KUBOTA DUCTILE IRON PIPE

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KUBOTA’S HISTORY WITH DUCTILE IRON PIPE

History

1890  Established as a foundry. Started production of cast iron pipe for water supply.
1893  Started production of centrifugal cast iron pipe.
1897  Changed the corporate name from Oide Chuzo-jo (Oide Foundry) to Kubota Tekko-jo (Kubota Iron Works).
1917  Supplied cast iron pipes and valves to Indonesia, our first experience of export.
1930  Developed high-grade cast iron.
1941  Started production of centrifugal cast iron pipe.
1954  Started production of Ductile Iron pipe.
1957  Started production of centrifugal Ductile Iron pipe.
1971  Started production of the world's largest DN2600 pipe.
1982  Started production of the world’s longest 9-meter length pipe.
1985  Produced the world’s largest DN2900 pipe.
1990  Celebrated our 100th year in business. Changed the corporate name to KUBOTA Corporation.
2009  Started production of restrained joint pipe (TLH-type).
2012  Supplied Earthquake Resistant Ductile Iron Pipe (ERDIP) to the United States.
2014  Supplied a huge number of Ductile Iron pipe to Mega Reservoir Project in Qatar, one of the Middle East’s largest water supply project.

Keiyo Plant

Site area  
Main Plant 141,000m²
Marushima Factory 159,000m²
Amagasaki Plant 54,000m²

Employees 850

Production capacity
Pipe 20,000 ton / month
Fitting 550 ton / month

Main products
Pipe DN75 to DN2600
Fitting DN600 to DN2600

(As of January 1, 2016)

Hanshin Plant

Site area  
Main Plant 141,000m²
Marushima Factory 159,000m²

Employees 439

Production capacity
Pipe 17,000 ton / month

Main products
Pipe DN75 to DN1500
9-meter length pipe DN600 to DN1600

(As of January 1, 2016)

Certificates
Both Hanshin Plant and Keiyo Plant are ISO 9001 and ISO 14001 certificated.


ductile iron pipe is manufactured.

Where the world’s longest 9-meter length Ductile Iron pipe is manufactured.

Advantages of Ductile Iron Pipe

Kubota Pipeline System
Kubota’s History with Ductile Iron Pipe
Plant Information
Advantages of Ductile Iron Pipe
Line Up
Manufacturing Process and Quality Control
Supply Record
ADVANTAGES OF DUCTILE IRON PIPE

1. Tough and Strong

Ductile iron pipe has excellent strength and ductility. It is flexible and will not crack even if passably deformed. It is suitable for high pressure or under main road pipeline.

2. Long-term Durability

Corrosion Resistance
Ductile iron is well known as a highly resistant material to corrosion all over the world. This is because ductile iron contains a certain amount of carbon and silicon. For example, we found pipe body and cement mortar lining remained usable condition. There was no leakage after hydraulic pressure test. This proves that Ductile Iron pipe has corrosion resistance and long-life service. In addition, Ductile Iron pipeline is insusceptible to electric corrosion. This is because the rubber gasket set in every joint works as an insulator.

Internal Lining and External Coating
Internal cement mortar lining or epoxy coating, and external zinc and bitumen synthetic resin coating work as corrosion protection systems of Ductile Iron pipe and fitting. Polyethylene sleeve also can be applied to ductile iron pipes to improve corrosion resistance. We continue developing new types of coating for higher corrosion resistance.

As a new type of superior corrosion protection method, "Zinc Alloy Coating" was developed. It is applied on the external surface of a pipe body, which brings excellent self-healing performance against scratches caused by transportation and handling. Zinc ions gradually dissolve out from the zinc alloy layer, and zinc compounds are formed on the scratched area. Thus, it prevents corrosion from proceeding. Duration of this sacrificial protection effect is much longer than that of normal zinc coating.

Upon request, other types of coating or lining may be applied.

Mechanical properties

<table>
<thead>
<tr>
<th>No.</th>
<th>Pipe Material</th>
<th>Wall Thickness (mm)</th>
<th>Tensile Strength (N/mm²)</th>
<th>Bending Strength (N/mm²)</th>
<th>Elongation (%)</th>
<th>Modulus of Elasticity (N/mm²)</th>
<th>Hardness (H/BW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ductile Iron</td>
<td>23.5</td>
<td>400</td>
<td>200-380</td>
<td>min.10</td>
<td>15-17x10^3</td>
<td>max.230</td>
</tr>
<tr>
<td>2</td>
<td>Cast Iron</td>
<td>14</td>
<td>300</td>
<td>200-380</td>
<td>min.10</td>
<td>10-12x10^3</td>
<td>max.230</td>
</tr>
<tr>
<td>3</td>
<td>Steel</td>
<td>10</td>
<td>400</td>
<td>200-380</td>
<td>min.10</td>
<td>10-12x10^3</td>
<td>approx.140</td>
</tr>
</tbody>
</table>

Ring action strength

<table>
<thead>
<tr>
<th>No.</th>
<th>Pipe Material</th>
<th>Span (m)</th>
<th>Maximum Deflection (mm)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ductile Iron</td>
<td>6.0</td>
<td>&gt;40,000</td>
<td>No Collapse</td>
</tr>
<tr>
<td></td>
<td>Cast Iron</td>
<td>7.5</td>
<td>&gt;3,500</td>
<td>No Collapse</td>
</tr>
<tr>
<td>2</td>
<td>Ductile Iron</td>
<td>6.0</td>
<td>&gt;7,000</td>
<td>No Collapse</td>
</tr>
<tr>
<td></td>
<td>Cast Iron</td>
<td>8.0</td>
<td>&gt;6,800</td>
<td>Collapsed</td>
</tr>
<tr>
<td>3</td>
<td>Ductile Iron</td>
<td>8.0</td>
<td>&gt;14,000</td>
<td>No Collapse</td>
</tr>
<tr>
<td></td>
<td>Cast Iron</td>
<td>8.8</td>
<td>&gt;12,700</td>
<td>Collapsed</td>
</tr>
<tr>
<td>4</td>
<td>Steel</td>
<td>10.0</td>
<td>&gt;24,000</td>
<td>No Collapse</td>
</tr>
<tr>
<td></td>
<td>Cast Iron</td>
<td>10.0</td>
<td>&gt;23,500</td>
<td>Collapsed</td>
</tr>
<tr>
<td>5</td>
<td>Ductile Iron</td>
<td>7.0</td>
<td>&gt;9,000</td>
<td>No Collapse</td>
</tr>
<tr>
<td></td>
<td>Cast Iron</td>
<td>11.5</td>
<td>&gt;4,900</td>
<td>Collapsed</td>
</tr>
</tbody>
</table>

Beam action strength

<table>
<thead>
<tr>
<th>DN</th>
<th>Pipe Material</th>
<th>Wall Thickness (mm)</th>
<th>Maximum Load (kGF)</th>
<th>Maximum Deflection (mm)</th>
<th>Span (m)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>Ductile Iron</td>
<td>6.0</td>
<td>&gt;4,000</td>
<td>&gt;450</td>
<td>3.6</td>
<td>No Collapse</td>
</tr>
<tr>
<td>150</td>
<td>Ductile Iron</td>
<td>7.5</td>
<td>&gt;3,500</td>
<td>135</td>
<td>3.6</td>
<td>No Collapse</td>
</tr>
<tr>
<td>200</td>
<td>Ductile Iron</td>
<td>6.0</td>
<td>&gt;7,000</td>
<td>&gt;450</td>
<td>4.8</td>
<td>Collapsed</td>
</tr>
<tr>
<td></td>
<td>Cast Iron</td>
<td>8.0</td>
<td>&gt;6,800</td>
<td>150</td>
<td>4.8</td>
<td>Collapsed</td>
</tr>
<tr>
<td>250</td>
<td>Ductile Iron</td>
<td>8.0</td>
<td>&gt;14,000</td>
<td>&gt;450</td>
<td>4.8</td>
<td>Collapsed</td>
</tr>
<tr>
<td></td>
<td>Cast Iron</td>
<td>8.8</td>
<td>&gt;12,700</td>
<td>125</td>
<td>4.8</td>
<td>Collapsed</td>
</tr>
<tr>
<td>300</td>
<td>Ductile Iron</td>
<td>6.0</td>
<td>&gt;24,000</td>
<td>&gt;400</td>
<td>5.8</td>
<td>Collapsed</td>
</tr>
<tr>
<td></td>
<td>Cast Iron</td>
<td>8.5</td>
<td>&gt;23,000</td>
<td>&gt;450</td>
<td>5.8</td>
<td>Collapsed</td>
</tr>
<tr>
<td>400</td>
<td>Ductile Iron</td>
<td>7.0</td>
<td>&gt;9,000</td>
<td>&gt;130</td>
<td>5.8</td>
<td>Collapsed</td>
</tr>
<tr>
<td></td>
<td>Cast Iron</td>
<td>11.5</td>
<td>&gt;4,900</td>
<td>100</td>
<td>5.8</td>
<td>Collapsed</td>
</tr>
</tbody>
</table>

Chemical composition

<table>
<thead>
<tr>
<th>Material</th>
<th>Carbon</th>
<th>Silicon</th>
<th>Manganese</th>
<th>Phosphorus</th>
<th>Sulfur</th>
<th>Magnesium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ductile Iron Pipe</td>
<td>3.3-3.8</td>
<td>1.7-2.7</td>
<td>0.4-0.6</td>
<td>0.5</td>
<td>0.02</td>
<td>0.02-0.3</td>
</tr>
<tr>
<td>Cast Iron Pipe</td>
<td>3.3-3.8</td>
<td>1.7-2.7</td>
<td>0.4-0.6</td>
<td>0.5</td>
<td>0.02</td>
<td>0.02-0.3</td>
</tr>
<tr>
<td>Steel Pipe</td>
<td>0.1-0.2</td>
<td>0.15-0.4</td>
<td>0.3-0.6</td>
<td>0.3-0.6</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Electric resistance of ductile iron and steel

<table>
<thead>
<tr>
<th>Material</th>
<th>Electrical Resistance (Ω-mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ductile Iron</td>
<td>70-700</td>
</tr>
<tr>
<td>Cast Iron</td>
<td>10-20</td>
</tr>
<tr>
<td>Steel</td>
<td>10-20</td>
</tr>
</tbody>
</table>

Microstructure of ductile cast iron (left) and cast iron (right).
3. Adaptability against Various Situations

Flexible Joint (See page 11)

A joint of Ductile Iron pipe is composed of a spigot and socket with a rubber gasket for sealing. It is flexible since it allows a certain amount of deflection, expansion and contraction. Because of its flexibility, small curves in a pipeline can be easily accommodated without use of bends. Furthermore, some ground movement can be also absorbed.

Restrained Joint (See page 11 and 12)

Restrained joints can be used to protect bends, tees or tapers from the thrust force caused by the internal pressure of a pipeline instead of using thrust concrete blocks.

Kubota has several types of Restrained Joint. The appropriate type is selected depending on the pipe diameter and operating pressure of a pipeline.

Earthquake Resistant Joint (See page 13 and 14)

Ground movement due to earthquake or soft ground could cause expansion and contraction forces and the bending moment to a pipeline. Kubota offers Earthquake Resistant pipe to withstand such ground undulations. Pipeline with earthquake resistant joints is called Chain Structure pipeline. Even when large ground displacement occurs and one joint fully expands/contracts, the joint can pull/push the adjacent pipes one after another like a buried chain.

Kubota’s Earthquake Resistant Ductile Iron Pipes (ERDIP) has had no documented damages or leaks in the past major earthquakes whose magnitude is larger than 6, including the 2011 Great East Japan magnitude 9.0 earthquake. The excellent performance of ERDIP is highly appreciated in many Japanese water agencies.

Besides the earthquake resistant purpose, Kubota ERDIP effectively performs against ground deformation and subsidence as “Pullout Prevention Pipe”.

Ground deformation occurs in such cases of landslide and uneven settlement/movement by underground structures and faults. Ground subsidence may occur in a tunnel construction for “subway”, mass transportation system.

Joint performance of ERDIP

<table>
<thead>
<tr>
<th>Property</th>
<th>Performance</th>
<th>ISO 16134</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount of separation/contraction</td>
<td>±1% of L*1</td>
<td>Class S-1</td>
</tr>
<tr>
<td>Slip-out resistance</td>
<td>30 MPa*2</td>
<td>Class A</td>
</tr>
<tr>
<td>Joint deflection angle</td>
<td>6°-12°*3</td>
<td></td>
</tr>
</tbody>
</table>

*1: L is the nominal length, in millimetres (mm).
*2: D is the nominal diameter of pipe, in millimetres (mm).
*3: The joint deflection angle differs depending on a pipe diameter.

Jacking Method (See page 12)

For road, railway and river crossing, Kubota offers special pipes for jacking method. This method enable to jack the pipe directly into the ground without sleeve pipes. As the result, the installation cost and time period can be reduced, and the installation work can be also carried out safely without disturbing traffic.

4. Easy and Quick Installation

There is no need of skilled operators/special tools for assembling ductile iron pipes. Ductile iron pipes can be also installed in the rain. Furthermore, ductile iron pipes can be immediately backfilled after its assembling.

In case of Push-on Joint (T-type), simply install a rubber gasket in the socket and apply lubricant paste both on the rubber gasket and the pipe spigot end. After alignment of the pipe, just insert the spigot end to the socket with lever hoists or a simple tool.

General assembling time

<table>
<thead>
<tr>
<th>DN</th>
<th>T-type (min)</th>
<th>NS-type (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DN500</td>
<td>10</td>
<td>16</td>
</tr>
<tr>
<td>DN1000</td>
<td>20</td>
<td>24</td>
</tr>
</tbody>
</table>

*Source : Technical reference of Japan Ductile Iron Pipe Association

Usage example Jacking Method
Flexible Joint
- T-type
  - Pipe: DN80-DN2600
  - Fitting: DN80-DN2600
  - Push-on Joint
  - Mechanical Joint
  - T-type joint is push-on joint. It has flexibility and excellent water tightness.
  - K-type joint is mechanical joint. It has flexibility and excellent water tightness.

Restrained Joint
- TLH-type
  - DN400-DN1600
  - TLH-type is restrained joint. It is converted from T-type joint by providing the spigot with projection and assembling the special joint accessories. It can be used under high pressures and can be used with deflection.
  - Spigot ring
  - Tie bolt
  - Socket ring
  - Lock ring B
  - Weld bead
  - Lock ring A

- RF-type
  - DN80-DN2600
  - RF type is rigid joint. Generally, it is used to joint valves and other parts.
  - Rubber gasket
  - Bolt & nut

Flanged Joint
- K-type
  - DN80-DN2600
  - Fitting: DN80-DN2600
  - Flanged Joint
  - Rubber gasket
  - Bolt & nut

Jacking Pipe
- T-type (For Jacking Method)
  - DN250-DN1600
  - Jacking method is used to install a pipeline without trench excavation. Pipe is covered with reinforced concrete, which allows the pipe to be jacked directly into the ground without a pipe casing.
  - T-type ductile iron pipe
  - Flange
  - Reinforced concrete
The Earthquake Resistant Ductile Iron Pipe (ERDIP) absorbs the large ground displacement such as ground subsidence and crack by joints expansion/contraction, deflection, and anti-pull out structure.

Earthquake Resistant Joint

The Earthquake Resistant Ductile Iron Pipe (ERDIP) absorbs the large ground displacement such as ground subsidence and crack by joints expansion/contraction, deflection, and anti-pull out structure.
MANUFACTURING PROCESS AND QUALITY CONTROL

Pipe Casting

Selection of Material
- Best raw materials (pig iron, steel scrap, coke, limestone, etc.) are selected for casting ductile iron pipes.

Desulfurization
- Calcium carbide (CaC2) is added to molten iron in order to remove sulfur.

Magnesium Treatment
- Magnesium, in a small quantity, is added to the molten iron in order to promote the formation of spheroidal graphite microstructure. The addition of magnesium is done by pressure plunging method. This method was developed by Kubota.

Composition Adjustment
- If the composition of molten iron is outside the standards, it will be adjusted by adding alloy and other elements.

Centrifugal Casting
- Pipes are casted by centrifugal casting method.

Annealing
- Annealing is a heat treatment process undertaken to improve the mechanical properties of the pipes. In annealing, cementite of the as-cast pipes is decomposed to obtain high toughness ferrite.

Inside Cement Mortar Lining, Steam Curing
- Cement Mortar lining is applied inside the pipe for corrosion protection.

Outside Coating
- Zinc and bitumen/synthetic resin coatings are applied outside of the pipe for corrosion protection.

Shipping
- Pipes are shipped all over the world.

Fitting Casting
- Fittings are casted by sand mold.

Spectrographic Analysis
- Composition is analyzed by using spectrographic analyzer.

Inspection of Spheroidal Graphite
- Spheroidal graphite microstructure is examined by microscopic test.

Inspection of Heat Treatment Effect
- Tensile test
- Hardness test

Hydrostatic Pressure Test
- All pipes are subjected to hydrostatic test to check water-tightness.

Final Inspection
- Pipes are inspected carefully before shipping.

Inspection of Appearance and Dimensions
### Project Details

**Project Name:** MEW/19  
**Year:** 2012-2013  
**End User:** Ministry of Electricity and Water  
**Size:** DN2200-DN2400  
**Length:** 1.8km

<table>
<thead>
<tr>
<th>Project Name</th>
<th>Year</th>
<th>End User</th>
<th>Size</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>MEW/19</td>
<td>2012-2013</td>
<td>Ministry of Electricity and Water</td>
<td>DN2200-DN2400</td>
<td>1.8km</td>
</tr>
</tbody>
</table>

### Project Details

**Project Name:** Seismic Improvement Project at Northridge Hospital  
**Year:** 2014-2015  
**End User:** Los Angeles Department of Water and Power (LADWP)  
**Size:** DN100-DN300  
**Length:** 4.3km

### Project Details

**Project Name:** Karnaphuli Water Supply Project C-2  
**Year:** 2011-2014  
**End User:** Chittagong Water Supply and Sewerage Authority (CWASA)  
**Size:** DN500-DN1600  
**Length:** 7.5km

### SUPPLY RECORD

**Kuwait**

- **Project Name:** Pipelines for Mega Reservoirs Corridor Main 2 (GTC599/2013 Package B)  
  - **Year:** 2014-2016  
  - **End User:** Qatar General Electricity and Water Corporation (KAHRAMAA)  
  - **Size:** DN500-DN1600  
  - **Length:** 8.8km

**United States of America**

- **Project Name:** Seismic Improvement Project at Northridge Hospital  
  - **Year:** 2014-2015  
  - **End User:** Los Angeles Department of Water and Power (LADWP)  
  - **Size:** DN100-DN300  
  - **Length:** 4.3km

**Bangladesh**

- **Project Name:** Karnaphuli Water Supply Project C-2  
  - **Year:** 2011-2014  
  - **End User:** Chittagong Water Supply and Sewerage Authority (CWASA)  
  - **Size:** DN500-DN1600  
  - **Length:** 7.5km