On the Leading Edge:Nippon Steel

NIPPON STEEL

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NIPPON STEEL UO PIPE
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NIPPON STEEL UO PIPE

Nippon Steel Corporation

Contents

INTRODUCTION

The origins of Nippon Steel Corporation go back more than a century to 1886. Today, Nippon Steel is the world's leading integrated steelmaker with a huge reservoir of advanced technology. The company offers a full range of competitive products in a wide range of grades, shapes and end uses. Tubular product production encompasses boiler and heat-exchanger tubes, high-test line pipe, oil-country tubular goods and high-pressure pipe and tubes.

Among the company's advanced production facilities is the Kimitsu Work's UO pipe mill, which is capable of manufacturing large-diameter pipe of outside diameters ranging from 18 inches (457.2 mm) to 56 inches (1,422.4 mm) and wall thicknesses from 0.250 inches (6.0 mm) to 1.57 inches (40.0 mm). The mill commenced operation in 1970 and cumulative production of large-diameter pipe surpassed eleven million tons by the end of 2007.

The top priorities of the UO pipe mill are the supply of products of the highest quality and reliability, and on-time delivery.

The products of this mill are required to meet increasingly stringent applications year after year, in frigid regions and highly corrosive environments. These adverse service environments demand special qualities and properties - qualities and properties that Nippon Steel has successfully incorporated into its products as a result of its R&D efforts.

The reputation of Nippon Steel's UO pipe is firmly established worldwide.

FEATURES AND ADVANTAGES

Volume Production of Quality Materials

The mechanical and chemical properties of UO pipe – strength, toughness, weldability and corrosion resistance – are largely determined in the phases from steelmaking to plate rolling. Nippon Steel has a world-class system for the volume production of quality steels.

Advanced Production Facilities Backed by Expertise and Long Experience

Fully automated mill equipment and the latest pipemaking technology – especially in the area of welding – ensure the high and stable quality of Nippon Steel's UO pipe.

Stringent QA/QC Systems

Every UO pipe is produced under a special quality assurance system comprised of:

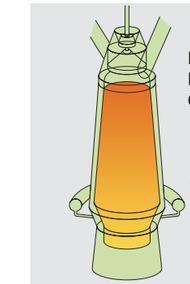
- An advanced tracking and identification system for the perfect control of the entire process flow from steelmaking to warehousing of finished pipe
- An array of automatic quality control instruments covering the entire process to ensure high reliability in inspections and tests
- A computer-assisted quality control and production specification system for high efficiency in process control
- Certified inspection staff for nondestructive, visual and dimensional inspections

Advanced R&D

Research and development are being made in constant pursuit of technical innovations in all areas of pipe production: steelmaking, plate rolling, pipe fabrication, inspection and surface treatment. The results of these R&D efforts are fed forward to the production line and reflected in the plant engineering concerned emphasis is placed on:

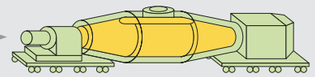
- Research aimed at improving the performance and mechanical properties of UO pipe in response to the changes in service conditions and environmental restrictions, as well as the quality of technical services Nippon Steel offers to its customers
- Research for technical standardization, innovation and automation to ensure high quality on a stable basis

INTEGRATED PRODUCTION PROCESS

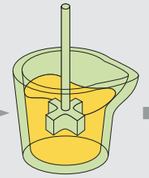


Iron Ore
Limes Tone
Coke

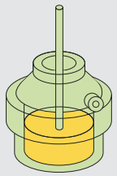
Blast Furnace



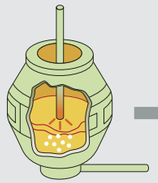
Torpedo Car



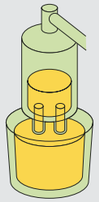
KR



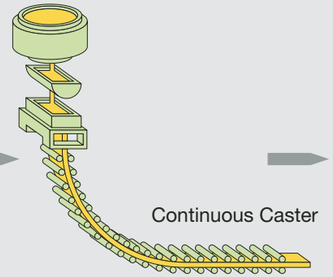
LD-ORP



LD-OB



Secondary
Refining



Continuous Caster

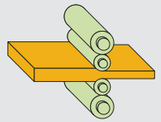
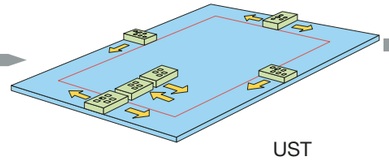


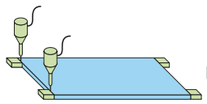
Plate Mill



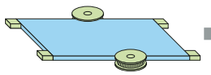
UST

Plate Piling

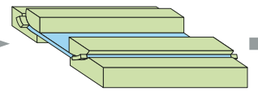
Unpiling



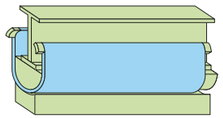
Automatic
Plate Tab Welding



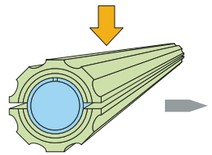
Edge Milling



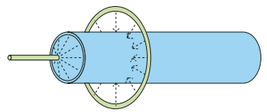
Edge Crimping



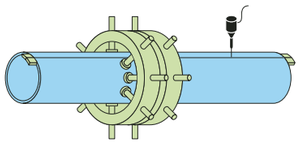
U-ing Press



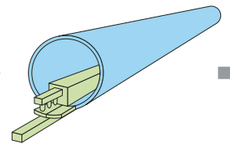
O-ing Press



Pipe Washing & Drying

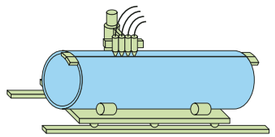


Tack Welding

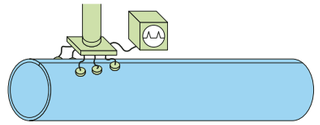


Automatic
Inside Welding

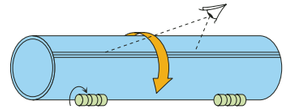
**Preliminary
Inside Visual Inspection**



Automatic Outside Welding



1st Ultrasonic Inspection

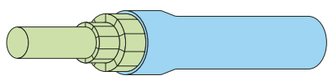


Preliminary
Outside Visual Inspection

1st X-Ray Radiography

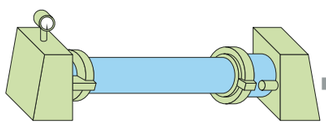
Fluoroscopy

Repair Welding

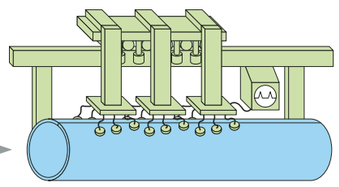


Expansion

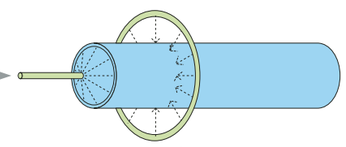
Degreasing



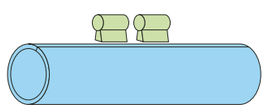
Hydrostatic Test



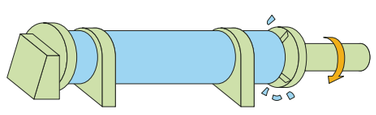
2nd Ultrasonic Inspection



Hot Water Flushing



X-Ray Radiographic Inspection



End Facing

**Final
Inspection**

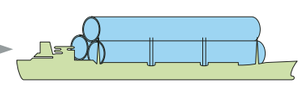
**Customer's
Inspection**

**Automatic Dimensional
Measurement
and Marking**

Products

Varnish

Coating



Shipping

MANUFACTURING PROCESS

Steelmaking, Secondary Refining and Continuous Casting

Volume Production of High-Purity Steel

For improvement of the mechanical properties of UO pipe, Nippon Steel has developed and established the following techniques that permit volume production of high-purity steel.

1 Pre-treatment and Secondary Refining Process
- 1) Reduction and shape-control of nonmetallic inclusions
- 2) Reduction of impurities: phosphorus, sulphur, oxygen, nitrogen and hydrogen
- 3) Reduction of easy-to-segregate elements: carbon and phosphorus

2 Continuous Casting Process
- 1) Prevention of steel reoxidation and nitrogen absorption
- 2) Vertical-bending type continuous casting machine

Reduction of Center Segregation in Continuous Casting

New techniques have also been developed to reduce center segregation in the continuous casting process in order to obtain UO pipe with improved sourenvironment resistance in particular.

1 Soft reduction of slab through the use of divided roll segments in the final stage of solidification

2 Reduced roll pitch and rigid roll segment to suppress slab bulging

Abbreviation	Name	Main Function
KR	Kanbara Reactor	• Desulfurization
LD-ORP	LD-Optimizing Refining Process	• Dephosphorization
LD-OB	LD Oxygen Bottom Blowing	• Decarburization
KIP	Kimitsu Injection Process	• Desulfurization • Sulphide Shape Control • Decreasing of Inclusion
RH	Rheinstahl Huttenwerke & Heraus	• Vacuum Degassing
VKIP	Vacuum Kimitsu Injection Process	• Desulfurization • Sulphide Shape Control • Decreasing of Inclusion • Deoxidation • Hydrogen Removal • Nitrogen Removal
CORD	CC Optimum Reduction by Divided Roll	• Decrease of Center Segregation

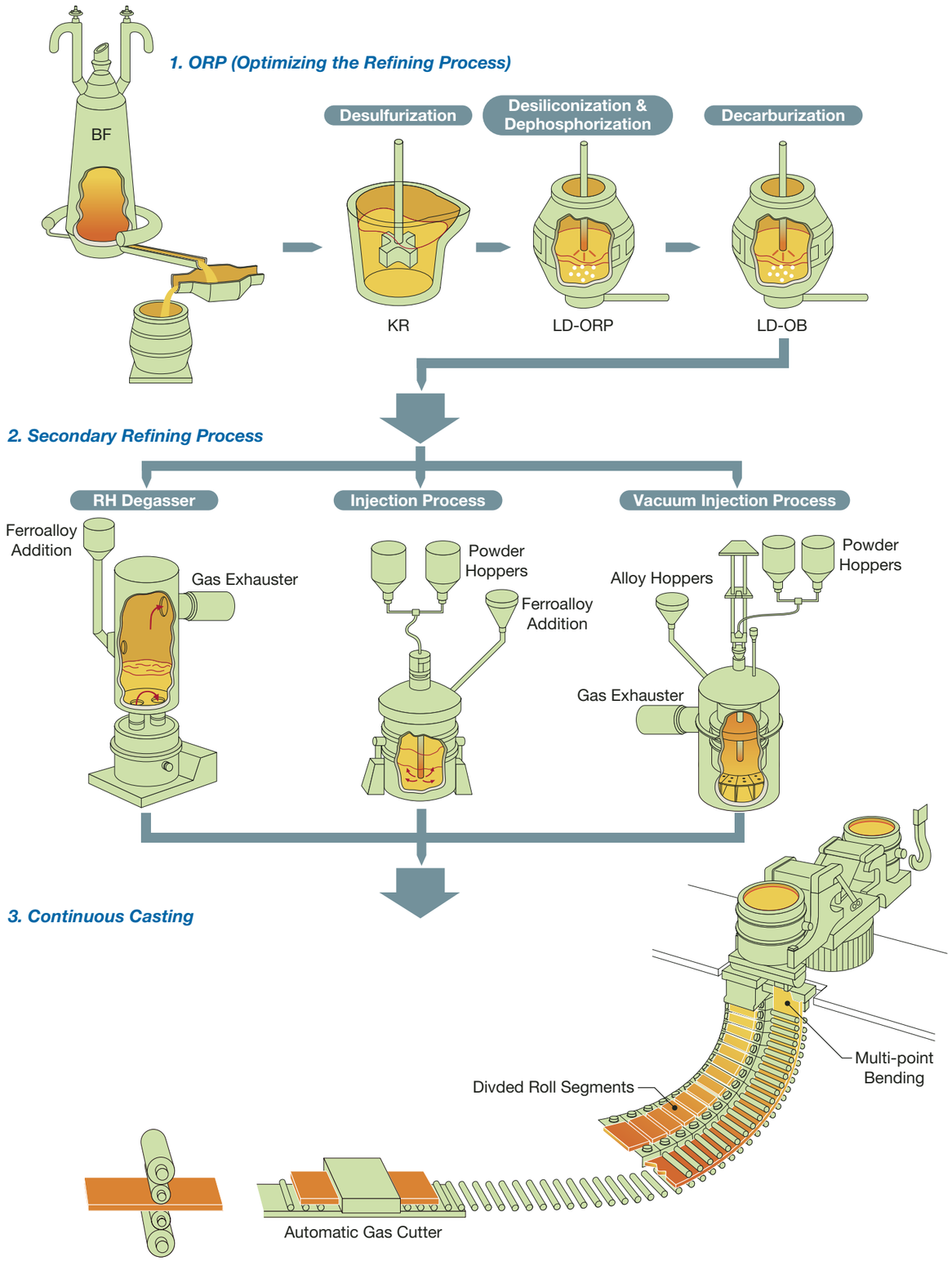


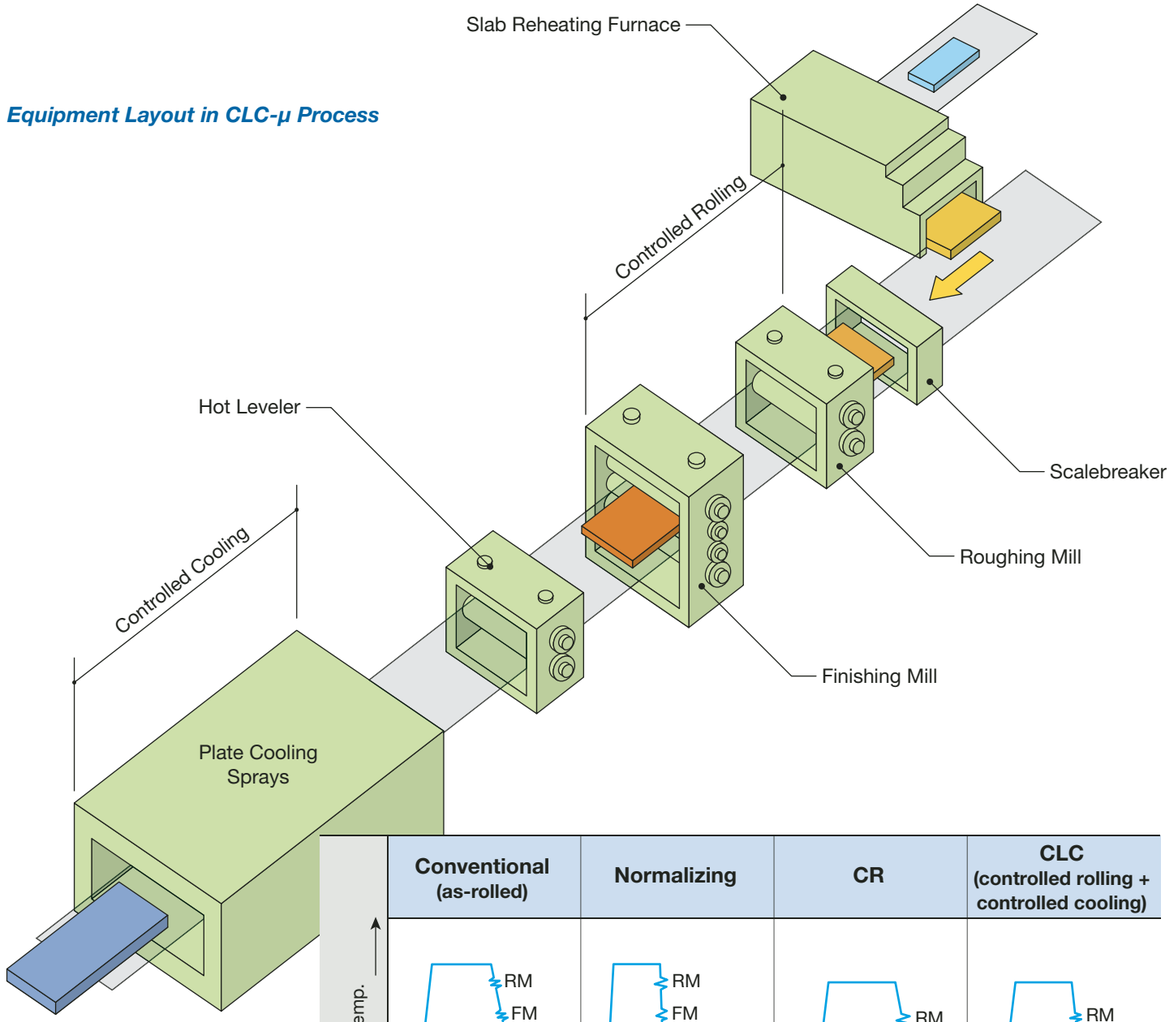
Plate Rolling

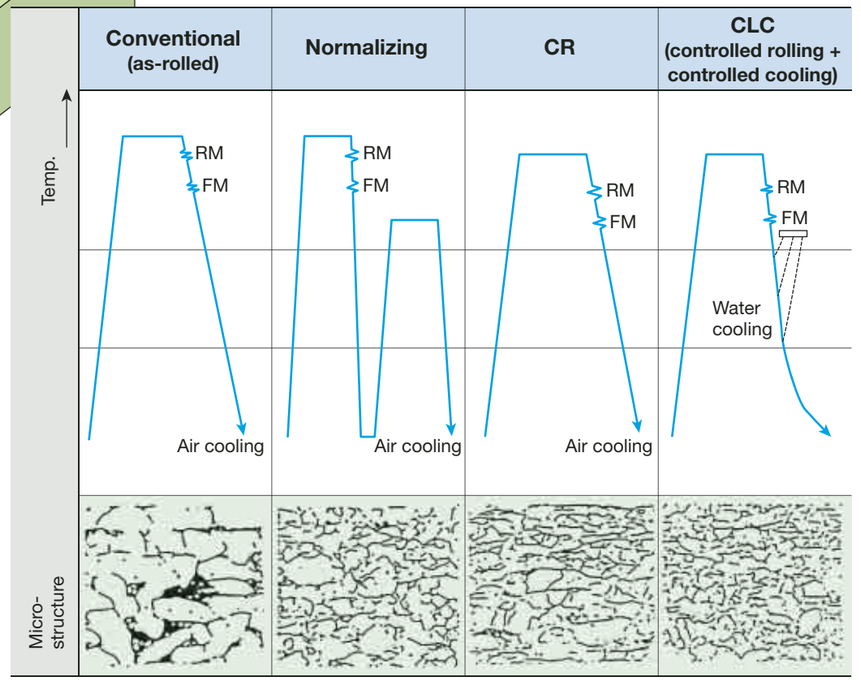
Technical breakthroughs in plate rolling based on Nippon Steel's proprietary thermo-mechanical control process (TMCP) impart excellent weldability and toughness to UO pipe.

1 CR (Controlled Rolling) Process
The CR process refines the steel by controlling various thermo-mechanical factors such as slab reheating temperature, rolling temperature and rolling reduction.

2 CLC (Continuous On-line Control) Process
This on-line cooling technique is designed for use immediately after the CR process to refine grain size and better control the transformation temperature.

Equipment Layout in CLC-μ Process





Steps Preliminary to Forming

Tab Plate Affixing:
A tab plate is precisely affixed to each corner of the plate for pipe by means of a dedicated MAG welding robot to permit quality welding beyond the pipe ends.

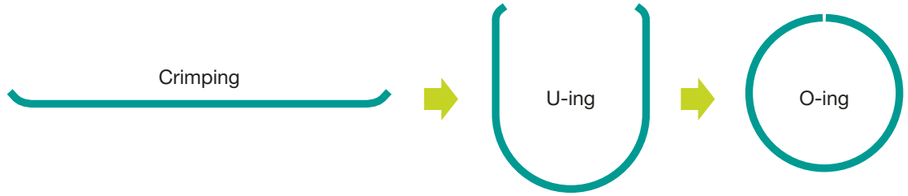
Edge Miller:
A precision plate feeder and milling cutter with positioning control, enable precise planing of the plate and tab edges, making the two edges parallel and square with the ends after planing. The edge miller also continuously monitors the plate during edging for faulty planing so that only accurately edge-planed plates will be fed to the subsequent process.

Tab MAG welding robot

Edge miller

Forming Plate into Circular Shape

"UO" Forming
The edge-planed plate is automatically fed through the crimping press, U-ing press and O-ing press and is deformed into the shape of an almost closed circle which is then ready for welding.



U-ing press

Continuous Tack Welding
To ensure sound welds by internal and external SAW, the continuous tack welder welds the gap along the full length of pipe from the outside by means of CO_2 welding process. This tack-welding eliminates many causes of weld defects, including burn-throughs and weld-cracks in subsequent welding, because unlike other commonly used tack-welding operations the seam in the pipe is completely welded.

O-ing press

Continuous CO_2 tack welding

Welding

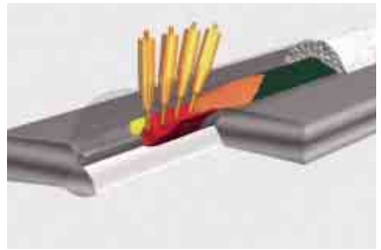


Image of outside welding

Inside and Outside Welding

The tack welded pipe is welded on the inside and outside by the multi-electrode SAW method.

The SAW machine used in this operation is capable of performing all welding operations automatically from receipt of the tack welded pipe and the seam alignment to delivery of the welded pipe.

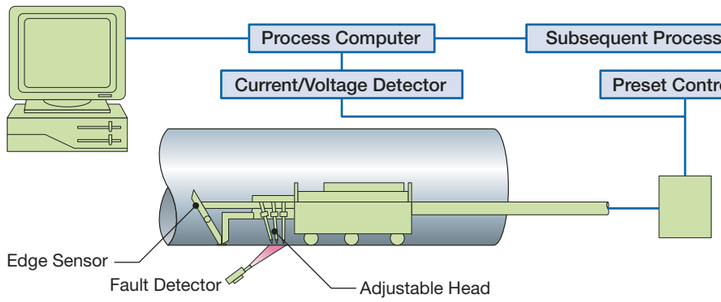
It also has many other features including a welding condition controller which can accurately control the welding process parameters to preset values.

All these add up to highly reliable, quality welds.

Automatic Supply of Moisture-Free Flux

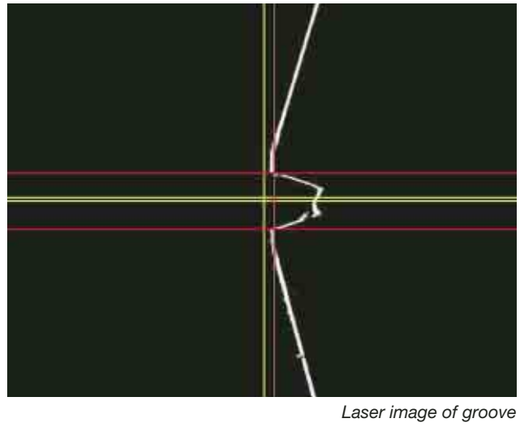
The flux used in SAW is supplied through an automatic circulation system of totally closed type. Hence, a continuous flow of high-quality, moisture-free flux is maintained.

Configuration of Automatic Welding (Inside) System



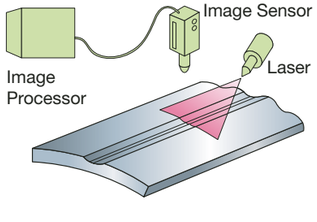
Inside welding

Inside welding remote monitor at control center



Laser image of groove

Seam Tracking Control System (Outside Welding)



UO Pipe Inspection and Testing

Mechanical Expansion

The final diameter and straightness of the pipe is obtained by mechanically expanding the pipe. This corrects any deformations such as out-of- roundness or bending that might have occurred during the welding process.

As pipe is expanded from inside, uniform diameters are obtained to facilitate field welding.

Simultaneously, residual stress is reduced by expansion. Nippon Steel uses a mechanical expander for greater accuracy.

Hydrostatic Testing

All pipes are subjected to automatic hydrostatic testing after mechanical expansion. Testing can be carried out up to a maximum pressure of 44.1 MPa (6450 psi).

Mechanical expansion

Hydrostatic test

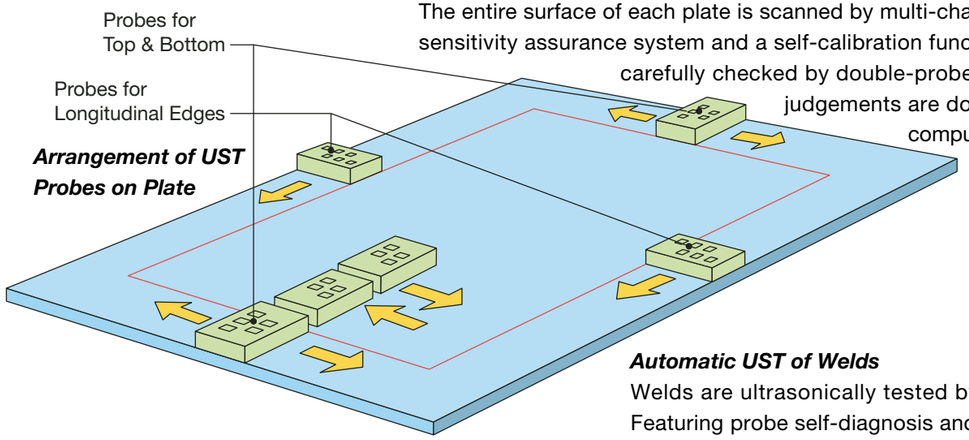
Inside cleaning

Nondestructive Examinations (NDE)

All pipes from Nippon Steel's UO pipe mills are subjected to a series of stringent nondestructive examinations such as ultrasonic testing, X-ray fluoroscopy, X-ray radiography and magnaflux testing. NDEs are carried out by qualified inspectors.

Automatic Plate UST (Kimitsu Plate Mill)

The entire surface of each plate is scanned by multi-channel UST with a self-sensitivity assurance system and a self-calibration function. Plate edges are carefully checked by double-probe mechanism. And all judgements are done automatically by a computer-controlled system.



Arrangement of UST Probes on Plate

Automatic UST of Welds

Welds are ultrasonically tested by Multi-channel UST. Featuring probe self-diagnosis and hydrostatic coupling functions, and AGC function designed to maintain system sensitivity, the UST system enables stable and accurate examinations.

Automatic UST of weld

X-ray Fluoroscopy

The X-ray fluoroscopic examination system consists of a small focus, high-performance X-ray tube and a special dynamic image processor and offers highly sensitive pictures.

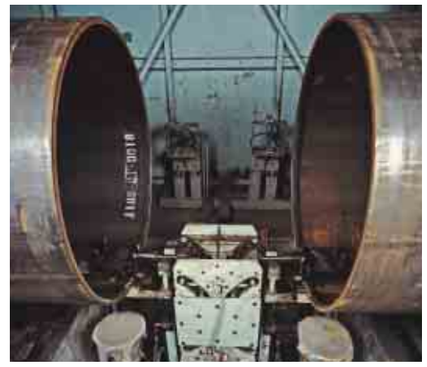
X-ray Radiography

The X-ray radiographic examination system features a small focus, high- performance X-ray tube and a special mechanism that allows the radiographic film to be brought into direct contact with the pipe being inspected to produce highly sensitive radiographs. The exposed films are processed in a fully-automatic manner – a feature that provides quality pictures in all cases.

The result of judgment of each radiograph is fed into the system from an input terminal for computer-aided total judgement of the quality of each pipe.

Full length X-ray radiographic examination system

X-ray fluoroscopic examination system



Pipe-end X-ray radiographic examination system

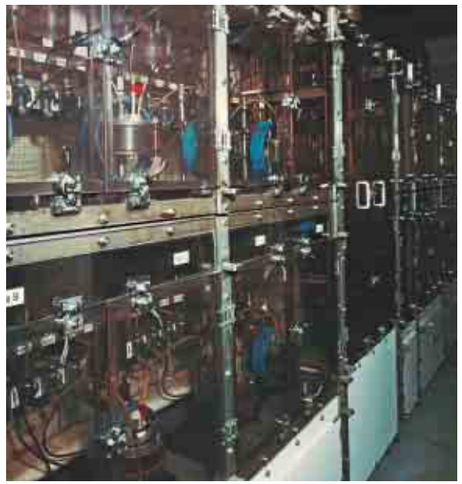
Radiographic film processor (robot)

Judgment of radiograph

Physical Testing

In addition to in-line testing, random samples of pipe are subjected to a rigorous program of off-line testing for mechanical properties of base metal and weld metal. These comprehensive testing procedures assure users of highest quality products that conform to or exceed the specifications.

Test specimens



Constant load stress corrosion cracking tester

Drop Weight Tear Test (DWTT)

Example of CTOA observation

DWTT specimens

Computer System for Quality and Production Control

Tracking System

Data Collation Between Plate Mill and Pipe Mill:
It is possible to completely eliminate the risk of unwanted plates entering the UO pipe mill by collating the output data of the automatic plate number reader with the computer tracking data from the plate mill.

In-Line Tracking:
By tracking electrical signals generated upon passage of the pipe through each process, the movement of each pipe can be accurately tracked.

Automatic Marking:
All finished pipes are automatically marked with such information as measured weight and length in accordance with the marking specifications each customer designates.

Storage Control:
Radio data transceivers are used for storage control. This storage control system provides in real time the address of each pipe and the image of each pipe pile at the storage yard.

Production Specifications and Quality Analysis System

Production Specification:
A sophisticated on-line production specification system is in operation, in which production conditions or process parameters are fed directly to visual displays (CRT) installed in each process for the effective elimination of human errors.

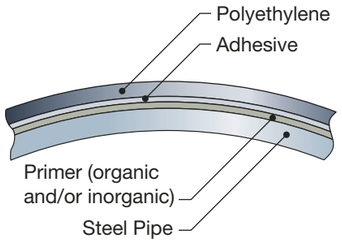
On-Line Quality Control:
An advanced on-line quality control system is in service which enables real-time feedforward and feedback of the quality-related data of each pipe measured between processes in the UO pipe mill.

Automatic pipe marking

Data Analysis:
All data are fed to an off-line data analysis system, where they are precisely analyzed to find optimum process parameters, and the results of the analysis are reflected in subsequent production specifications.

External Polyethylene Coating

The external polyethylene coating of UO pipe is applied by extrusion of polyethylene resins using T-dies. Nippon Steel started production of polyethylene-coating UO pipe in 1974: the first example in Japan. Since then, polyethylene coated large-diameter pipe has been finding widening application as oil and natural gas line pipe and is today highly reputed among third-party testing institutions.



The Coating is of A Three-Layer Construction:
Primer layer, adhesive layer and polyethylene layer. It exhibits good adhesion to the base metal and is excellent also in electric insulating properties, weathering resistance and resistance to chemicals.

Available Sized
Outside Diameter : 16 to 64 in. (400 to 1625.6 mm)
Length : 30 to 60 ft. (9.0 to 18.6 m)

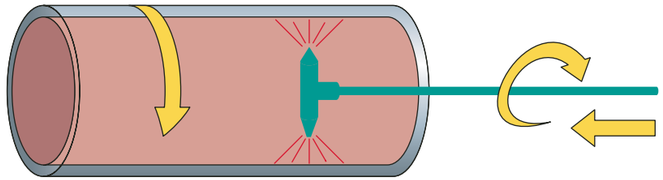
Coating Method

Polyethylene-coated pipe

Internal Coating

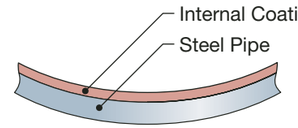
Internal-coating UO pipe is also available from Nippon Steel. This type of UO pipe is enjoying widening acceptance for use in such applications as require both high corrosion resistance and improved transport efficiency of fluids.

Coating Method



Internal Coating

Liquid epoxy resin pipe



Available Sized
Outside Diameter : 18 to 56 in. (457.2 to 1422.4 mm)
Length : 30 to 42 ft. (9.0 to 12.8 m)

Liquid epoxy resin mill

SIZE RANGE OF UO PIPE

Nippon Steel's Kimitsu UO pipe mill produces pipe with outside diameters from 18 inches to 56 inches. The equipment to produce such pipes reflects Nippon Steel's intent to meet the great demand for larger and heavier steel pipe.

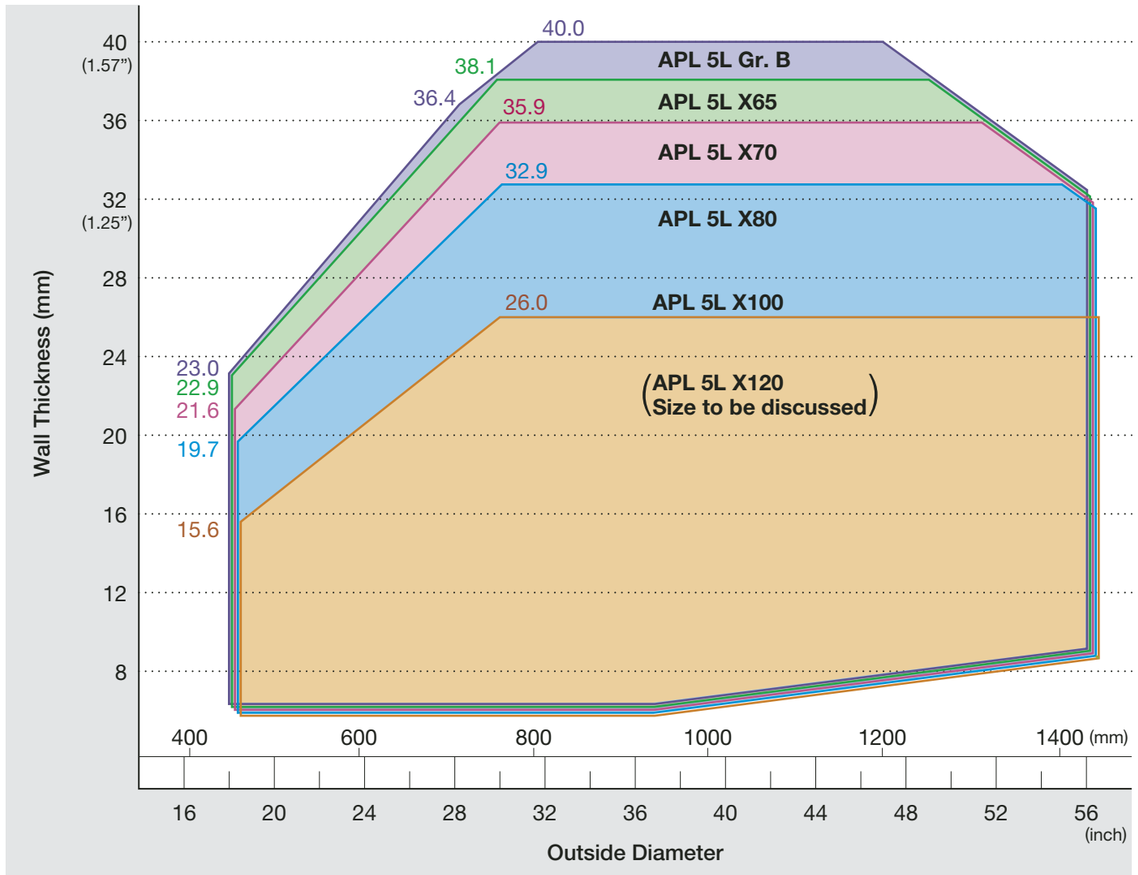
Wall Thickness

Submarine pipelines require pipe of greater strength and toughness. To produce pipe with wall thickness of up to 1.57 inches Nippon Steel has installed very large crimping, U-ing press, O-ing press and expander.

Length

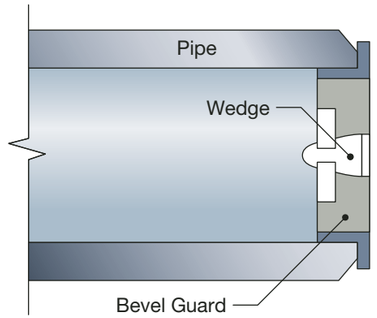
Nippon Steel's UO pipe mill can produce pipes with lengths up to 60 feet. These long pipes reduce the number of weld joints and inspections necessary at the site, thus leading to faster construction and lower costs.

Size Range of UO Pipe



HANDLING AND STORAGE

Special consideration and attention are given to the handling and storage of UO pipe. Improper handling or storage results in damage such as scratches, deformation, fatigue cracks and so on.



End Protection:

The ends of UO pipes are protected by steel bevel guards. The bevel guard is fitted so as not slip off in transit, but can be easily removed and refitted wherever necessary.

Handling:

Pipe-handling crane hooks are cushioned and specially designed to prevent pipe-end damage. Also, all handling equipment and practices are designed to avoid excessive stresses on the pipe.

Example of marking and bevel guard

Storage:
In the pipe mill, all pipes are placed neatly on dunnage in level and drained storage so that they will be safe from permanent deformation such as out-of-roundness.

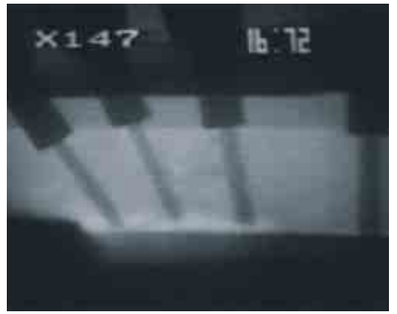
Similar safety precautions are also used for marine transport. In order to prevent pipe damage such as deformation and fatigue cracking, stowing is performed strictly in accordance with Nippon Steel's own standards which are more rigorous than API RP5LW.

RESEARCH AND DEVELOPMENT

The combined resources of the Technical Development Bureau, and the research department of the Engineering Divisions Group are the driving force in Nippon Steel's R&D programs. The Technical Development Bureau, comprised of five main units which liaise with steelworks research laboratories, is highly active in quest of technical innovations in production processes, application technologies and basic technologies.

R&E Center for the Technical Development Bureau, located at Futtsu, Chiba Prefecture, serves as the company's base for the most modern technology development and engineering, consolidating research organizations in the fields of steelmaking and plant engineering/technology.

EBSP analysis



Radiographic observation of SAW

Solidifying cycle weld simulator

Research & Engineering Center