Cold rolling is accomplished by processing steel strip through a series of tandem rolling mill stands. Each stand has vertically stacked rolls that are powered by huge motors to impart high compressive stresses into the strip. Hot-rolled, pickled coils are fed into the cold rolling mill from an entry-end reel and progressively reduced in thickness in each stand to achieve the final desired thickness as the strip exits the last stand. After the last stand, the strip is recoiled. At this point, the strip is highly cold-worked and not very useful for most applications. It needs to be annealed to soften the steel, and make it more formable.

Another method of cold reduction is through the use of a reversing mill. In this operation, the strip is passed back and forth between mandrels on each side of a single or two-stand mill. The strip is reduced in thickness on each pass until the final required thickness is attained. Typical percent cold reduction ranges from 60 to 80 percent; for example, reducing a hot rolled strip of 0.100-inch thick to a 0.030-inch thickness results in 70 percent cold reduction.

**Additional Processing Steps in the Manufacture of Cold Rolled Sheets**

As mentioned previously, the cold-reduced coil, as it exits from the cold mill, is very hard and possesses very limited applicability. It cannot be easily bent, it is very stiff and exhibits high amounts of springback when bent. Thus, for most applications, this steel must be annealed (heated to high temperatures) to soften it, and make it useful.

Annealing is accomplished by two primary methods. One is batch annealing and the other is continuous annealing. Batch annealing, as practiced within U. S. Steel, involves stacking full-size coils of cold-
reduced material onto 1 to 4 stools that comprise an annealing base. The stools are then covered with a protective heat-resistant cover which allows the coils to be maintained within a protective (non-oxidizing) atmosphere. A large annealing furnace is then placed over the stools to subject the coils to a closely prescribed annealing (heating) cycle.

During the heating process, the steel becomes very soft and can subsequently be used for a multitude of applications. Continuous annealing involves passing the steel through a high temperature furnace in the form of a continuous ribbon. That is, the coil is fed from a payoff reel into the furnace. It reaches a high temperature during its passage through the furnace. The steel sheet is then cooled, and recoiled at the exit end of the furnace.

Whether the steel is batch annealed or continuous annealed, the specific properties of the steel sheet, after annealing, depends on the steel chemistry, the temperatures used during hot rolling, the amount of cold reduction, and the annealing cycle (time and temperature).

Whichever method of annealing is used, the steel is maintained under a protective (non-oxidizing) atmosphere using hydrogen and nitrogen to prevent oxidizing the steel while it is at high temperature. In addition to preventing oxidation, the protective atmosphere is designed to clean the steel by breaking down the oils that are present after cold rolling and entraining the oil vapors in the hydrogen/nitrogen gases that are passed through the furnace.

**Temper Rolling**

Following annealing, the steel coil is most often temper rolled by passing it through a set of rolls that appear similar to the rolls used during cold rolling. In fact, temper rolling does impart a small amount of cold reduction, typically between 0.25 and 1.0 percent.

Various things are accomplished during temper rolling:
• The tendency for discontinuous yielding, fluting/Lüders lines, is removed.

• The surface finish is controlled to provide a range of finishes from rough matte to a luster finish.

• The flatness is improved, and the sheet is oiled with a rust preventative oil.