threads.

Part E — inspection

- Rods plumb, jam-nutted at the top, nut and washer above and below the channel.
- Channel level, ends capped, no raw burrs.
- Every clamp bolt torqued. Every spring nut engaged.
- Hanger spacing at or under 10 feet for EMT, with a hanger within 3 feet of every box.
- Nothing hung from another raceway or from ceiling grid wires.

Part F — Working Space: Lay It Out Right

Working space is the clear floor area in front of a panel or switchboard where someone will stand to work on it live. The code sets a depth, a width, and a height, and it also reserves the space above the gear. Lay this out with chalk **before** the duct, piping, and sprinkler trades arrive, because once their work is in, moving it costs money.

NEC 2026 110.26 — working space

- **Depth (Table 110.26(A)(1)).** 0 to 150 V to ground: 3 ft in every condition. 151 to 600 V to ground: 3 ft (Condition 1), **3½ ft** (Condition 2), **4 ft** (Condition 3). 601 to 1000 V: 3, 4, and 5 ft.
- **The conditions.** Condition 1: nothing grounded across from the gear, or live parts on both sides but guarded. Condition 2: a grounded surface across from the gear. "Concrete, brick, or tile walls shall be considered as grounded." Condition 3: exposed live parts on both sides of the space.
- **Width:** "the width of the equipment or 762 mm (30 in.), whichever is greater." Doors and hinged panels must open at least **90 degrees**.
- **Height:** floor to **2.0 m (6½ ft)** or the height of the equipment, whichever is greater.
- **Dedicated space (110.26(E)(1)(a)):** the footprint of the gear, floor to 6 ft above the equipment or to the structural ceiling, whichever is lower. "No piping, ducts, leak protection apparatus, or other equipment foreign to the electrical installation" may be in it. A drop ceiling may pass through it, because a drop ceiling is not a structural ceiling.
- **Other rules:** the working space "shall not be used for storage" (110.26(B)). Gear rated 1200 A or more and over 6 ft wide needs an entrance at each end of the space (110.26(C)(2)). Personnel doors within 25 ft of gear rated 800 A or more must open outward with panic hardware (110.26(C)(3)). The space needs lighting that is not controlled by an automatic-only means (110.26(D)).

NEC 2026 110.3(B): listed equipment installed and used per its listing and the manufacturer's instructions. The instruction sheet is enforceable, whether it came on paper or as a QR code.

Worked layout

You are setting a 277/480 V panelboard, 20 inches wide, on a wall with a concrete block wall facing it. Voltage to ground is 277 V, so you are in the 151 to 600 V row. A concrete wall across from the gear is a grounded surface, so this is **Condition 2**. The space is **42 inches deep** (3½ ft), **30 inches wide** (30 beats 20), and **6½ ft high**. The dedicated zone runs the panel's 20-inch footprint from the floor to 6 ft above the top of the can. Chalk the rectangle on the floor and tape the zone on the wall. If a duct is drawn through that zone on the mechanical sheets, it is an RFI, not a shrug.

Part F — mistakes to avoid

- Measuring working space from the wall instead of from the face of the gear.
- Treating a block wall as "nothing there." Concrete, brick, and tile are grounded surfaces by definition.
- Letting the mechanical trade run a duct or a sprinkler main over the panel. The 6-foot zone above belongs to you.

- Using the space in front of the panel for material storage during construction. It is a habit that follows the building into service.

Part F — inspection

- Depth, width, and height chalked and checked with a tape before other trades rough in.
- Doors open 90 degrees with nothing in the swing.
- Nothing foreign in the dedicated zone above the gear.
- Arc-flash label (NEC 2026 110.16) and fault-current marking (408.6) present on the gear before turnover.

Hands-On Field Exercise

- Read a drawing set and its spec book: find the revision, find the scale, count devices by symbol, trace one panel-schedule row from the plan to the panel, and find one requirement that is in the spec but not on the drawings.
- Scale a conduit run with an architect's scale and add the vertical drops the plan hides.
- Punch a knockout with a hydraulic punch and check the hole against the size table.
- Set a **wedge** anchor and a **drop-in** anchor with a torque wrench and a setting tool. Clean the hole each time and look for the four set marks on the drop-in.
- Build a short **trapeze**, clamp two EMTs to it, and do the load check on paper.
- Lay out a panel location to **110.26** depth, width, height, and dedicated space with chalk.

Sources used in this module (public documents)

- NFPA 70, National Electrical Code 2026, free read-only access: nfpa.org/codes-and-standards/nfpa-70-standard-development/70 — sections 110.3(B), 110.12, 110.13, 110.14(D), 110.16, 110.26, 300.13, 358.30, 408.4, 408.6.
- NAVEDTRA 14026, Construction Electrician Basic, Chapter 2 (Drawings and Specifications): constructionknowledge.net/public_domain_documents/Div_16_Electrical/
- BCcampus Trades Access Common Core, D-3 Read Drawings and Specifications and C-2 Describe Common Power Tools: collection.bccampus.ca
- Unistrut General Engineering Catalog No. 17A (load tables, torque, beam clamps, raceway weights).
- OSHA 29 CFR 1926.302 Power-operated hand tools; OSHA Fact Sheet FS-3630, Control of Silica Dust in Construction (29 CFR 1926.1153 Table 1): [osha.gov](https://www.osha.gov)
- Greenlee Quick Draw Hydraulic Punch Driver instruction manual; Milwaukee SDS Plus rotary hammer and portable band saw operator's manuals; RIDGID 700 Power Drive operator's manual.
- DEWALT Power-Stud+ SD1 technical page (ICC-ES ESR-2818); Hilti Kwik Bolt TZ2 product data (ICC-ES ESR-4266); Simpson Strong-Tie Drop-In (DIAB) installation instructions; Hilti DX operator training (hilti.com).

Next: Module 1.2 — Raceway & Conduit Systems.