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New Products & Technologies

Development of Flexible Corrugated Stainless Steel Tubing for Gas Piping*

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1 Introduction

Conventional indoor gas piping generally consists of rigid galvanized tubes joined by screw joints. Recently, however, a radically different process was developed aimed at rationalizing the handling of such gas piping. Desired features were a shorter installation period, easy workability, and improved safety.

The new piping system uses flexible stainless steel tubing. The tubing, supplied in coils, is run directly from the gas meter to the individual gas cocks. A single tube is used for each cock, no need for intermediate branching for connections. The system was developed by Osaka Gas Co., Ltd. and other leading city gas utility in Japan, and is now being adopted also for LP gas.

Kawasaki Steel has established a manufacturing process for flexible stainless steel tubing which completely satisfies the specifications of the new piping system, and has begun already the commercial supply of the new tubing.

2 Manufacturing Method

The flexible stainless steel tubing is supplied to customers in coil form. The tubing itself is vinyl-coated, annularly-corrugated (peak-shaped, with each peak independent) stainless steel of grade AISI 304. The manufacturing process is shown in **Fig. 1**.

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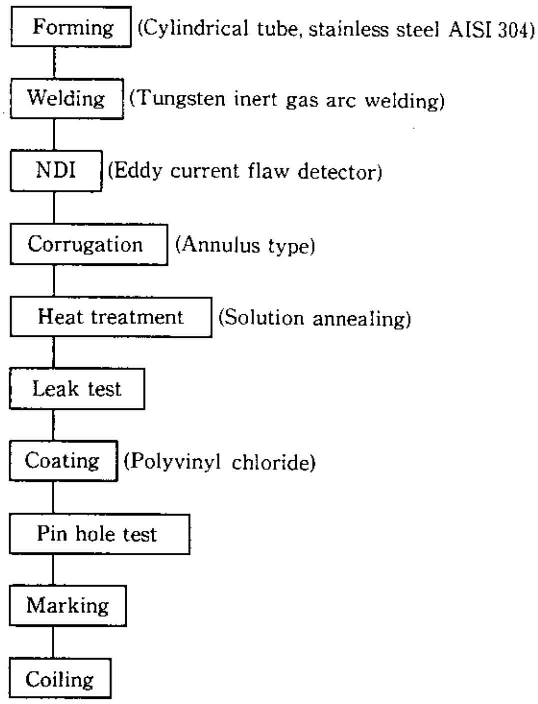

Fig. 1 Manufacturing process

3 Product Specifications and Features

3.1 Typical Specifications

Six standard sizes, 8A to 32A, are currently available. The flexible stainless steel tubing is made in independent rings, as shown in **Fig. 2**, to facilitate cutting and improve sealability when a joint connection is used. **Table 1** shows the typical dimensions of the available tubing sizes.

The base material of the tubing is AISI 304 stainless steel; the outside coating material is soft polyvinyl chloride. In service, the tubing carries combustible gas, and in some circumstances is repeatedly bent. Considering the potential dangers involved, performance tests, as

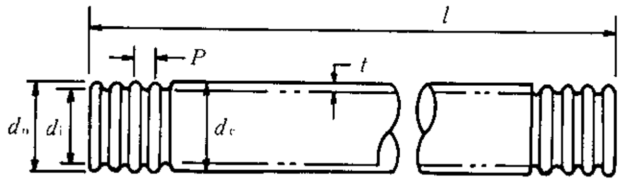

Fig. 2 Configuration of corrugated stainless steel tube

Table 1 Dimensions and material of stainless steel flexible pipe

Material	SUS 304					
External coating	PVC					
Nominal diameter	8A	10A	15A	20A	25A	32A
t (mm)	0.20	0.20	0.20	0.20	0.25	0.25
d_i (mm)	8.9	11.5	15.0	20.8	25.0	32.0
d_o (mm)	11.5	14.2	18.4	24.2	30.8	38.8
P (mm)	3.3	3.4	3.8	4.2	6.0	7.0
d_c (mm)	12.7	15.4	19.6	25.4	32.0	40.0
l (m)	30,50	30,50	30	30	30	20

Table 2 Performance test of flexible stainless steel tube

Item	Bare pipe	Coated pipe	Test condition
Stress corrosion cracking test	○		No leakage after 14 h in boiling NaCl (20%) and $NaNO_2$ (30 ppm) solution at the 180° bend
Hydraulic test	○		No leakage at 8 kgf/cm² for 30 s
Pressure leakage test	○		No leakage at 5 kgf/cm² for 15 min
Tensile test	○		No leakage at 160 kgf tensile load
Twisting test	○		No leakage after 5 times of 90° reverse twist
Bending test	○	○	No leakage and no coating damage after 8 times (R=40 mm) of 180° reverse bend
Flame test		○	No burning more than 5 s after exposure to flame for 5 s
Weathering test		○	No damage on the coating after 600 h exposure to sunshine carbon weather meter
Chemical resistance test		○	No damage on the coating after dipping in oil, chemical, etc.
Thermal cycle test		○	No damage on the coating after 5 thermal cycle (70°C→−5°C)

shown in **Table 2**, are conducted as a quality assurance measure.

3.2 Characteristics

The characteristics of the flexible gas-piping are shown below for representative sizes, 8A, 10A, and 15A.

3.2.1 Pressure resistance test

The results of the pressure resistance test are shown in **Table 3**. In general, the house gas is used at pressures of below 1 kgf/cm², but the tubing showed no anomalies at pressures as high as 8 kgf/cm². The bursting pressure was 100 kgf/cm² or above, indicating sufficient pressure resistance.

Table 3 Hydraulic test

Nominal diameter	8.0 kgf/cm²	Burst pressure (kgf/cm²)
8 A	No leakage	240
10 A	No leakage	220
15 A	No leakage	180

3.2.2 Bending characteristics

The results of the bending test and repetitive twisting test are shown in **Table 4**. The tubing is corrugated, with deep grooves, single peaks, and short pitches, and bright annealed, ensuring satisfactory bending characteristics.

Table 4 Formability

Nominal diameter	Bending		Twisting	
	Specification	Test data	Specification	Test data
8 A	≥8	22	≥5	11
10 A	≥8	24	≥5	12
15 A	≥8	38	≥5	14

3.2.3 Weather resistance test

Figure 3 shows the physical properties of poly vinyl chloride when a sample was irradiated using a sunshine carbon weather meter for 2 000 hr. Deterioration was

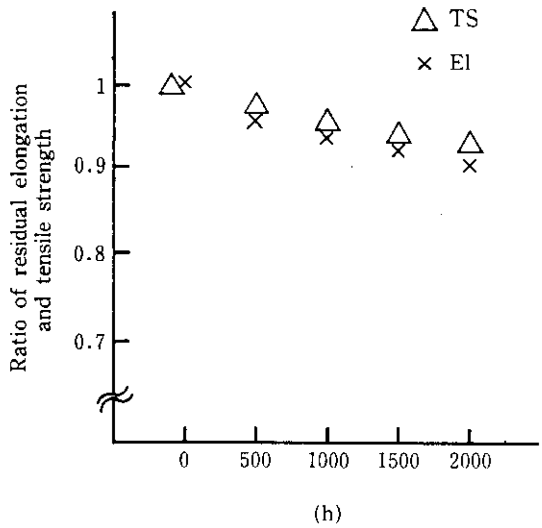

Fig. 3 Results of weathering test

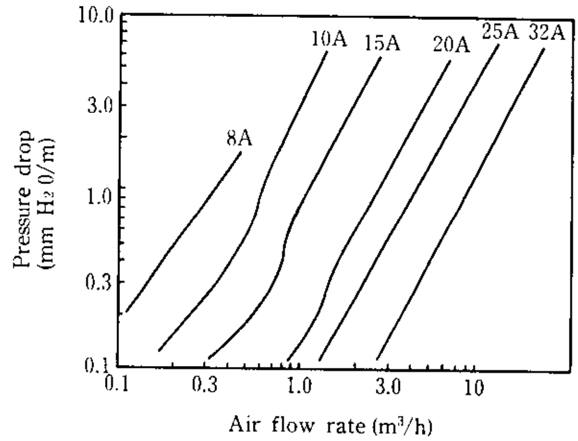

Fig. 4 Pressure drop diagram of flexible stainless steel tube

slight, and no defects such as cracking of the coating film occurred, indicating satisfactory weather resistance.

4 Bore Selection Method

For Practical use, the tubing bore is determined based on the design gas flow rate, the pipe laying length, and pressure loss.

Figure 4 shows pressure loss per meter for various tubing bores. The pressure loss values are obtained from the Pressure Loss Chart, which is used in determining the required bore. The pressure loss values shown in Fig. 4 are values when air is passed through the tubing. The effect of the bent portion (one bend per 2 meters of flexible tubing, bending radius $R = 50$ mm) has been included in the calculation. For use with gas, the design gas flow rate is converted into an air flow rate using the following equation. The pressure loss at an air flow rate corresponding to service conditions is then read from Fig. 4:

$$Q_{air} = \sqrt{S} \times Q_{gas}$$

where

Q_{air}: Air flow rate (m^3/h)
Q_{gas}: Design gas flow rate (m^3/h)
S: Specific gravity of gas (air = 1)

5 Concluding Remarks

Kawasaki Steel has established a manufacturing process for high-performance, high-quality flexible stainless steel tubing suitable for the type of flexible-tubing gas piping now being widely adopted in residential construction in Japan. The application of this system in the U.S. is being developed by Gas Research Institute in Chicago with the cooperation of Japanese gas utilities on agreement basis. It may require to clear the technical and regulation code approvals as is promoted by the gas industries there for this system to be accepted. This type of gas supply system represents a revolution in gas piping and is likely to find increasingly wide acceptance, and Kawasaki Steel is confident that its products will fully satisfy all necessary safety and handling requirements.