

Electric Resistance-welded Steel Tubes for Boilers and Heat Exchangers

Pipes
& Tubes

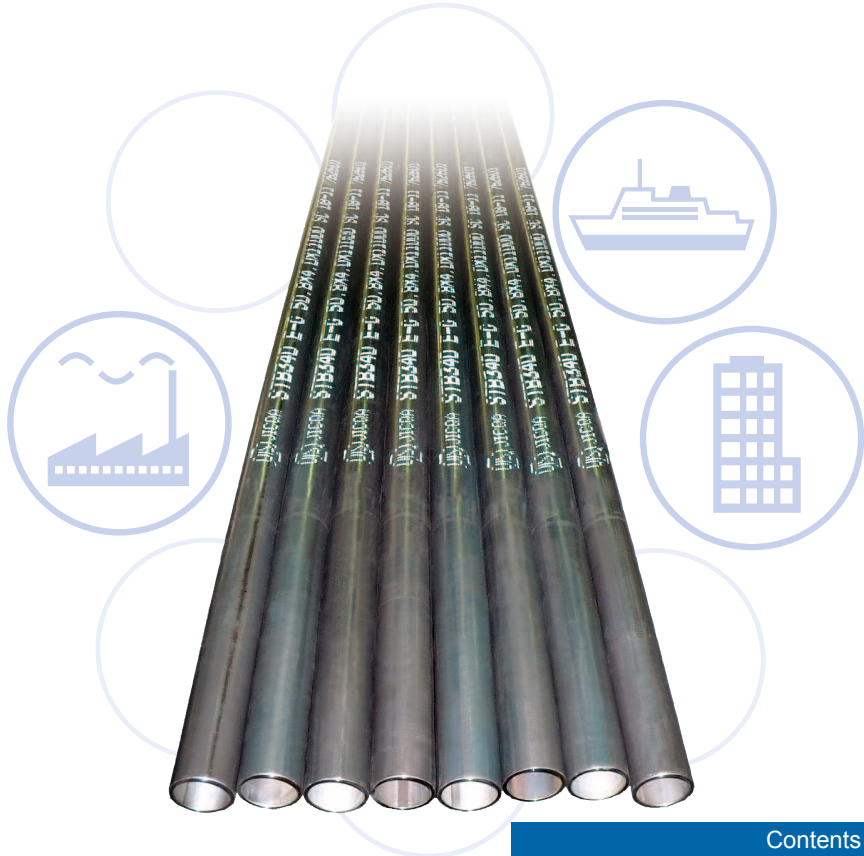
Introduction

NIPPON STEEL has established a special electric resistance-welded tube factory dedicated to high-grade tubes for boilers and plants in order to conduct the full-scale production of high-grade electric resistance-welded (ERW) steel tubes equivalent to seamless steel tubes.

Based on our preminent steel-making technology and hot-rolling equipment, we manufacture electric resistance-welded steel tubes for boilers and heat exchangers that

rivals or exceeds seamless steel tubes, all by adopting: tube-making equipment designed for especially high-grade steel tubes, automatic welding control systems, various pieces of extremely highly reliable full-automatic nondestructive test equipment, and large-capacity bright heat treatment furnaces.

We will make an unflagging effort to ensure that customer needs can be served, and we hope that you will try our electric resistance-welded tubes for boilers and heat exchangers.



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Features

NIPPON STEEL ERW steel tubes for boilers and heat exchangers are manufactured consistently, from the raw material process to the tube-making and purification process, and have the following superior features—all through superior manufacturing equipment and thorough quality control.



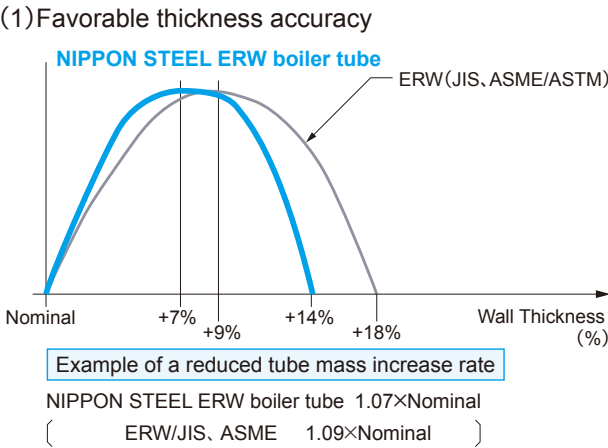
Extremely favorable welded part quality

- The highest quality killed steel developed especially for boiler tubes is used, and the welded part quality is extremely favorable—achieved through accurate forming and high-frequency induction welding, adopting an automatic welding control system.
- A string of nondestructive testing facilities centered on state-of-the-art fully automatic ultrasonic inspections are used to ensure quality assurance, and the products are provided with the high quality required by boiler tubes.
- The welded part provides the same metal composition as the base material through bright heat treatment, and it has uniform and superior quality equivalent to seamless steel tubes.
- The specification in (58) in “Note 1 (Remark 1)” in Attached Table 1 of “Interpretation of the Thermal Power House Technical Standard” is satisfied, and the same allowable stress as seamless steel tubes can be applied.



Superior size and shape

- Formed precisely by a state-of-the-art tube-making machine, the product has extremely superior dimensional accuracy and roundness.
- The removal of internal and external surface beads on the welded part from during the steel-making process is extremely superior. Especially, the removal shape of the internal surface bead is distinguished, and a smooth internal surface property is assumed.
- The product has favorable thickness accuracy, and the tube mass increase rate can be reduced.
- Due to high inside diameter accuracy, steam supply pressure loss can be reduced.

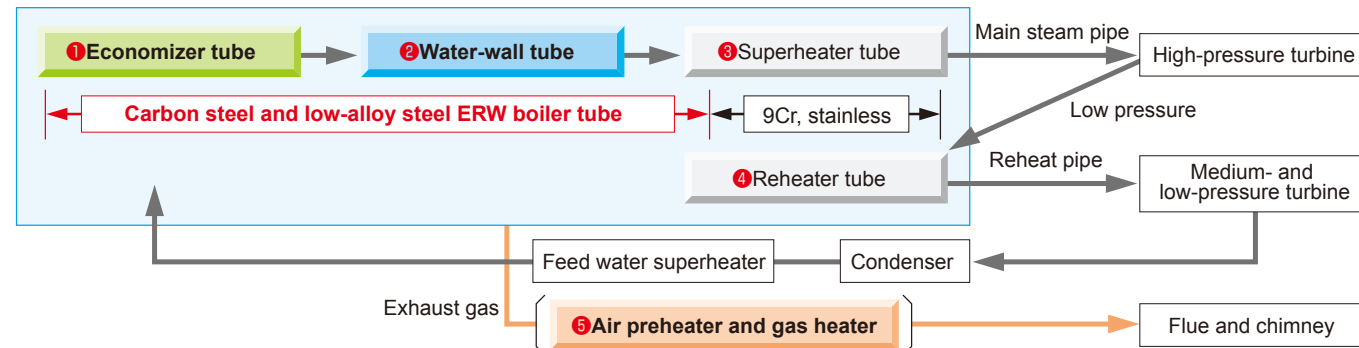


Enhanced management system

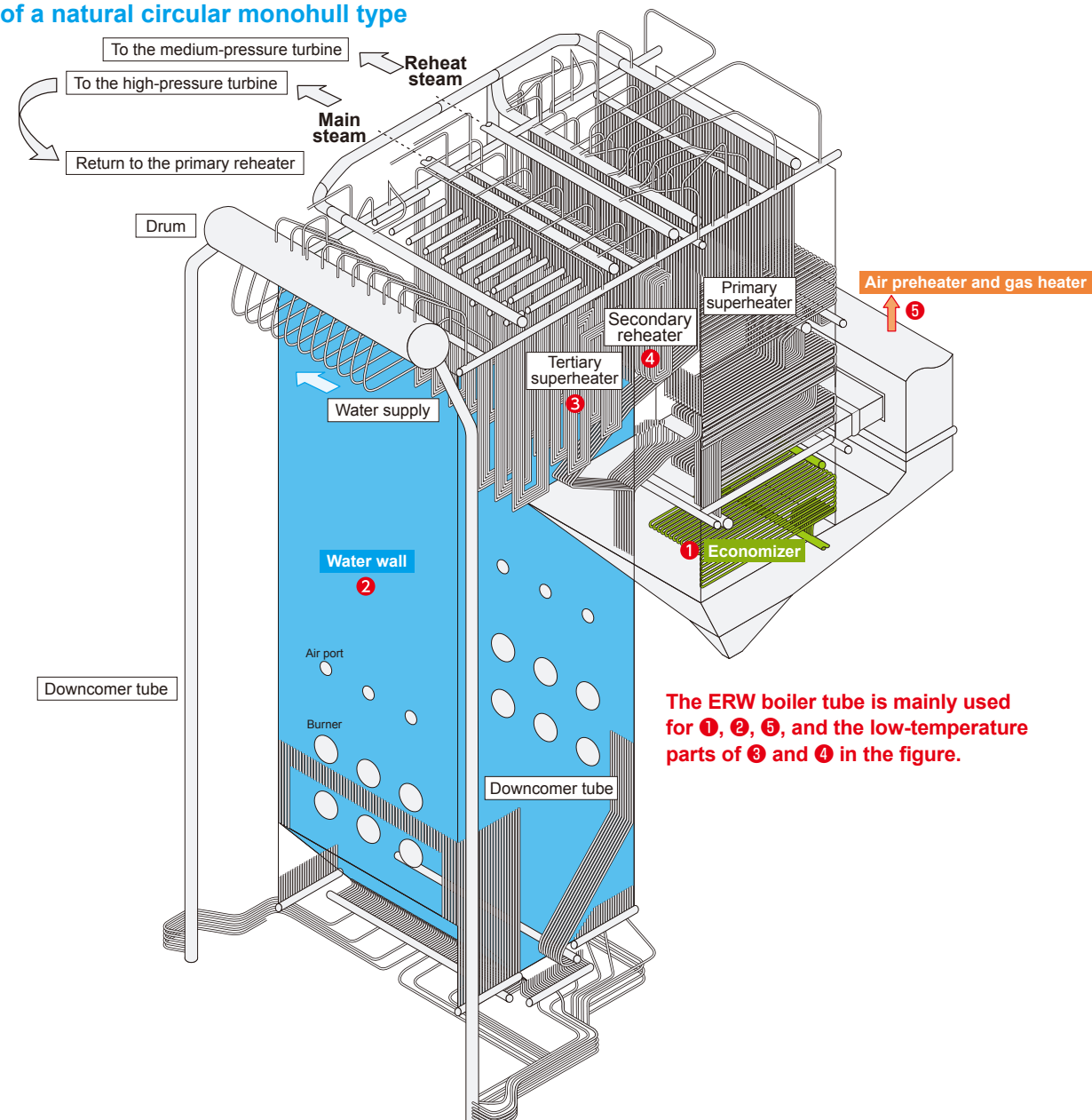
- We have established a thorough management system, ranging from technical service to product delivery, in order to respond to every request and offer consultation regarding usage.

Boiler Structure and an Example of the Utilized Parts of an ERW Boiler Tube

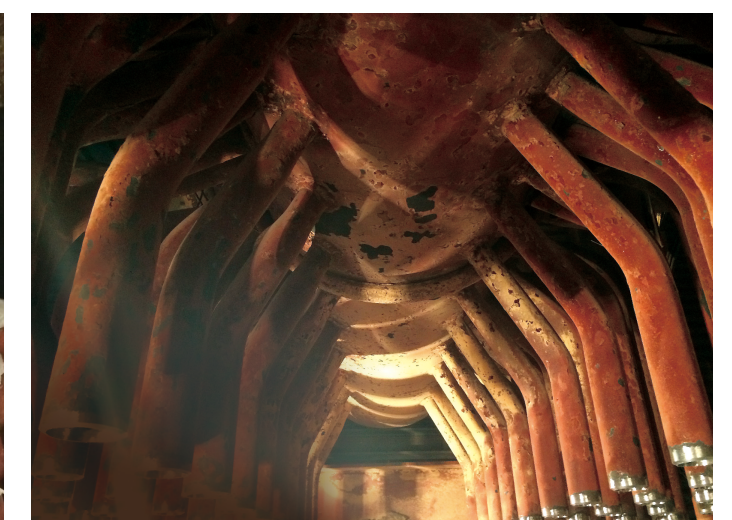
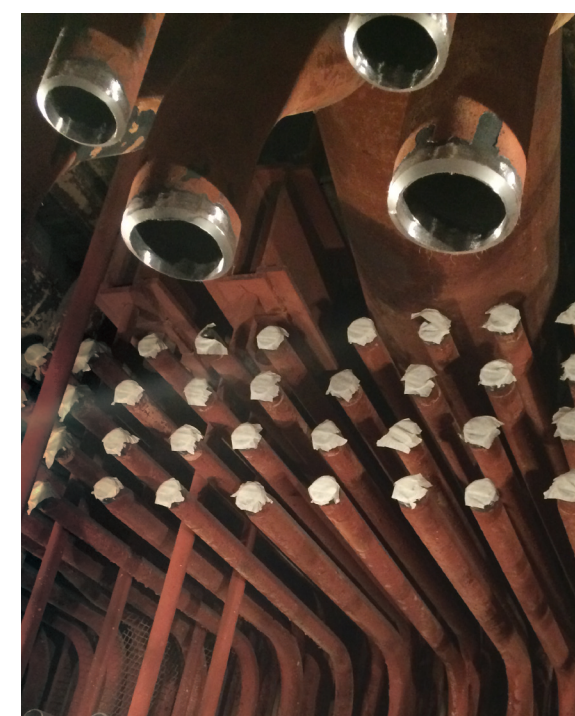
Steam circulation flow



Example of a natural circular monohull type



Application Examples



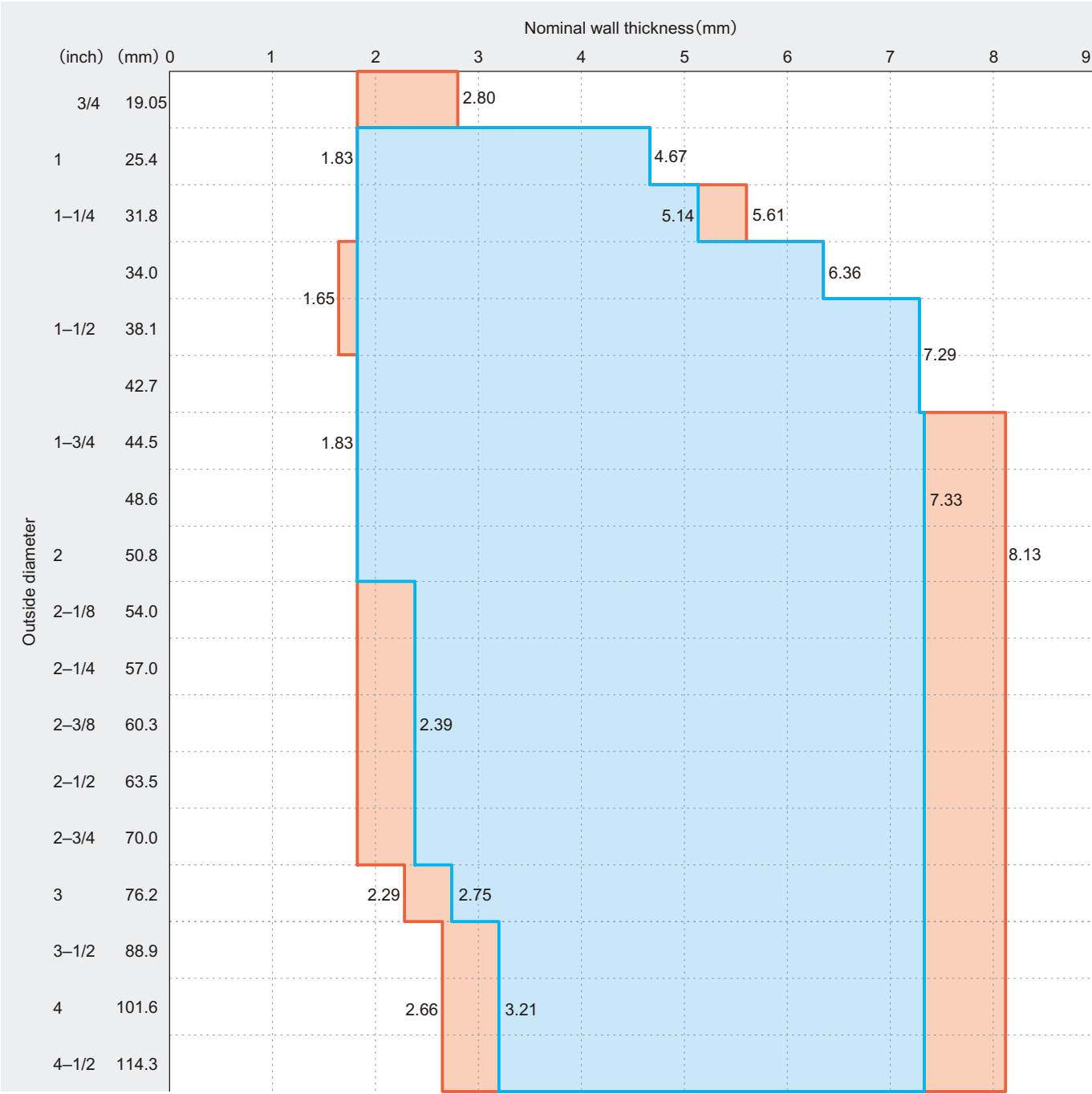
Production Standard

Classification	Grade	Example of the standard		
		National standard		
		ASTM/ASME(U.S.)	BS(U.K.)	JIS(Japan)
Low-carbon steel tube	320	A214/SA-214		
		A178/SA-178-Gr.A	3059-Pt.1-320	
	340			G 3461 STB340
Medium-carbon steel tube	360		3059-Pt.2-360	
	410	A178/SA-178-Gr.C	3059-Pt.2-440	G 3461 STB410
High-tensile steel tube	440			
	480	A178/SA-178-Gr.D		
	510			G 3461 STB510
Molybdenum alloy steel tube	0.5Mo	A250/SA-250-Gr.T1		G 3462 STBA12
		A250/SA-250-Gr.T1a		G 3462 STBA13
		A250/SA-250-Gr.T1b		
Chrome molybdenum alloy steel tube	1Cr-0.5Mo	A250/SA-250-Gr.T12	3059-Pt.2-620-460	G 3462 STBA22
Sulfuric and hydrochloric acid dew-point corrosion resistance steel tube	S-TEN™ 1 ²⁾	A423-Gr.3/ ASME Code Case 2494		KA-STB380J2 (METI)
Sulfuric acid dew-point corrosion resistance tube	CR1A			KA-STBA10 (METI)

Classification	Grade	Example of the standard				
		Classification standard ¹⁾				
		ABS(U.S.)	LR(U.K.)	DNV(Norway)	BV(France)	NK(Japan)
Low-carbon steel tube	320	AB-G			B320	KSTB33
	340					KSTB35
	360		LR-1-B360		B360	
Medium-carbon steel tube	410	AB-D				KSTB42
High-tensile steel tube	440					
	480	AB-F				
	510				B510	
Molybdenum alloy steel tube	0.5Mo					
Chrome molybdenum alloy steel tube	1Cr-0.5Mo				B1Cr-0.5Mo	
Sulfuric and hydrochloric acid dew-point corrosion resistance steel tube	S-TEN™ 1 ²⁾		S-TEN1			S-TEN1-EG
Sulfuric acid dew-point corrosion resistance tube	CR1A					CR1A

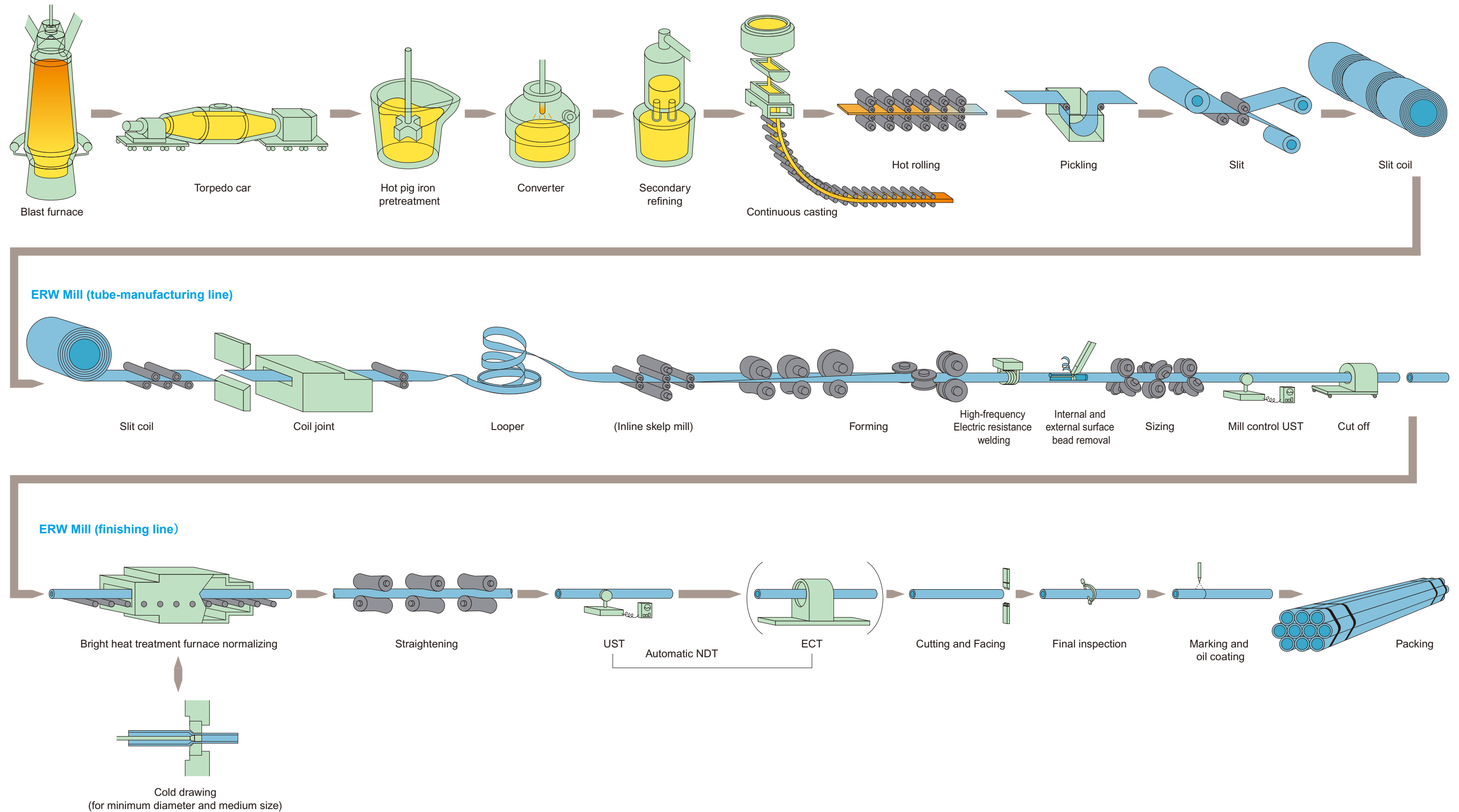
Notes : 1) The Classification standard DNV (Norway) was revised to quote international and national standards from the 2005 edition. Thus, unless otherwise specified, the JIS standard is applied.
In addition to the above standards, the product is also certified by KR (South Korea), and CR (Taiwan). Concerning the classification society (e.g., CCS [China], etc.) by which the product has not been certified, the product may be able to receive certification individually; thus, please consult with us.
2) S-TEN™ is our proprietary steel grade. For details, refer to the S-TEN™ series technical information.

Available Size Range



Blue box : All steel grades including Cr-Mo steel can be manufactured.
Orange box : Carbon steel, S-TEN™ 1, and 0.5% Mo steel can be manufactured.

Manufacturing Process



Grooving Corrosion Prevention

During the 1960s, overseas-made ERW boiler tubes were adopted for thermal power plants and various plant tubing in Japan. However, since trouble caused by grooving corrosion occurred, the adoption of ERW boiler tubes was discontinued. Then, the clarification of grooving corrosion came to light, ERW tube manufacturing technology progressed, and ERW boiler tube performance was significantly improved. ERW boiler tubes have since been increasingly adopted in electric utility thermal power plants as well as industrial thermal power plants.

Figure 1 shows the grooving corrosion mechanism.

During ERW welding, the proximity of the butt portion is rapidly heated and cooled, and non-metallic inclusion MnS melts and then re-precipitates. However, due to high cooling speed, elemental diffusion does not catch up, the re-precipitation of MnS becomes incomplete, and the S concentration part is formed around MnS. Any potential difference between the S concentration part and MnS causes corrosion. The potential difference between the rapid-cooled composition in the proximity of the butt portion and normal rapid-cooled composition also causes grooving corrosion.

Therefore, the solution to grooving corrosion is: ❶ **lowering the S concentration in the steel** and ❷ **after welding, diminishing the potential difference from the base material through heat treatment such as by normalization to equalize the composition.**

Figure 2 shows the effect of S concentration and normalizing temperature affecting grooving corrosion depth.

It is said that the S quantity of the ERW boiler tubes imported from overseas in the past was about 0.020 to 0.040%. Then, manufacturing technology (of blast furnace manufacturers) in Japan progressed significantly, and according to our track records, the S quantity is currently reduced to a single-digit low level, such as 0.003% or less.

Since ❶ **S quantity has been extremely lowered** and as ❷ **the entire tube is normalized and heat treated including the welded part after welding**, as described above, there is no concern that our ERW tubes could cause grooving corrosion during use.

Figure 1 : Mechanism of grooving corrosion

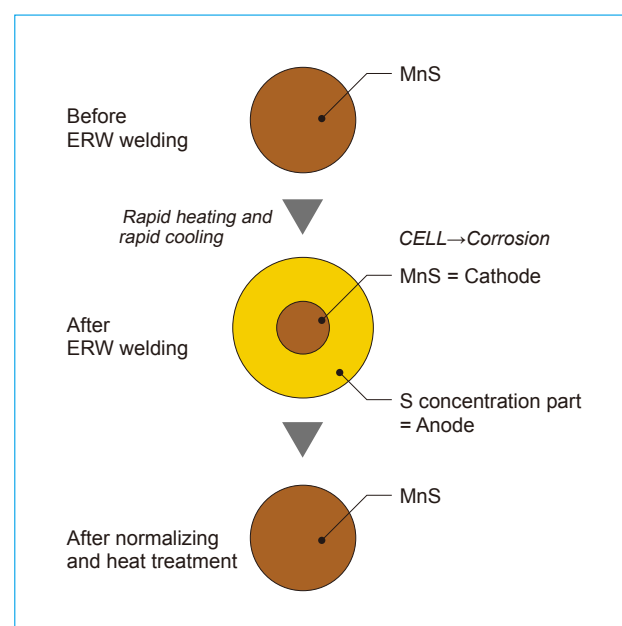
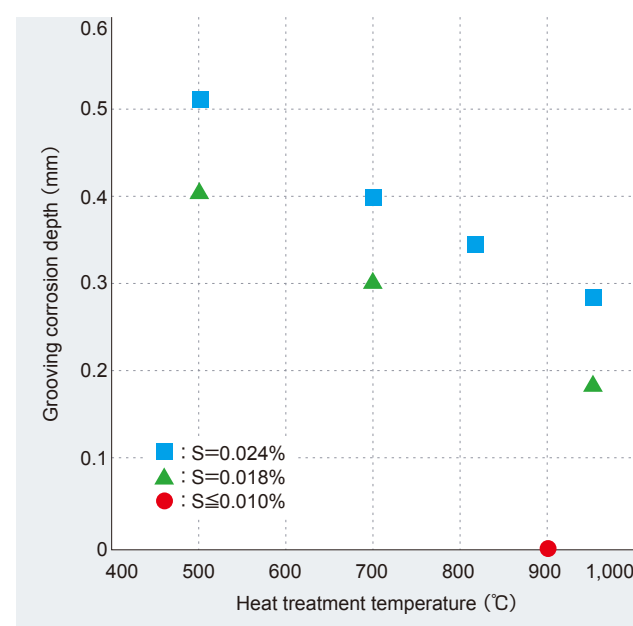
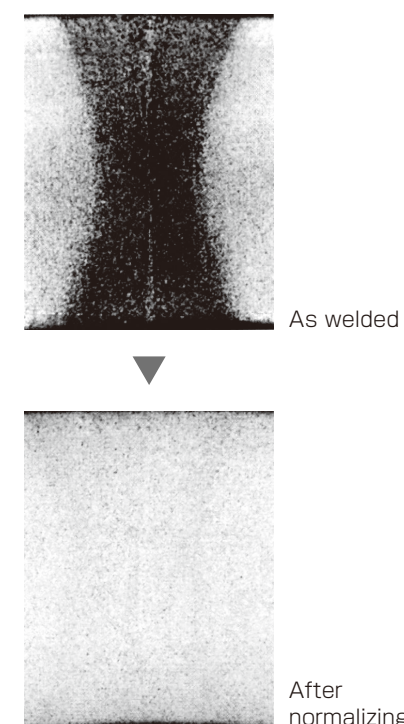


Figure 2 : Effect of S concentration and normalizing temperature on grooving corrosion (40°C, artificial seawater, one month)

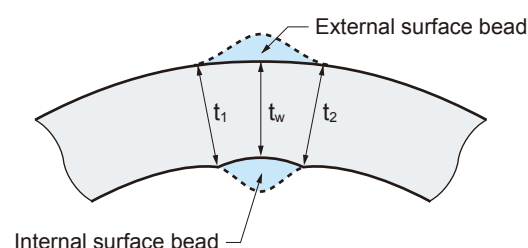
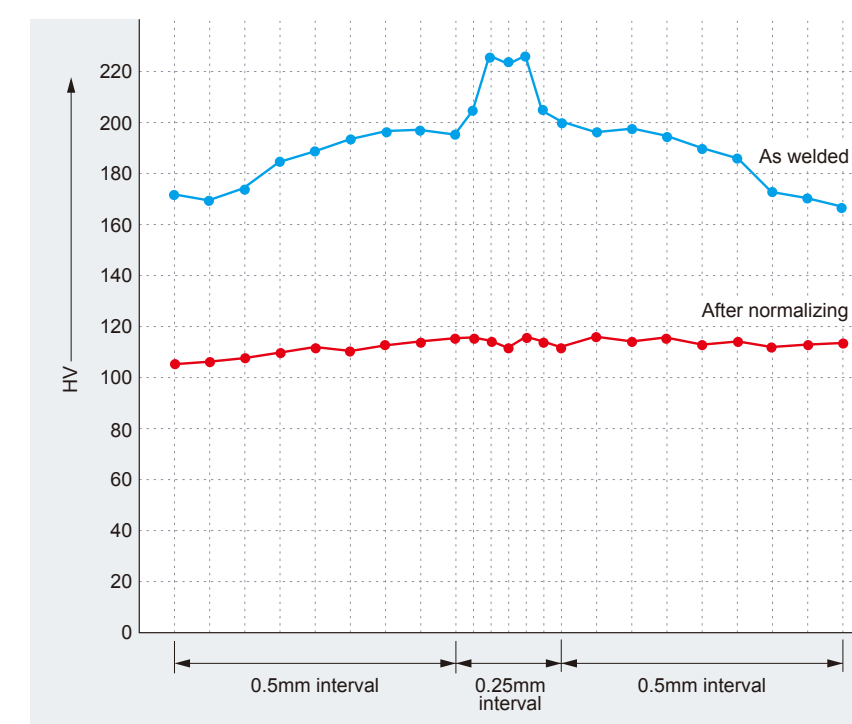


Welded Part Quality

Welded part composition



Hardness distribution (STB340 E-G 63.5×3.1mm)

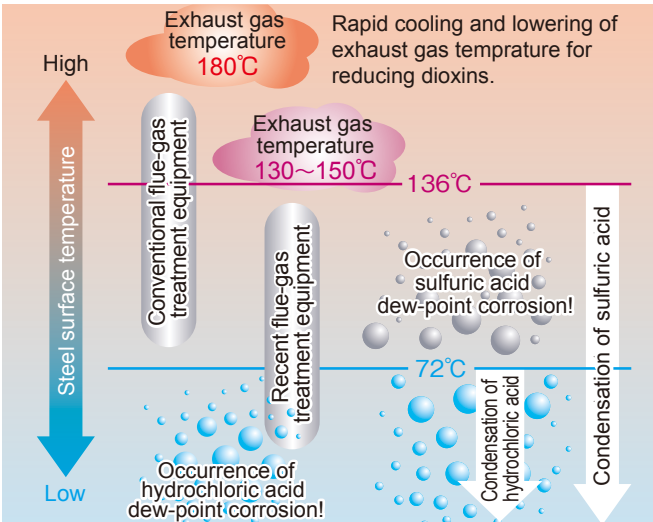


Notes 1) Internal surface bead height = $t_w - (t_1 \text{ or } t_2)$
 2) t_1 , t_2 , and t_w satisfy the lower limit of the thickness specification.

Introduction to original high-function steel grade

Sulfuric and Hydrochloric Acid Dew-point Corrosion Resistance Steel Tubes : S-TEN™1

There are cases where the exhaust gas treatment equipment of refuse incineration facilities or boiler air preheaters using fuel containing sulfur and chlorine is subjected to sulfuric and hydrochloric acid dew-point corrosion. In such an acid dew-point corrosion environment, not only common steel but also stainless steel cannot be used. We have thus developed S-TEN™ as a material that can be used in such an environment, and we manufacture and sell S-TEN™1 steel tubes. The S-TEN™1 steel tubes can be used as METI "KA-STB380J2," "KA-STPT380J2," and "ASME Code Case 2494." They are also certified by the NK (Japan) and LR (United Kingdom) classification societies.



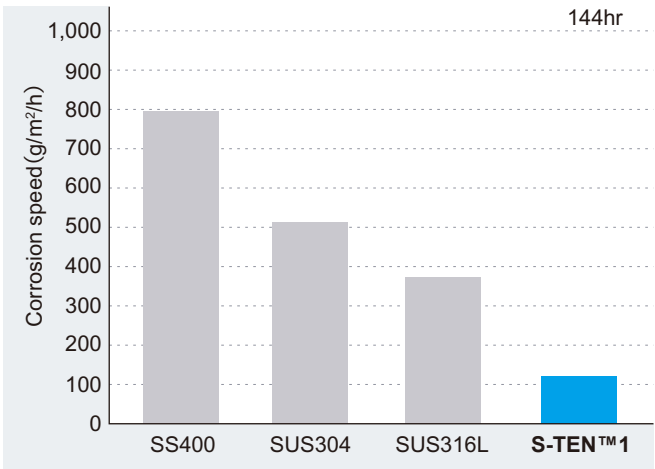
Chemical composition (mass%)

Steel grade	C	Si	Mn	P	S	Cu	Sb	Ni
S-TEN1	≤0.14	≤0.55	≤1.60	≤0.025	≤0.025	0.25~0.50	≤0.15	≤0.50

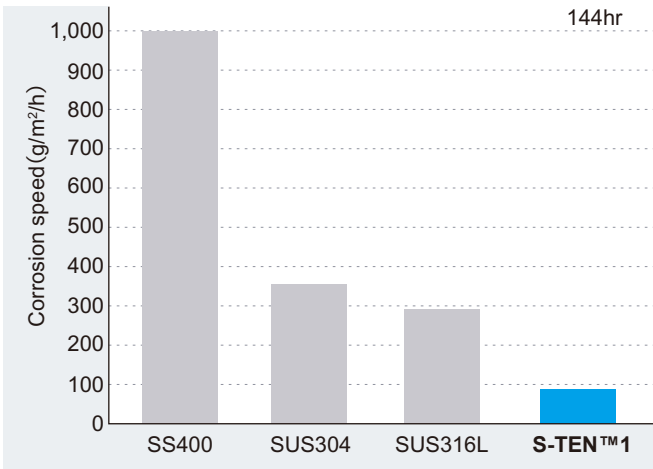
Quality property

•Corrosion resistance

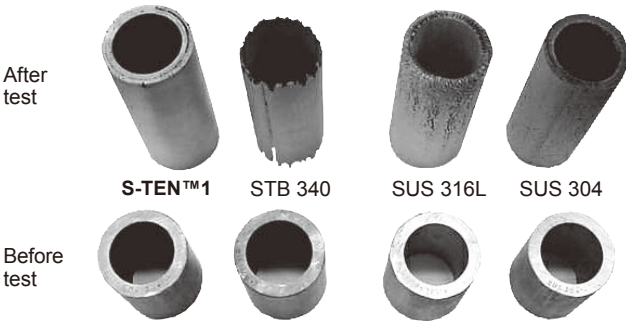
Sulfuric acid resistance(50%, 70°C H₂SO₄)



Hydrochloric acid resistance(10.5%, 80°C HCℓ)



Steel tube corrosion test sample
(10.5% hydrochloric acid, 80°C , 144 hr)



In such environment, this steel has a corrosion resistance that is superior to the stainless steel.

•Mechanical property

	Tensile strength (MPa)	Yield strength (MPa)	Elongation (%)
Specification	380min.	230min.	35min.

Introduction to original high-function steel grade

Sulfuric Acid Dew-point Corrosion Resistance Steel Tubes : CR1A

In a air preheater, economizer, etc., in the oil-fired boiler using waste gas generated when fuel containing sulfur combusts, sulfuric acid dew-point corrosion at the cold portion may cause corrosion problem. We also manufacture and sell CR1A, which protects corrosion using a Cr-Cu system, together with the S-TEN™1 steel tubes described at left, for these applications.

Standard : METI KA-STBA10 (with seamless tube and welded tube products)

Chemical composition (mass%)

Steel grade	C	Si	Mn	P	S	Cu	Cr
CR1A	0.10max.	0.20~0.80	0.80max.	0.025max.	0.015~0.030	0.25~0.35	1.00~1.50

Quality property

•Mechanical property

Steel grade	Dimensions (mm)	Tensile strength (MPa)	Yield strength (MPa)	Elongation (%)
CR1A	Specification	—	410min.	25min.
	Example	φ63.5×t7.0	473	322

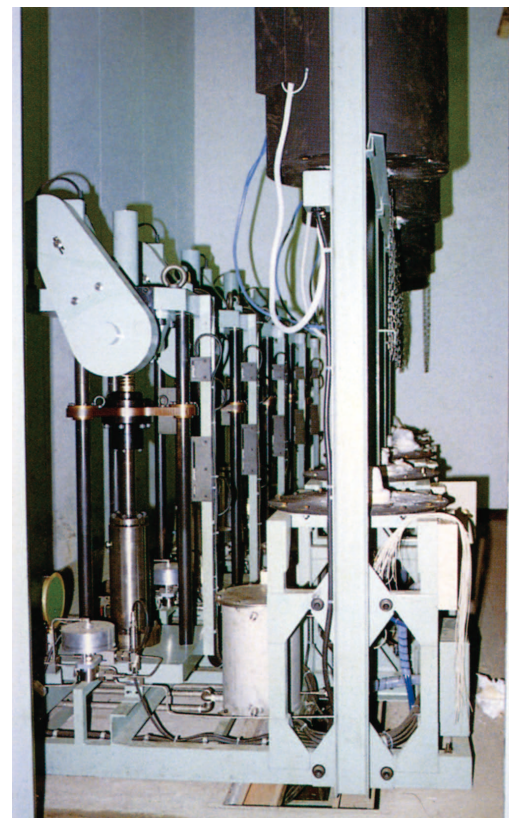
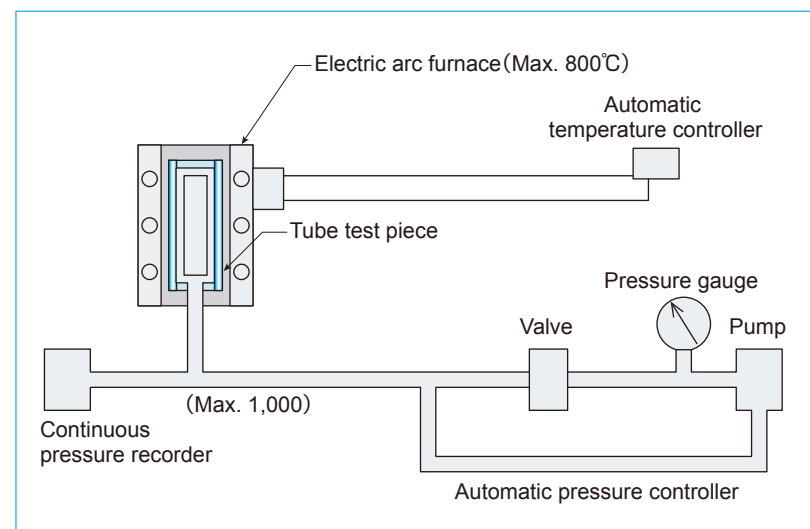
Example of a track record

Usage condition	Dimensions (mm)	Code	Material used			
			Quantity of corrosion		Depth of corrosion	
			Average (%)	Ratio	Average (mm)	Ratio
Boiler air preheater Fuel : C heavy oil Usage condition : 2,627 hrs External surface : Air Inside tube : Combustion gas	φ48.6×3.6t	CR1A	1.85	1.00	0.17	1.00
		Carbon steel	9.32	5.04	1.61	9.48

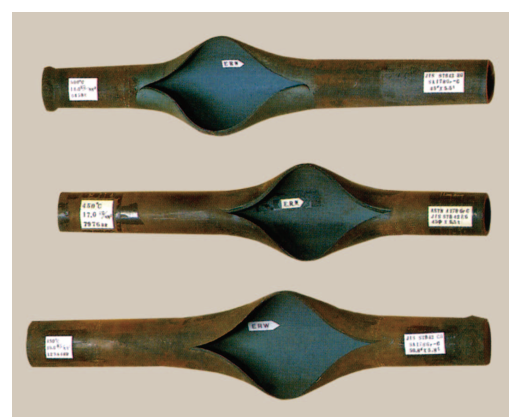
Creep Strength

We have an internal pressure creep test system for the ERW boiler tubes.
Figure 1 shows a schematic view of the test system.

Figure 1 : Internal pressure creep test system



Internal pressure creep test equipment



Internal pressure creep test piece and rupture position

Marking, Oil Coating, and Packing

Any steel tube that has passed the inspection is marked with a corporate name or emblem, the JIS mark, a standard code, the manufacturing method, dimensions, facility abbreviation, and date of manufacture, etc., is coated with anti-corrosion oil as specified by the customer, and is then bundled and packed for shipment.

Example of marking



① Manufacturer	③ Manufacturing Process	⑤ Manufacture Number
② Specification and Grade	④ Size (Outside Diameter, Wall Thickness, Length)	⑥ Country of Manufacturing

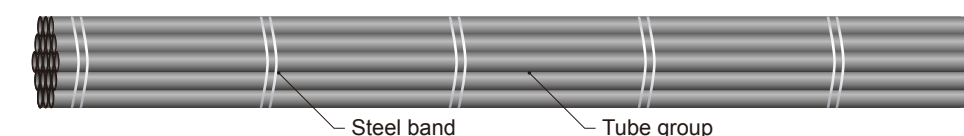
* If the marking of the inspected tube according to the classification standard is required, etc., the steel tube is attached with a metal tag on the bundle instead of the tube body, and this metal tag is marked.

Oil coating and packing

Unless otherwise specified, up to 2.5-ton steel tubes are tied together with a steel band in a hexagonal shape. The steel tubes are tied directly with the steel band, in principle. However, the steel tubes can also be tied with the steel band after the tube groups are protected with a vinyl sheet, chemical fiber cloth, etc.

* Standard specification

The standard oil coating and tying specification for our electric resistance-welded steel tube for boilers and heat exchangers is as follows.



Oil coating: Long-term anti-corrosion oil coating

Tube end protection: None

Tying: Steel band (without protection under the band)

Requests during orders

When ordering and inquiring about our stainless steel tubes, you are requested to inform us about the following items.

- | | |
|---|---|
| 1. Steel tube standard and type | 6. Packing type |
| 2. Dimensions (outside diameter, thickness, and length) | 7. Number of copies of the inspection certificate |
| 3. Quantity | 8. With or without a witnessed inspection |
| 4. Delivery date and destination | 9. Other and specially requested items |
| 5. Applications and usage condition | |