Pipe
About Nucor Skyline

Nucor Skyline, your true project partner

We are a premier steel foundation manufacturer and supplier, serving the North American market. Skyline Steel, LLC (doing business as Nucor Skyline) is a Nucor company, the largest producer of steel in the United States, and this relationship strengthens our ability to service our customers and the industry.

- Over 20 Sales Offices in North America
- Manufacturing, Coating and Fabrication Expertise
- Dozens of Stocking Locations
- Exclusive Engineering Support

Our flagship products include an unparalleled assortment of:

- H-Piles
- Steel Sheet Piles
- Pipe Piles
- Geostructural Products
- Wide Flange and other Structural Sections
- Piling Accessories

Nucor Skyline’s knowledgeable engineering team works with owners, engineers, and contractors long before ground is broken. To ensure seamless project coordination and completion, our engineers propose solutions throughout all aspects of design, material selection, installation, and construction sequencing. Skyline’s engineering support is extended even further to include provision of onsite assistance after a project has started. Our relationships extends beyond sales – we are your true project partner.
Nucor Skyline has vast experience in manufacturing pipe piling products for the North American steel foundation industry. With our strategically located manufacturing plants, we can service the needs of any public or private project throughout the region.

- Wide Range of Diameters, Thicknesses and Lengths
  - ERW Straight Seam: From 2-3/8” to 24” OD; Up to 0.625” Thickness
  - Spiralweld: Up to 120” OD; 1” Thickness
  - Rolled & Welded: Up to 204” OD; 2.25” Thickness
  - Micropile: 5.5” – 20” OD; Prime and Secondary

- Custom Lengths and Thicknesses

- Custom Fabrication Services

- Spiralweld Pipe Accepted by DOTs in Seismically Active Areas

- In-house and Third-Party Testing Capabilities

- Made in the USA

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ERW Pipe

Please inquire about additional diameters and thicknesses.

**Formulas**

<table>
<thead>
<tr>
<th>Cross Section</th>
<th>Moment of Inertia</th>
<th>Section Modulus</th>
<th>Radius of Gyration</th>
</tr>
</thead>
<tbody>
<tr>
<td>$A$</td>
<td>$I_{xx}$</td>
<td>$S_{xx}$</td>
<td>$r_{xx}$</td>
</tr>
<tr>
<td>($n/4$) * ($D_o^2 - D_i^2$)</td>
<td>$n (D_o^4 - D_i^4)$</td>
<td>$m (D_o^4 - D_i^4)$</td>
<td>$\sqrt{(D_o^2 + D_i^2)}$</td>
</tr>
</tbody>
</table>

Maximum Rolled Lengths***

<table>
<thead>
<tr>
<th>Outside Diameter ($D_o$)</th>
<th>Maximum Rolled Lengths</th>
</tr>
</thead>
<tbody>
<tr>
<td>80 feet (24.4 m)</td>
<td>1890 lbs (8510 kg)</td>
</tr>
</tbody>
</table>

*** LARGER LENGTHS MAY BE POSSIBLE UPON REQUEST.

Nucor Skyline: Pipe
Manufacturing Process

Electric Resistance Welded (ERW) pipe is manufactured by cold forming a flat steel strip into a rounded tube by passing it through a series of forming rollers to obtain a longitudinal seam. The two edges are then simultaneously heated with a high frequency current and squeezed together to produce a bond. The longitudinal ERW seam does not require filler metal while impurities in the heat affected zone are extruded during the welding process.
### Spiralweld Pipe

#### Formulas

- Cross Section Area: $A = n(D_d^2 - D_t^2)$
- Moment of Inertia: $I_x = \frac{n(D_d^2 + D_t^2)}{64}$
- Section Modulus: $S_x = \frac{n(D_d^2 - D_t^2)}{32D_t}$
- Radius of Gyration: $r_g = \sqrt{\frac{D_d^2 + D_t^2}{16}}$

#### Pipelengths

- Spiralweld: 130 feet (39.6 m)

**Please inquire about additional diameters and thicknesses.**
Manufacturing Process

The spiralweld manufacturing process is one of the most cost effective ways to produce steel pipe. Spiralweld pipe is manufactured from steel coil and typically utilizes a helical double submerged arc weld (DSAW). The mill setup offers a varying degree of flexibility, allowing for production of a wide range of pipe diameters and wall thicknesses. As a result, Nucor Skyline is able to offer spiralweld products for structural and non-structural applications.

**UNCOILING**
Upon receipt of the coil, it is placed on a horizontal uncoiler mandrel and fed into the straightener.

**FLATTENING**
The strip of coil is introduced into the flattener through a roll stand and the coil set is removed.

**JOINING OF THE COIL ENDS**
As the coil continues to move through the straightener, the leading and trailing edges of the strip are trimmed in preparation for butt welding – coil to coil.

**EDGE MILLING**
The edges of the coil are trimmed with carbide teeth to prepare for welding.

**PIPE SPIRALING**
The strip of coil enters the three roll apparatus composed of lead, buttress and mandrel roll sets. At this stage, the coil starts to form the spiral shape that will then become pipe.

**PIPE WELDING**
The welding system welds the pipe, first along the inside diameter and then along the outside diameter, using a submerged arc welding process.

**QUALITY CONTROL**
Once the welding is complete, the finished pipe is visually inspected by Quality Control (QC) and, if required, Ultrasonic (UT) testing is performed to ensure the weld is defect-free.

**PIPE CUT-OFF**
Once the pipe reaches the desired length, the cut-off machine is engaged. Traveling with the pipe, a plasma torch provides the cut-off of the finished pipe. Specific end props, such as bevel or square cut ends, can be requested to allow for simpler splicing in the field.
### Rolled & Welded Pipe

**Approximate Values**

- **Pipe Weight (lbs/ft) = 10.691(D_o - t)**
- **D_o (in) - outside diameter**
- **t (in) - thickness of pipe**
- **Pipe Weight (kg/m) = 0.02471(D_o - t)**
- **D_o (mm) - outside diameter**
- **t (mm) - thickness of pipe**

<table>
<thead>
<tr>
<th>Outside Diameter (D_o) in</th>
<th>Wall Thickness (t) in</th>
<th>Weight (lbs/ft)</th>
<th>Coating Area ft/ft</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.250</td>
<td>0.375</td>
<td>0.383</td>
<td>0.438</td>
</tr>
<tr>
<td>0.525</td>
<td>0.625</td>
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<td>0.750</td>
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<td>1.250</td>
<td>1.750</td>
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<tr>
<td>6.000</td>
<td>7.500</td>
<td>7.500</td>
<td>9.000</td>
</tr>
</tbody>
</table>

**Formulas**

- **Cross Section Area** \( A \)
- **Moment of Inertia** \( I_{xx} \)
- **Gyration Radius** \( r_{xx} \)

\[
A = \frac{\pi}{4} (D_o^2 - t^2)
\]
\[
I_{xx} = \frac{\pi}{64} (D_o^4 - t^4)
\]
\[
r_{xx} = \sqrt[4]{\frac{I_{xx}}{A}}
\]

**Maximum Rolled Lengths**

<table>
<thead>
<tr>
<th>Outside Diameter (D_o) in</th>
<th>Wall Thickness (t) in</th>
<th>Rollable Length</th>
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<td>72</td>
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<td>78</td>
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<tr>
<td>168</td>
<td>5.500</td>
<td>1797.15</td>
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</table>

**Please call for weight.**
Manufacturing Process

Rolled & welded pipe is one of the oldest processes of manufacturing steel pipe. This manufacturing process is utilized when the pipe wall thickness exceeds the capabilities of the ERW and spiralweld manufacturing processes.

**PLATE**
The raw material – pieces of flat steel plate – is received into our manufacturing plant.

**CUTTING**
A single flat sheet of steel plate is cut on a burning table using plasma or cutting gases. This plate is cut according to the required width and length for each individual can that will form the final product.

**WELDING**
The can is then staged for longitudinal welding (Long Seam). During this process, the seam between the two plates is welded on both the inside and outside.

**BEVELING**
After the plate is cut, it is transferred to the beveling station where the plate edges are beveled and prepped for welding.

**QUALITY CONTROL**
Once the welding is complete, the finished pipe is visually inspected by Quality Control (QC) and, if required, Ultrasonic (UT) testing is performed to ensure the weld is defect-free.

**BENDING**
After beveling, the plate is transferred to the bending rolls. Nucor Skyline uses a 4-roll system to produce a true cylinder, also referred to as a can.

**CIRCUMFERENTIAL WELDING**
During this last step of the manufacturing process, cans are fit together using the submerged arc weld (SAW) process, according to customer requirements for specific lengths.

**FINISHED PIPE**
The finished pipe is then removed and ready for delivery.
### Prime Domestic Casing

<table>
<thead>
<tr>
<th>Outside Diameter</th>
<th>Thickness</th>
<th>Inside Diameter</th>
<th>Weight</th>
<th>Cross sectional Area</th>
<th>Total Area of Shaft</th>
<th>Internal Volume</th>
<th>External Surface Area</th>
<th>Moment of Inertia</th>
<th>Section Modulus</th>
<th>Coating Area</th>
</tr>
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<tbody>
<tr>
<td>in</td>
<td>in</td>
<td>in</td>
<td>lbs/ft</td>
<td>ft²/ft</td>
<td>ft²/ft</td>
<td>ft³/ft</td>
<td>ft²/ft</td>
<td>ft³</td>
<td>ft²/ft</td>
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</tr>
<tr>
<td>9.625</td>
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<td>72.76</td>
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<tr>
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<td>54.79</td>
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<td>731.94</td>
<td>149.90</td>
<td>4.19</td>
</tr>
</tbody>
</table>

Contact your Nucor Skyline representative for additional diameters, lengths, and starter details.

Nucor Skyline can provide threaded micropile casing up to 40 feet.
<table>
<thead>
<tr>
<th>Outside Diameter</th>
<th>Thickness</th>
<th>Inside Diameter</th>
<th>Weight</th>
<th>Cross Sectional Area</th>
<th>Total Area of Shaft</th>
<th>Internal Volume</th>
<th>External Surface Area</th>
<th>Moment of Inertia</th>
<th>Section Modulus</th>
<th>Coating Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.5 mm</td>
<td>0.415</td>
<td>4.670</td>
<td>22.56</td>
<td>6.63</td>
<td>23.76</td>
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<td>21.57</td>
<td>784</td>
<td>1.44</td>
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<td>181.28</td>
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Contact your Nucor Skyline representative for additional diameters, lengths, and start details.
Nucor Skyline pipe is manufactured according to the following pipe specifications which provide guidance on manufacturing processes, dimensional requirements and tolerances.

## Available Steel Pipe Grades

<table>
<thead>
<tr>
<th>ASTM</th>
<th>Yield Strength</th>
<th>Manufacturing Process</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ksi</td>
<td>ERW</td>
</tr>
<tr>
<td>A 139 Grade A</td>
<td>30</td>
<td>✔</td>
</tr>
<tr>
<td>A 139 Grade B</td>
<td>35</td>
<td>✔</td>
</tr>
<tr>
<td>A 139 Grade C</td>
<td>42</td>
<td>✔</td>
</tr>
<tr>
<td>A 139 Grade D</td>
<td>46</td>
<td>✔</td>
</tr>
<tr>
<td>A 139 Grade E</td>
<td>52</td>
<td>✔</td>
</tr>
<tr>
<td>A 252 Grade 1</td>
<td>30</td>
<td>✔</td>
</tr>
<tr>
<td>A 252 Grade 2</td>
<td>35</td>
<td>✔</td>
</tr>
<tr>
<td>A 252 Grade 3</td>
<td>45</td>
<td>✔</td>
</tr>
<tr>
<td>A 252 Grade 3 (Mod)</td>
<td>50</td>
<td>✔</td>
</tr>
<tr>
<td>A 252 Grade 3 (Mod)</td>
<td>60 - 80*</td>
<td>✔</td>
</tr>
<tr>
<td>A 500 Grade B</td>
<td>42</td>
<td>✔</td>
</tr>
<tr>
<td>A 500 Grade C</td>
<td>46</td>
<td>✔</td>
</tr>
<tr>
<td>A 1085</td>
<td>50 - 70</td>
<td>✔</td>
</tr>
</tbody>
</table>

Highlighted fields represent the most commonly used and readily available steel grades. Additional grades available upon request. Please call with any questions or special requests. *Availability is dependent on pipe diameter and thickness.

### ASTM A252

This specification was written specifically for steel pipe piles and is the most common specification for this application. “This specification covers nominal (average) wall steel pipe piles of cylindrical shape and applies to pipe piles in which the steel cylinder acts as a permanent load-carrying member, or as a shell to form cast-in-place concrete piles.... The piles shall be made by the seamless, electric resistance welded, flash welded, or fusion welded process. The seams of welded pipe piles shall be longitudinal, helical-butt, or helical-lap.”

### ASTM A139/A139M

“This specification covers five grades of electric-fusion (arc)-welded straight-seam or helical-seam steel pipe. Pipe of NPS 4 and larger with nominal (average) wall thickness of 1.0 in. [25.4mm] and less are covered. Listing of standardized dimensions are for reference. The grades of steel are pipe mill grades having mechanical properties which differ from standard plate grades. The pipe is intended for conveying liquid, gas or vapor.”

### ASTM A500/A500M

“This specification covers cold-formed welded and seam-less carbon steel round, square, rectangular, or special shape structural tubing for welded, riveted, or bolted construction of bridges and buildings, and for general structural purposes. This tubing is produced in both welded and seamless sizes with a periphery of 88 in. [2235 mm] or less, and a specified wall thickness of 0.875 in. [22 mm] or less. Grade D requires heat treatment.”

### AWWA C200†

“This standard describes electrically but-welded straight-seam or spiral-seam pipe and seamless pipe, 6 in. (150mm) in nominal diameter and larger, for the transmission and distribution of water or for use in other water system facilities.”

Source: ASTM International

† Source: American Water Works Association (AWWA)
The pipe specifications have limited chemical and mechanical property requirements of the steel plate, sheet, or coil the pipe is manufactured from. The following ASTM requirements address these properties in more detail and may be specified in addition to the pipe grades if the design professional deems them to be necessary.

<table>
<thead>
<tr>
<th>ASTM</th>
<th>Yield Strength</th>
<th>Manufacturing Process</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ksi</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MPa</td>
<td>ERW</td>
</tr>
<tr>
<td>A 36</td>
<td>36 250</td>
<td>✔</td>
</tr>
<tr>
<td>A 516 Grade 55</td>
<td>30 205</td>
<td>✔</td>
</tr>
<tr>
<td>A 516 Grade 60</td>
<td>32 220</td>
<td>✔</td>
</tr>
<tr>
<td>A 516 Grade 65</td>
<td>35 240</td>
<td>✔</td>
</tr>
<tr>
<td>A 516 Grade 70</td>
<td>38 260</td>
<td>✔</td>
</tr>
<tr>
<td>A 572 Grade 42</td>
<td>42 290</td>
<td>✔</td>
</tr>
<tr>
<td>A 572 Grade 50</td>
<td>50 345</td>
<td>✔ ✔ ✔</td>
</tr>
<tr>
<td>A 572 Grade 55</td>
<td>55 380</td>
<td>✔ ✔ ✔</td>
</tr>
<tr>
<td>A 572 Grade 60</td>
<td>60 415</td>
<td>✔ ✔ ✔</td>
</tr>
<tr>
<td>A 572 Grade 65</td>
<td>65 450</td>
<td>✔ ✔ ✔</td>
</tr>
<tr>
<td>A 588</td>
<td>50 345</td>
<td>✔ ✔ ✔</td>
</tr>
<tr>
<td>A 690</td>
<td>50 345</td>
<td>✔ ✔ ✔</td>
</tr>
<tr>
<td>A 709</td>
<td>50 345</td>
<td>✔ ✔ ✔</td>
</tr>
<tr>
<td>A 1011/1018</td>
<td>50 345</td>
<td>✔ ✔ ✔</td>
</tr>
</tbody>
</table>

| Abrasion Resistant | Brinell Hardness – 190 | ✔ | ✔ |

Highlighted fields represent the most commonly used and readily available steel grades. Additional grades available upon request. Please call with any questions or special requests.

**ASTM A1011/A1011M**

“This specification covers hot-rolled, carbon, structural, high-strength low-alloy, high-strength low-alloy with improved formability, and ultra-high strength steel sheet and strip, in coils and cut lengths.” Maximum coil thickness for this specification is 0.23 in.

**ASTM A1018/A1018M**

“This specification covers hot-rolled, heavy-thickness coils beyond the size limits of Specification A1011/A1011M.”  
Coil thickness is from 0.23 in. to 1.000 in.

**ASTM A572/A572M**

“This specification covers five grades of high-strength low-alloy structural steel shapes, plates, sheet piling, and bars. Grades 42 [290], 50 [345], and 55 [380] are intended for riveted, bolted, or welded structures. Grades 60 [415] and 65 [450] are intended for riveted or bolted construction of bridges, or for riveted, bolted, or welded construction in other applications.”

**ASTM A690/A690M**

“This specification covers high-strength low-alloy nickel, copper, phosphorus steel H-piles and sheet piling of structural quality for use in the construction of dock walls, sea walls, bulkheads, excavations, and like applications in marine environments.”

**ASTM A709/A709M**

“This specification covers carbon and high-strength low-alloy steel structural shapes, plates, and bars, quenched and tempered alloy steel, and stainless steel for structural plates intended for use in bridges.”

**ASTM A913/A913M**

“This specification covers high-strength low-alloy structural steel shapes in Grades 50 [345], 60 [415], 65 [450] and 70 [485], produced by the quenching and self-tempering process (QST). The shapes are intended for riveted, bolted or welded construction of bridges, buildings and other structures.”
Nucor Skyline pipe mills are capable of a wide variety of fabrication services. Please do not hesitate to call for any fabrication needs.
Certifications
All weld systems are qualified and certified to AWS D1.1. Our mills are quality certified by the Steel Plate Fabricators Association (SPFA). Additionally, each plant is staffed with Certified Weld Inspectors to assure a quality weld in every pipe.

Qualifications
• American Welding Society (AWS)
  – AWS Section 3
  – AWS Section 4 / ASME Section IX
  – AWS Section 4 WPS – Weld Procedure Specification
  – AWS Section 4 PQR - Procedure Qualification Test Record
• Steel Plate Fabricators Association (SPFA) Quality Program
  • Pre-qualified
  • Qualified by Test
  • Weld Quality Control Plan (WQCP)

Quality Assurance
• Non-destructive Testing (NDT)
  – Visual Inspection (VI)
  – Inline Ultrasonic Testing (UT)
  – Magnetic Particle Testing (MT)
  – Radiographic Testing / X-ray (RT)
  – Hydrostatic Testing
  – Dye Penetration Testing (PT)
  – Macro Etch Testing
• Destructive Testing
  – Tensile Strength Test: Base Metal/Across the Weld
  – Bend Test: Root, Face, Side
  – Charpy Impact Test (CVN): Base Metal, Weld Metal, Heat Affected Zone (HAZ)
• Custom Tests: Hoop Stresses, etc.
• Third-party Inspection
  • UT, RT, VI, Etch and Weld Observations
  • Procedure QA/QC Review

Manufacturing & Stocking Locations
Nucor Skyline has several manufacturing locations and dozens of stocking locations throughout North America. Our proximity to the water, coupled with our extensive distribution network allows for fast and efficient delivery via truck, rail, or barge.
Increasing Durability

The durability of steel is a very important part of the design process. Although most steel buried in the ground does not need any protection from corrosion, there are cases where it is necessary. As a steel section corrodes, it loses strength and the designer must ensure that the section can carry its intended loads at the end of the design life. Determining the design life of a pipe is a straightforward process using the section properties, corrosion rate and any corrosion protection measures.

The corrosion rate of a particular environment is critical when calculating the design life. Different soils and types of water will have varying influences on the rate of loss. There are tables on the following page which give average values for the loss, in thickness, in soil and water. These values were gathered from measurements taken from actual jobsites. If there is historical information available locally, that information should be used instead. The engineer should determine the rate for both the inside and outside of the pipe. It should be noted that soil resistivity is sometimes used to determine the corrosiveness of a soil sample. This method for determining the corrosion rate does not take into account the level of oxygen in the soil and should not be used. The steel will not corrode without oxygen or extremely acidic soil.

Once the rate of loss has been determined, the reduced section properties and design life can be calculated. Increasing the design life of a steel pipe can be done in a variety of ways. Most of these will fall under three main categories; over design, corrosion rate reduction and steel protection.

Over design is most often done by increasing the thickness, diameter or steel grade. All of these methods will reduce the stress in the pipe. Although increasing the yield strength will not change the corrosion rate, it allows the pipe to carry the same loads with a smaller thickness.

Reducing the corrosion rate can be done with specialty steels (A690 and A588) or with cathodic protection. ASTM A690 reduces the corrosion rate for steel in the splash zone in salt water. ASTM A588 is an atmospheric corrosion resistant steel. Cathodic protection involves either sacrificial anodes or an impressed current system. Both systems create a battery cell to prevent the loss of material from the exposed steel. Galvanization is commonly used for atmospheric protection, but should not be used in the permanent immersion, tidal, or splash zones.

Protecting the steel through coating or painting is very common. Coating is relatively inexpensive and works well on exposed steel, but it can be damaged and once the steel is exposed it will corrode at the normal rate. The steel can also be protected using concrete encasement, jackets, or sleeves.

Calculating the Design Life of a Pipe Pile

1. Design Pipe Pile
2. Determine Internal and External Corrosion Rates
3. Determine Maximum Allowable Stress
4. Calculate Reduced Diameter and Thickness that will Result in Maximum Allowable Stress
5. Calculate Section Loss
6. Calculate the Design Life Using Corrosion Rate and Section Loss
7. If the Design Life is Too Low, Choose from One of the Methods Below and Re-Calculate the Design Life

Over Design
- Increase Diameter
- Increase Thickness
- Increase Yield Strength
- Splice Thicker Pipe Section into Pile in Area of High Stress or High Corrosion

Corrosion Reduction
- A690 Steel — Salt Water Splash Zone Resistant Steel
- A588 Steel — Atmospheric Corrosion Resistant Steel
- Cathodic Protection
- Galvanization

Barrier
- Coating
- Concrete Encasement
- Sleeves or Jackets
# Increasing Durability

## Loss of Thickness Due to Corrosion for Piles in Soil with or without Groundwater

<table>
<thead>
<tr>
<th>Required design working life</th>
<th>5 Years</th>
<th>25 Years</th>
<th>50 Years</th>
<th>75 Years</th>
<th>100 Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>in / mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Undisturbed natural soils (sand, clay, schist, …)</td>
<td>0.000</td>
<td>0.012</td>
<td>0.024</td>
<td>0.035</td>
<td>0.047</td>
</tr>
<tr>
<td></td>
<td>0.00</td>
<td>0.03</td>
<td>0.06</td>
<td>0.09</td>
<td>0.12</td>
</tr>
<tr>
<td>Polluted natural soils and industrial grounds</td>
<td>0.006</td>
<td>0.030</td>
<td>0.059</td>
<td>0.089</td>
<td>0.118</td>
</tr>
<tr>
<td></td>
<td>0.15</td>
<td>0.75</td>
<td>1.50</td>
<td>2.25</td>
<td>3.00</td>
</tr>
<tr>
<td>Aggressive natural soils (swamp, marsh, peat, …)</td>
<td>0.008</td>
<td>0.039</td>
<td>0.069</td>
<td>0.098</td>
<td>0.128</td>
</tr>
<tr>
<td></td>
<td>0.20</td>
<td>1.00</td>
<td>1.75</td>
<td>2.50</td>
<td>3.25</td>
</tr>
<tr>
<td>Non-compacted and non-aggressive fills (clay, schist, sand, silt, …)</td>
<td>0.007</td>
<td>0.028</td>
<td>0.047</td>
<td>0.067</td>
<td>0.087</td>
</tr>
<tr>
<td></td>
<td>0.18</td>
<td>0.70</td>
<td>1.20</td>
<td>1.70</td>
<td>2.20</td>
</tr>
<tr>
<td>Non-compacted and aggressive fills (ashes, slag, …)</td>
<td>0.020</td>
<td>0.079</td>
<td>0.128</td>
<td>0.177</td>
<td>0.226</td>
</tr>
<tr>
<td></td>
<td>0.50</td>
<td>2.00</td>
<td>3.25</td>
<td>4.50</td>
<td>5.75</td>
</tr>
</tbody>
</table>

Notes:
1. Corrosion rates in compacted fills are lower than those in non-compacted ones. In compacted fills, the figures in the table should be divided by two.
2. The values given are only for guidance. Local conditions should be considered because they may affect the actual corrosion rate, which can be lower or higher than the average value given in the table.
3. The values given for 5 and 25 years are based on measurements, whereas the other values are extrapolated.

## Loss of Thickness Due to Corrosion for Piles in Fresh Water or in Sea Water

<table>
<thead>
<tr>
<th>Required design working life</th>
<th>5 Years</th>
<th>25 Years</th>
<th>50 Years</th>
<th>75 Years</th>
<th>100 Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>in / mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Common fresh water (river, ship canal, …) in the zone of high attack (water line)</td>
<td>0.006</td>
<td>0.022</td>
<td>0.035</td>
<td>0.045</td>
<td>0.055</td>
</tr>
<tr>
<td></td>
<td>0.15</td>
<td>0.55</td>
<td>0.90</td>
<td>1.15</td>
<td>1.40</td>
</tr>
<tr>
<td>Very polluted fresh water (sewage, industrial effluent, …) in the zone of high attack (water line)</td>
<td>0.012</td>
<td>0.051</td>
<td>0.091</td>
<td>0.130</td>
<td>0.169</td>
</tr>
<tr>
<td></td>
<td>0.30</td>
<td>1.30</td>
<td>2.30</td>
<td>3.30</td>
<td>4.30</td>
</tr>
<tr>
<td>Sea water in temperate climate in the zone of high attack (low water and splash zones)</td>
<td>0.022</td>
<td>0.074</td>
<td>0.148</td>
<td>0.220</td>
<td>0.295</td>
</tr>
<tr>
<td></td>
<td>0.55</td>
<td>1.90</td>
<td>3.75</td>
<td>5.60</td>
<td>7.50</td>
</tr>
<tr>
<td>Sea water in temperate climate in the zone of permanent immersion or in the intertidal zone</td>
<td>0.010</td>
<td>0.035</td>
<td>0.069</td>
<td>0.102</td>
<td>0.138</td>
</tr>
<tr>
<td></td>
<td>0.25</td>
<td>0.90</td>
<td>1.75</td>
<td>2.60</td>
<td>3.50</td>
</tr>
</tbody>
</table>

Notes:
1. The highest corrosion rate is usually found at the splash zone or at the low water level in tidal waters. However, in most cases, the highest stresses are in the permanent immersion zone.
2. The values given are only for guidance. Local conditions should be considered because they may affect the actual corrosion rate, which can be lower or higher than the average value given in the table.
3. The values given for 5 and 25 years are based on measurements, whereas the other values are extrapolated.
Since corrosion occurs at different rates depending on environment, one must design for each of these zones to determine which controls.

### Example Durability Calculation

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Pipe</th>
<th>Total Thickness Loss for 50 Years (in)</th>
<th>Max. Ultimate Bending Moment (K-ft/ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 5</td>
<td>Splash</td>
<td>Soil</td>
<td>Soil</td>
</tr>
<tr>
<td>10</td>
<td>Intertidal</td>
<td>Soil</td>
<td>Soil</td>
</tr>
<tr>
<td>15</td>
<td>Low Water</td>
<td>Soil</td>
<td>Soil</td>
</tr>
<tr>
<td>30</td>
<td>Immersion</td>
<td>Soil</td>
<td>Soil</td>
</tr>
<tr>
<td>60</td>
<td>Soil</td>
<td>Soil</td>
<td>Soil</td>
</tr>
</tbody>
</table>

**Corrosion Zones**
- Splash Zone
- Intertidal Zone
- Low Water Zone
- Immersion Zone
- Permanent Immersion Zone
- Buried Zone (Water Side)
- Buried Zone (Soil Side)

**Corrosion Rate Distribution**

**Typical Bending Moment Distribution**

**PIPE PROPERTIES**
- Diameter: 48 in
- Thickness: 0.5 in
- $F_y$: 50 ksi
- System Width: 49.25 in
- $S_x$: 10,857 in³

**Design Minimum Section Modulus**

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Design Minimum Section Modulus (in³/ft)</th>
<th>Min. Base Pipe Thickness (in)</th>
<th>Min. Thickness with Corrosion (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 5</td>
<td>6.0</td>
<td>0.014</td>
<td>0.124</td>
</tr>
<tr>
<td>10</td>
<td>120.0</td>
<td>0.277</td>
<td>0.347</td>
</tr>
<tr>
<td>15</td>
<td>144.0</td>
<td>0.333</td>
<td>0.443</td>
</tr>
<tr>
<td>30</td>
<td>156.0</td>
<td>0.362</td>
<td>0.432</td>
</tr>
<tr>
<td>60</td>
<td>96.0</td>
<td>0.221</td>
<td>0.269</td>
</tr>
</tbody>
</table>

From this, we can see that a 48”Ø x ½” Grade 50 pipe works.
Applications of Steel Pipe

Steel pipe offers mechanical and physical characteristics that make it one of the most versatile construction products available. As a structural element, steel pipe remains unrivaled when compared to alternate materials. The flexibility offered by the manufacturing process, quality control and low production cost positions steel pipe to be the new shape of steel in many industries.

Bearing Piles

Driven steel piles are a very efficient way to carry loads from structures and one of the most tested elements in the construction industry. Pipe piles offer several advantages over other types of driven piles. The circular shape of the pipe means there is no weak axis and the interior of the pile can be augered out to remove obstructions or socket the pipe into rock. The pipe interior can be filled with reinforced concrete to increase the pile strength. Pipes can be manufactured to extremely long lengths and are easy to handle due to the bending strength-to-weight ratio and lack of a weak axis. The manufacturing process of pipe allows for millions of different combinations of diameters, thicknesses and steel grades.

The manufacturing of spiralweld pipe is especially flexible for thicknesses of one inch or less. The multitude of different diameters, cut to length sections, and speed of production, makes spiralweld a very attractive product for bearing piles.

Rolled and welded pipe is ideal in applications requiring larger-sized pipe or small custom quantities. The Tappan Zee Bridge in New York used tens of thousands of tons of 48 inch diameter pipe. Pipe piles of this size have the capability of carrying thousands of tons of axial load and very high lateral loads.

Several accessories are available to assist the contractor during installation. Inside and outside cutting shoes or conical points are good for hard driving conditions. Points are also useful if the interior of the pipe needs to be kept free of soil. Three different types of splicing mechanisms are also available. Backing rings are used when the pile needs a full penetration butt weld. Drive on and weld fit splicers are used for projects where speed is important and the full bending loads do not need to be carried through the splice.

Drilled Shaft Casing

Pipe casing, temporary or permanent, is often required during the construction of drilled shafts. The casing is used to hold the hole open while the reinforcement cage and concrete are installed. The ability to inspect the bottom of the hole and the elimination of any variations in the diameter of the finished drilled shaft makes for a much higher quality, finished pile. In the “Standard Guidelines for the Design and Installation of Pile Foundations” ASCE recommends a factor of safety that is 38% higher on the structural capacity of drilled shafts without casing, than those with casing.
Combination Walls

Large diameter pipes have high bending strengths and are often used in combination sheet pile walls. The combination of large diameter pipe piles and steel sheet piles, which is often referred to as combi-walls, pipe-z walls or king pile walls, makes a very efficient system.

Like other combined walls, the king pile takes the majority of the load and the sheet pile transfers the load to the pipe and to the soil. In most cases, the sheet piles are between 60% and 80% of the length of the pipe pile. The king pile is almost always spiralweld pipe and the flexibility of the manufacturing process makes it easy for the designer to pinpoint the most efficient system. The design of the system assumes that there is no transfer of shear forces across the interlock. Therefore, the offset of the neutral axis, due to the sheet pile, is not taken into account.

\[
\text{Inertia}_{\text{system}} = \frac{(\text{Inertia}_{\text{pipe}} + \text{Inertia}_{\text{sheet pile}})}{(\text{System Width})}
\]

\[
\text{Modulus}_{\text{system}} = \frac{\text{Inertia}_{\text{system}}}{\text{Radius}_{\text{pipe}}}
\]

Pipe-Z walls are most often used for bulkhead walls for container, cruise and bulk terminals. In addition, they can be used for breakwaters or for high cantilevered retaining walls.

Structural Sections

The symmetry of pipe gives it the same bending strength, in any direction, which makes it an excellent product for the resistance of buckling. The stress required to buckle an axial member decreases with length. The radius of gyration has the opposite effect and increases the ability of a section to resist buckling. The W and HP sections have different radii of gyration \((r_x\) and \(r_y\)) for the X and Y axes, while remaining constant for a pipe. The end result is that a pipe can take much higher loads for long, unsupported lengths.

<table>
<thead>
<tr>
<th>Sample: 40 foot axially loaded section</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section</td>
</tr>
<tr>
<td>------------------------</td>
</tr>
<tr>
<td>W 12 x 53</td>
</tr>
<tr>
<td>HP 12 x 53</td>
</tr>
<tr>
<td>12” x 0.375*</td>
</tr>
</tbody>
</table>

The ability of pipes to resist buckling makes them ideally suited for the bracing of cofferdams and for large open structures.
Threaded Micropile Casing

Micropiles are small diameter, bored cast-in-place piles, with most of the applied load being resisted by steel reinforcement. They are constructed by drilling a borehole, often using casing, then placing steel reinforcement and grouting the hole. Micropiles have a wide range of uses and are becoming a more mainstream method of supporting and resupporting foundations, seismic retrofits, stabilization of slopes and even earth retention.

Micropiles are usually designed in small clusters or groups, with each typically carrying an equal amount of load. These piles may also be designed with a batter to improve the lateral rigidity of the group. They can be designed to resist a combination of compression, tension and lateral forces.

Micropiles are an ideal pile for complex sites where low vibration or low noise levels are required, or where limited access such as low headroom and drilling is difficult. Other site conditions that make micropiles attractive are: obstructions, large cobbles or boulders, nearby sensitive structures, karst topography or high groundwater conditions. The unique characteristics of micropiles make them a perfect solution when other deep foundation methods are not suitable.

Sign Poles, Towers, & Transmission Lines

Sign poles and towers are designed to resist large bending loads at the base of the structure. The availability and wide variety of thicknesses of large diameter pipe allow designers to pick the exact size needed to handle their particular project. Pipes can also be supplied in very long lengths, are simple to splice and easy to drill into hard ground. Reduction collars can facilitate the splicing of different diameters to make the design as efficient as possible.

Mining

Mining operations take place far beneath the surface in hazardous conditions. Personnel, equipment and air shafts are all integral parts of the mine. Vertical pipe sections are often used to construct the shafts. The large range of diameters and thicknesses make steel pipe the material of choice for various shaft requirements. Some of the shafts are hundreds, if not thousands, of feet long and pipe can be supplied in sections with the ends prepped for splicing. Bracing rings can be used to keep the pipe thicknesses to a minimum.
Jacked & Bored

The placement of underground utilities is often done with jacked and bored pipe. Sections of pipe are pushed through the ground with hydraulic jacks between excavations or under a hill. The next section of pipe is then spliced onto the first and the jacking continues. Once the jacking is complete, the pipe is cleaned out to install the utilities. This allows the placement of utilities without extensive excavation which can disrupt roads, railroads, homes and businesses.

Line Pipe

Welded steel pipe provides an effective method for transporting liquids, air, and gas. Steel pipe is pound per pound stronger than any other type of line pipe. Pipe can be designed to handle both the internal and external pressures of most applications. Welded steel pipe offers many advantages, such as: strength, economy and ease of installation. Nucor Skyline is SPFA certified and manufactures hydrostatically tested pipe in outside diameters ranging from 10¾” to 90”. Our production process utilizes a double submerged arc weld process in both spiralweld and rolled & welded pipe. Hydrostatically tested pipe lengths range from 30’ to 60’, wall thicknesses from 0.250” to 2.0” and are produced to one of the following industry standards: AWWA C200/ASTM A139/ASTM A134.