



PRODUCTION PROCESS FOR ASTM A416 LOW-RELAXATION PC STRAND – TECHNICAL DATA

Raw Material

AISI/SAE 1080 Carbon Steel Hot-rolled Wire Rod with alloys to achieve desired tensile and ductility properties. Normally, the wire rods used to make PC Strand are between 3/8" – 1/2" in diameter. Typical wire rod coils are 1.6 NT – 2.8 NT, depending on the wire rod manufacturer's process.

Production Process

1. Wire Rod Descaling & Precoating

- a. All wire rod (raw material) must be de-scaled to remove the mill scale (iron oxides) present on the steel surface. This descaling process is done either chemically (most common) or mechanically.
- b. After the mill scale has been removed, the wire rod is then coated with a textured carrier coating that promotes lubricant adherence during the subsequent wire drawing process. The most commonly used carrier coating is Zinc Phosphate ($ZnPO_4$) but other coatings are sometimes used (specialized polymers, borax, lime, etc.).

2. Wire Drawing

- a. The wire rod is drawn through a series of 8 or 9 carbide dies to achieve the desired mechanical properties. This is a cold-working process; therefore the wire drawing practices are tightly controlled to prevent premature die wear or damage to the steel wire.
- b. During wire drawing, the wire rod and wire are drawn through a lubricant box just before the drawing die to introduce lubricant to the wire surface. The lubricants are dry and granular. The chemical composition of the lubricants is normally sodium stearate or calcium stearate plus other additives. The lubricant forms a thin barrier between the steel wire surface and the carbide drawing die to prevent premature die wear/failure and to control the frictional heat on the wire surface.
- c. In PC Strand wire drawing, the wire rod cross-sectional area is reduced by ~85% when comparing the finished wire area to the area of the original wire rod.
- d. The tensile strength of the wire rod is normally ~172 ksi. After the wire drawing process, the wire tensile strength is >270 ksi; therefore the tensile gain is >50% due to work hardening.
- e. In order to achieve the desired lengths of finished wire and to maintain operational efficiency, each new coil of wire rod is joined to the previous coil by a resistance butt-weld.
- f. The finished size of the wire is tightly controlled to within an approximate range of +/-0.002" (0.05mm). The center wire diameter is greater than the outer wire diameter as specified in ASTM A416.

3. Stranding

- a. Once seven (7) spools of wire are produced, six (6) outer wires and one (1) center wire, they are loaded into the stranding machine.
- b. The stranding machine pulls the wire off of the spools while maintaining a specified rate of wrapping. This rate controls the lay of the strand to comply with ASTM A416 specifications.
- c. After the wires have been wound into strand, the strand is subjected to a thermo-mechanical process in which the strand is continuously heated to ~700°F (375°C) +/- 80°F (25°C) while under tension at ~40% of the minimum ultimate tensile strength of the strand. This process acts to relieve the residual wire drawing stresses, permanently elongate the strand, increase the yield strength and reduce relaxation losses. This combination of factors gives the strand a very consistent modulus of elasticity up to and exceeding 80% of the strand's ultimate strength.
- d. Before the strand is wound back into a coil, it is quenched in a water bath to freeze the steel in the permanently elongated condition and to rinse residual drawing lubricants from the strand surface.

- e. The strand is produced in varying quantities depending on the capacity of the stranding equipment and the size of the wire drawing spools. Typical quantities of the master coil (one production run) are 20 – 27 net tons.

4. Rewinding & Packaging

- a. After one master coil (one production run) of strand is produced in the strander, the master coil is rewound into the desired package size, typically 3.0 – 3.5 net tons.
- b. Sampling for compliance to ASTM A416 is done at this stage of production.
- c. After the strand is wound, it is banded and removed from the machine. At this point or at time of shipment, the finished coil of strand is packaged according to customer specifications.

5. Inspection

- a. Each 20 – 27 net ton master coil is tested for compliance to ASTM A416. These tests include:
 - i. Ultimate Tensile Strength (UTS)
 - ii. Total Elongation at UTS
 - iii. Yield Point at 1% Extension Under Load (EUL)
 - iv. Strand Diameter
 - v. Minimum Diameter Difference between center wire and outer wire.
 - vi. Strand Lay (Pitch)
 - vii. Strand Area & Modulus of Elasticity are measured and reported.
- b. Relaxation testing is also performed after process changes and on an annual basis.

