Kubota Pipeline System

Kubota’s History with Ductile Iron Pipe

Plant Information

Advantages of Ductile Iron Pipe

Line Up

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COMPANY PROFILE

Corporate Name
KUBOTA Corporation
Established
1890
Capital
¥ 84.1 billion (as of April 25, 2017)
Revenues (Consolidated)
¥ 1,596.1 billion
Fiscal Year ended December 31, 2016
Number of employees (Consolidated)
38,291 (as of December 31, 2016)
*The number of full-time employees

CONNECT TO THE FUTURE
**KUBOTA’S HISTORY WITH DUCTILE IRON PIPE**

**History**

1890  Established as a foundry. Started production of castings for weighting equipment and daily commodities.
1893  Started production of cast iron pipe for water supply.
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.

**PLANT INFORMATION**

**Hanshin 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: DN900 to DN2600

(as of January 1, 2016)

**Keiyo Plant**

- **Site area**
  - Main Plant: 300,000m²
  - Logistics center: 142,000m²
- **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

Ductile iron is a family of cast iron. The difference between ductile iron and cast iron is in the graphite formation in the metal. Cast iron is characterized by a random flake graphite pattern. In ductile iron, the graphite form is small spheroids rather than flakes. This creates fewer discontinuities in the structure of the metal and produces a stronger ductile iron.

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.

Chemical composition

<table>
<thead>
<tr>
<th></th>
<th>Ductile Iron Pipe</th>
<th>Cast Iron Pipe</th>
<th>Steel Pipe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon</td>
<td>3.2-3.8</td>
<td>3.2-3.8</td>
<td>0.1-0.2</td>
</tr>
<tr>
<td>Silicon</td>
<td>1.7-2.7</td>
<td>1.4-2.2</td>
<td>0.15-0.4</td>
</tr>
<tr>
<td>Manganese</td>
<td>max. 0.4</td>
<td>0.4-0.6</td>
<td>0.3-0.6</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>max. 0.1</td>
<td>max. 0.5</td>
<td>0.02-0.03</td>
</tr>
<tr>
<td>Sulfur</td>
<td>max. 0.02</td>
<td>max. 0.1</td>
<td>0.02-0.03</td>
</tr>
<tr>
<td>Magnesium</td>
<td>min. 0.02</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Microstructure of ductile cast iron (left) and cast iron (right).

1. Mechanical properties

- **Ductile Iron Pipe**
  - Tensile Strength (N/mm²): min. 420
  - Bending Strength (N/mm²): min. 390
  - Modulus of Elasticity (N/mm²): 15.1-17 x 10⁶
  - Hardness (HBW): max. 230

- **Cast Iron Pipe**
  - Tensile Strength (N/mm²): 150-260
  - Bending Strength (N/mm²): 200-380
  - Modulus of Elasticity (N/mm²): 10-12 x 10⁶
  - Hardness (HBW): max. 230

- **Steel Pipe**
  - Tensile Strength (N/mm²): min. 400
  - Bending Strength (N/mm²): min. 400
  - Modulus of Elasticity (N/mm²): 150-260
  - Hardness (HBW): min. 18

2. Electric resistance of ductile iron and steel

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.

- **Chemical composition**

  - **Ductile Iron Pipe**
    - Carbon: 3.2-3.8
    - Silicon: 1.7-2.7
    - Manganese: ≤0.4
    - Phosphorus: ≤0.1
    - Sulfur: ≤0.02
    - Magnesium: ≤0.02

  - **Cast Iron Pipe**
    - Carbon: 3.2-3.8
    - Silicon: 1.4-2.2
    - Manganese: 0.4-0.6
    - Phosphorus: 0.5
    - Sulfur: 0.02

  - **Steel Pipe**
    - Carbon: 0.1-0.2
    - Silicon: 0.15-0.4
    - Manganese: 0.3-0.6
    - Phosphorus: 0.02

3. Microstructure

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 expansion/contraction</td>
<td>±1% of L*</td>
<td>Class S-1</td>
</tr>
<tr>
<td>Slip-out resistance</td>
<td>30 kN*</td>
<td>Class A</td>
</tr>
<tr>
<td>Joint deflection angle</td>
<td>6°-16°</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>DN600</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

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Usage example: Jacking Method

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Flexible Joint

T-type joint is mechanical 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 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 pressure and can be used with deflection.

RF-type is rigid joint. Generally, it is used to joint valves and other parts.

Flanged Joint

Jacking Pipe

T-type (For 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.
The Earthquake Resistant Ductile Iron Pipe (ERDIP) absorbs the large ground displacement such as ground subsidence and cracks 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.

**Melting in Hot Blast Cupola**
- Calcium carbide (CaC2) is added to molten iron in order to remove Sulfur.

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

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

**Centrifugal Casting**
- Pipes are casted by centrifugal casting method.

**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 is analyzed by using spectrographic analyzer.**

**Spectrographic Analysis**
- Spheroidal graphite microstructure is examined by microscopic test.

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

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

**Final Inspection**
- Pipes are inspected carefully before shipping.

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

**Inpection of Heat Treatment Effect**
- 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.

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

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

**Tensile test**
- Tensile test

**Hardness test**
- Hardness test

**Fittings are casted by sand mold.**

**Fitting Casting**
- Fittings are casted by sand mold.

**Inspexion of Appearance and Dimensions**
- Pipes are shipped all over the world.
### SUPPLY RECORD

#### Kuwait

<table>
<thead>
<tr>
<th>Project Name</th>
<th>Year</th>
<th>End User</th>
</tr>
</thead>
<tbody>
<tr>
<td>MEW/19</td>
<td>2012-2013</td>
<td>Ministry of Electricity and Water</td>
</tr>
<tr>
<td>Size DN200-DN2400</td>
<td>Length 1.8km</td>
<td></td>
</tr>
</tbody>
</table>

#### Qatar

<table>
<thead>
<tr>
<th>Project Name</th>
<th>Year</th>
<th>End User</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipelines for Mega Reservoirs Corridor Main 2 (GTC599/2013 Package B)</td>
<td>2014-2016</td>
<td>Qatar General Electricity and Water Corporation (KAHRAMAA)</td>
</tr>
<tr>
<td>Size DN900-DN1600</td>
<td>Length 8.8km</td>
<td></td>
</tr>
</tbody>
</table>

#### United States of America

<table>
<thead>
<tr>
<th>Project Name</th>
<th>Year</th>
<th>End User</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seismic Improvement Project at Northridge Hospital</td>
<td>2014-2015</td>
<td>Los Angeles Department of Water and Power (LADWP)</td>
</tr>
<tr>
<td>Size DN100-DN300</td>
<td>Length 4.3km</td>
<td></td>
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</tbody>
</table>

#### Bangladesh

<table>
<thead>
<tr>
<th>Project Name</th>
<th>Year</th>
<th>End User</th>
</tr>
</thead>
<tbody>
<tr>
<td>Karnaphuli Water Supply Project C-2</td>
<td>2011-2014</td>
<td>Chittagong Water Supply and Sewerage Authority (CWASA)</td>
</tr>
<tr>
<td>Size DN500-DN1200</td>
<td>Length 72km</td>
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