



# Recent Progress in Techniques of Manufacturing Small Diameter Electric-Resistance Weld Tubes\*

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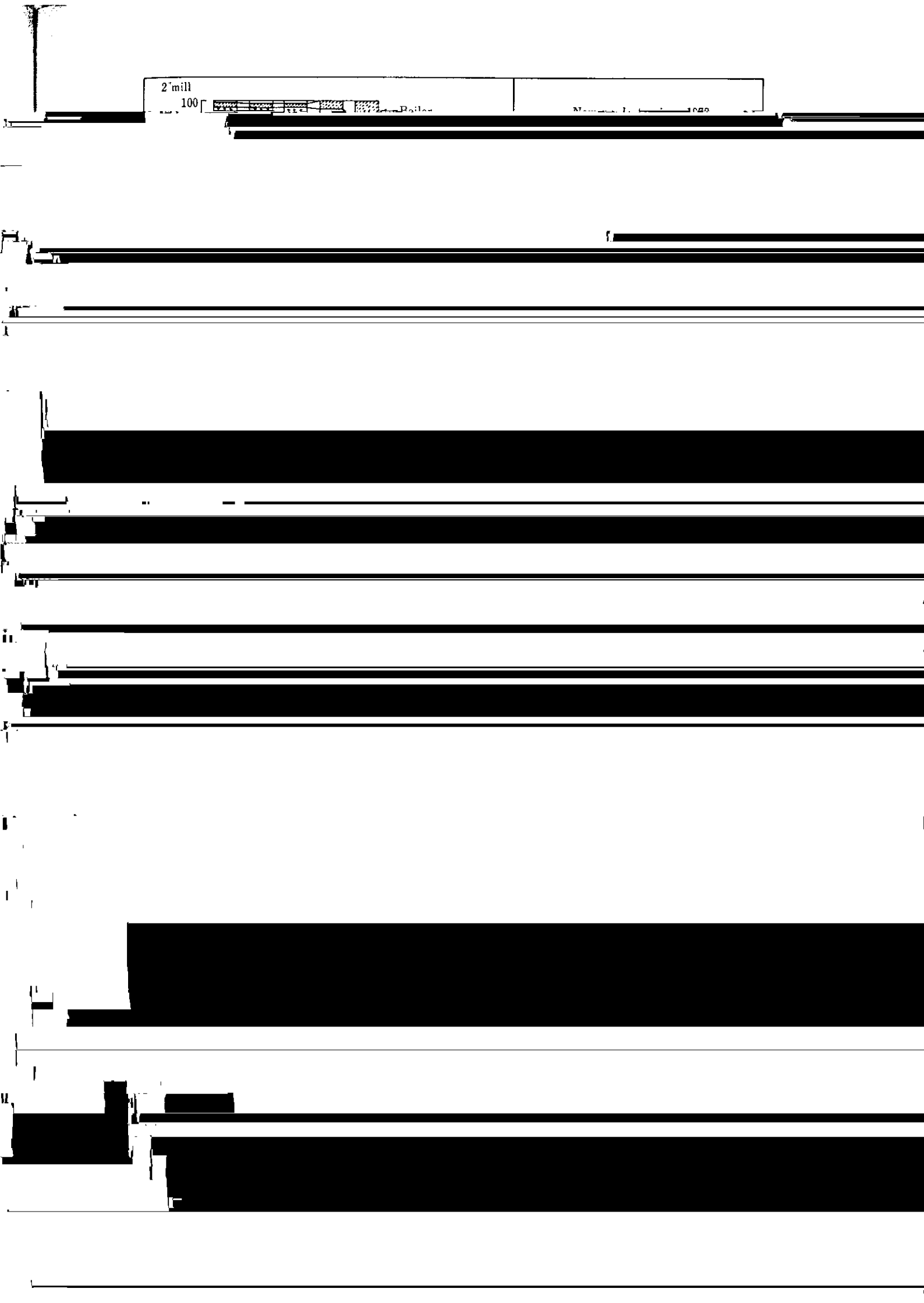
*To meet an ever-increasing demand for higher-grade small diameter electric-resistance weld (ERW) tubes, such as oil country tubular goods (OCTG), mechanical tubing and boiler tubes, remarkable technical developments have been achieved in the manufacture of these products. This report deals with some of the achievements made in this field by Kawasaki Steel Corporation.*

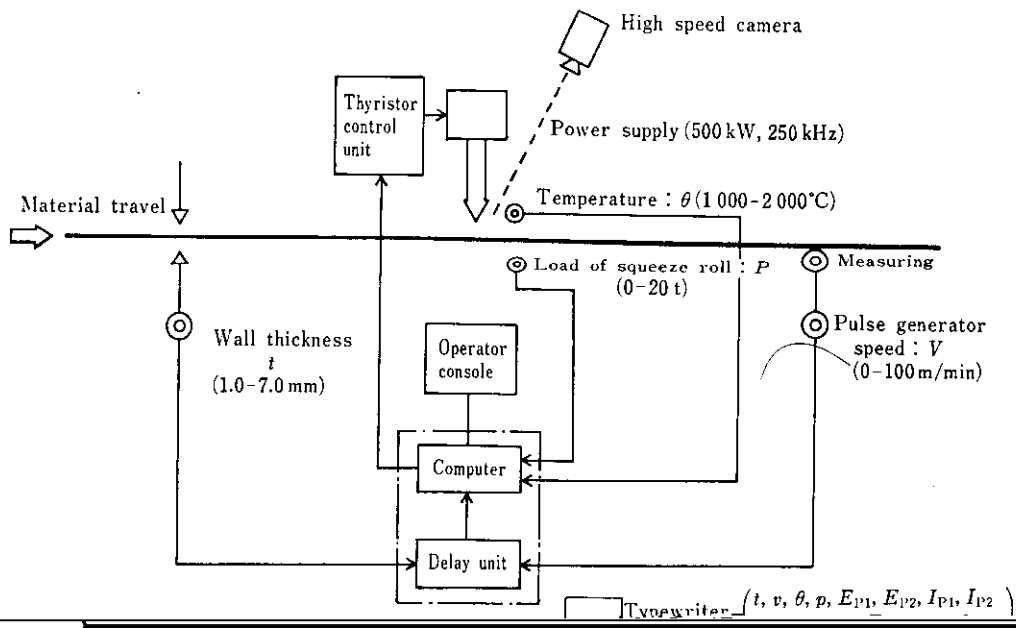
material advanced pipe-making techniques and a

Remarkable progress in techniques of manufacturing small diameter ERW tubes in recent years has considerably increased the weld integrity of the tubes. As the result, small diameter ERW tubes are now

deals with the following major techniques developed to manufacture high-grade small diameter tubes:

- 1) Automatic heat control technique
- 2) ERW OCTG manufacturing technique





$E_p$  : Plate voltage,  $I_p$  : Plate current  
 $I_g$  : Grid current

Fig 2 Automatic heat input control system in 2400 kW mill

longitudinal variation of sheet coil thickness and the

$$\Delta E = (A \cdot \frac{t - t_s}{t_s} + B \cdot \frac{v - v_s}{v_s})$$

Now, since there is a correlation between the upset

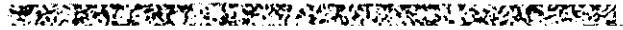
Size (mm) and grade

Amount of

**Table 2** API specifications

| Grade | Type | Chemical composition(%) |    |    |   |   | Heat Treatment | Yield strength |     | Tensile strength | Elongation | Flattening tests |     | Hardness |
|-------|------|-------------------------|----|----|---|---|----------------|----------------|-----|------------------|------------|------------------|-----|----------|
|       |      | C                       | Mn | Si | P | S |                | Min            | Max | Min              |            | S                | Min |          |

Pipe size :  $5\frac{1}{2}''\phi \times 0.304''t$   
Nominal pipe temperature : 00000



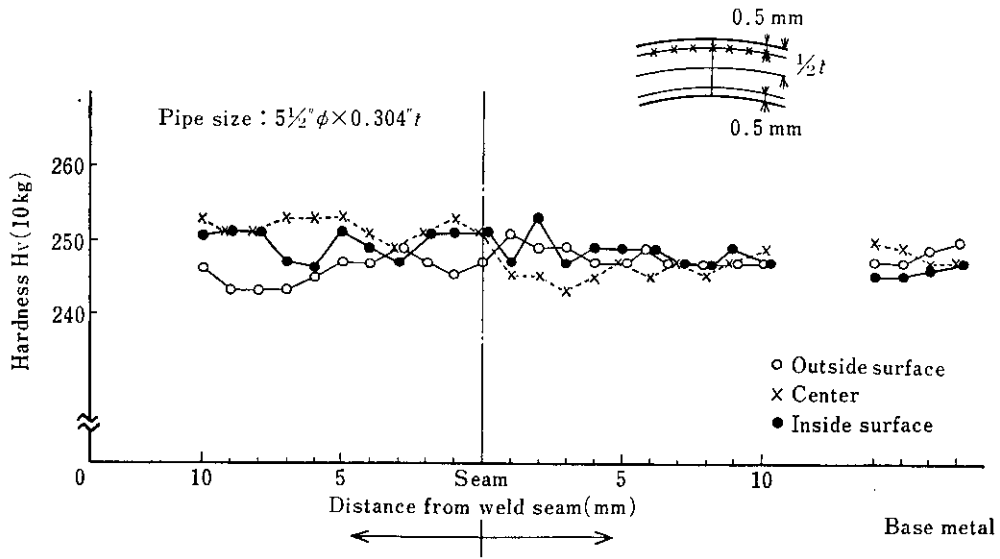


Fig. 8 Hardness distribution of API 5A N-80 across weld

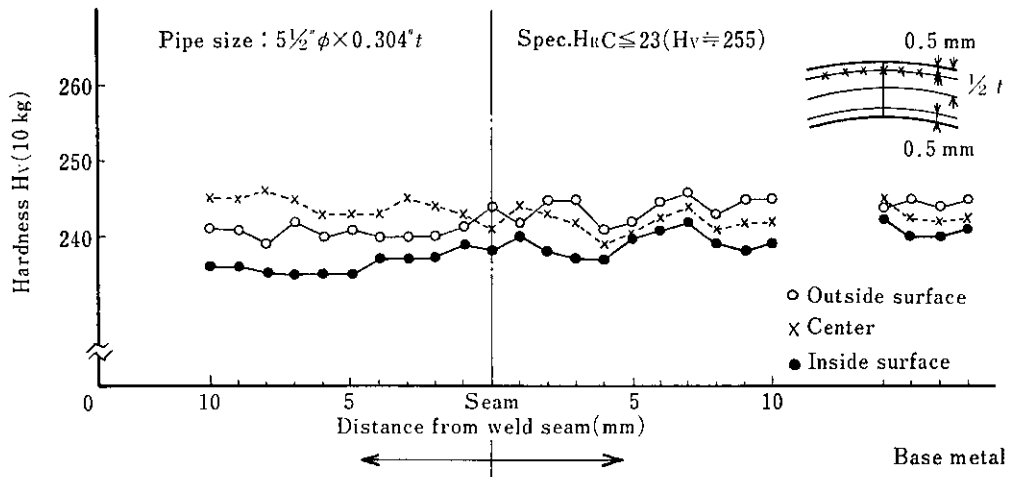


Fig. 9 Hardness distribution of API 5AC L-80 across weld

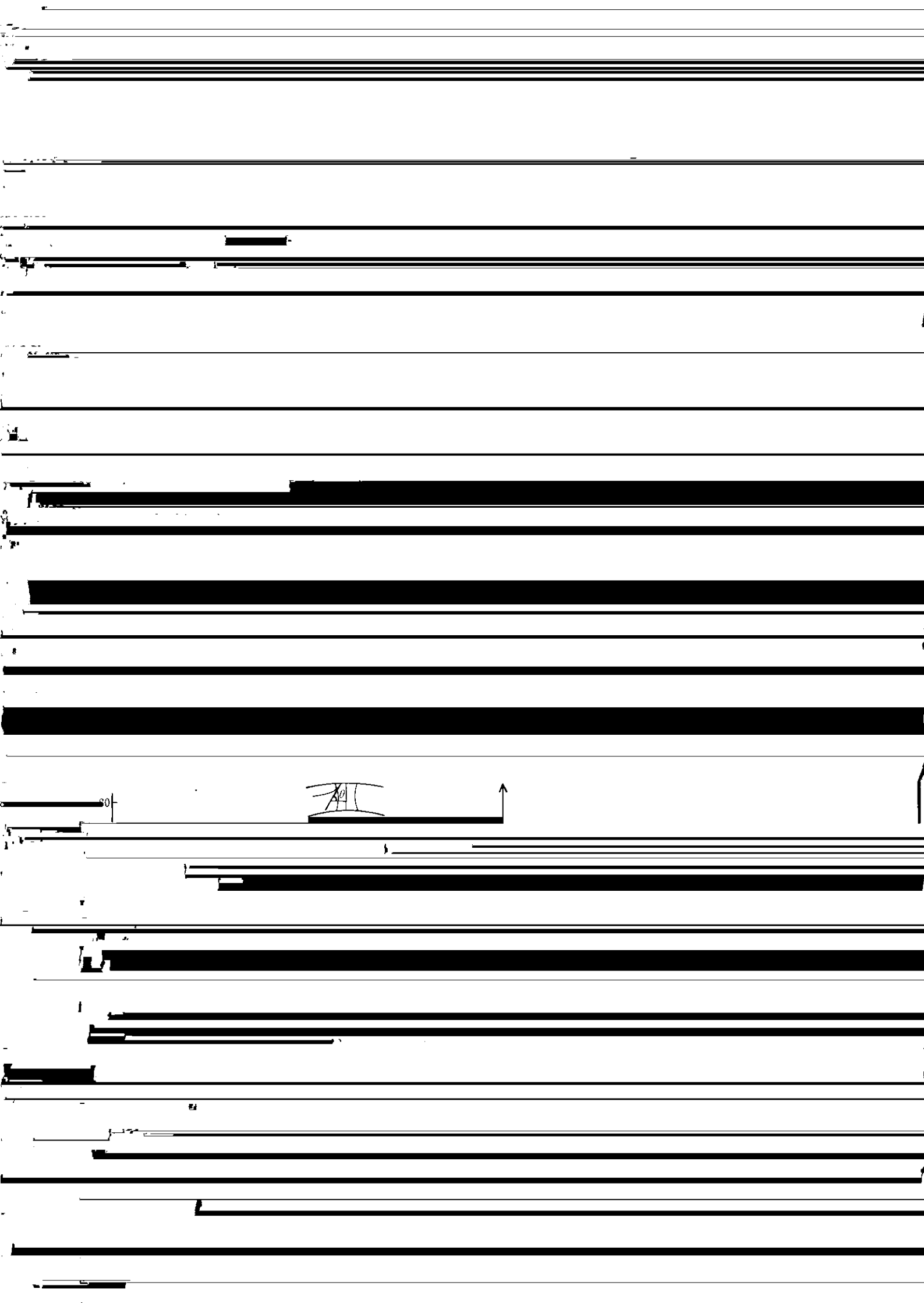
1.1.1 Weld quality

1.1.2 Collapse strength

The API standard stipulates that the flattening test should be performed as one of the methods for evaluating the strength of weld seam portions. In the case of high strength steel pipes such as those of N-80

One of the factors which affect the collapse strength value is the dimensional accuracy of pipes, namely the degree of out-of-roundness and eccentricity; in the case of the quenched and tempered pipes  $0.14 < D/t < 20$  and  $55 \text{ kbf/in}^2 < \sigma < 100 \text{ kbf/in}^2$





**Table 3** Chemical compositions of penetrator in Cr bearing low alloy ERW steel pipes

| Element | Chemical Composition (%) |
|---------|--------------------------|
| C       | 0.05 - 0.15              |
| Mn      | 0.10 - 0.30              |
| P       | 0.005 - 0.010            |
| S       | 0.005 - 0.010            |
| Cr      | 0.50 - 1.00              |
| Mo      | 0.01 - 0.03              |
| Ni      | 0.01 - 0.03              |
| Al      | 0.01 - 0.03              |
| Si      | 0.01 - 0.03              |
| Fe      | Balance                  |

Table 4 Measured melting temperature of various FeO-MnO-SiO<sub>2</sub>-Cr<sub>2</sub>O<sub>3</sub> oxides

| Sample No. | Composition (wt%)  | Measured Melting Temperature (°C) |
|------------|--|-----------------------------------|
| 1          | FeO 50, MnO 30, SiO <sub>2</sub> 10, Cr <sub>2</sub> O <sub>3</sub> 10 | 1200                              |
| 2          | FeO 40, MnO 40, SiO <sub>2</sub> 10, Cr <sub>2</sub> O <sub>3</sub> 10 | 1150                              |
| 3          | FeO 30, MnO 50, SiO <sub>2</sub> 10, Cr <sub>2</sub> O <sub>3</sub> 10 | 1100                              |
| 4          | FeO 20, MnO 60, SiO <sub>2</sub> 10, Cr <sub>2</sub> O <sub>3</sub> 10 | 1050                              |
| 5          | FeO 10, MnO 70, SiO <sub>2</sub> 10, Cr <sub>2</sub> O <sub>3</sub> 10 | 1000                              |
| 6          | FeO 5, MnO 80, SiO <sub>2</sub> 10, Cr <sub>2</sub> O <sub>3</sub> 5   | 950                               |
| 7          | FeO 1, MnO 90, SiO <sub>2</sub> 5, Cr <sub>2</sub> O <sub>3</sub> 4    | 900                               |
| 8          | FeO 0, MnO 95, SiO <sub>2</sub> 5, Cr <sub>2</sub> O <sub>3</sub> 0    | 850                               |
| 9          | FeO 0, MnO 90, SiO <sub>2</sub> 10, Cr <sub>2</sub> O <sub>3</sub> 0   | 800                               |
| 10         | FeO 0, MnO 85, SiO <sub>2</sub> 15, Cr <sub>2</sub> O <sub>3</sub> 0   | 750                               |
| 11         | FeO 0, MnO 80, SiO <sub>2</sub> 20, Cr <sub>2</sub> O <sub>3</sub> 0   | 700                               |
| 12         | FeO 0, MnO 75, SiO <sub>2</sub> 25, Cr <sub>2</sub> O <sub>3</sub> 0   | 650                               |
| 13         | FeO 0, MnO 70, SiO <sub>2</sub> 30, Cr <sub>2</sub> O <sub>3</sub> 0   | 600                               |
| 14         | FeO 0, MnO 65, SiO <sub>2</sub> 35, Cr <sub>2</sub> O <sub>3</sub> 0   | 550                               |
| 15         | FeO 0, MnO 60, SiO <sub>2</sub> 40, Cr <sub>2</sub> O <sub>3</sub> 0   | 500                               |
| 16         | FeO 0, MnO 55, SiO <sub>2</sub> 45, Cr <sub>2</sub> O <sub>3</sub> 0   | 450                               |
| 17         | FeO 0, MnO 50, SiO <sub>2</sub> 50, Cr <sub>2</sub> O <sub>3</sub> 0   | 400                               |
| 18         | FeO 0, MnO 45, SiO <sub>2</sub> 55, Cr <sub>2</sub> O <sub>3</sub> 0   | 350                               |
| 19         | FeO 0, MnO 40, SiO <sub>2</sub> 60, Cr <sub>2</sub> O <sub>3</sub> 0   | 300                               |
| 20         | FeO 0, MnO 35, SiO <sub>2</sub> 65, Cr <sub>2</sub> O <sub>3</sub> 0   | 250                               |
| 21         | FeO 0, MnO 30, SiO <sub>2</sub> 70, Cr <sub>2</sub> O <sub>3</sub> 0   | 200                               |
| 22         | FeO 0, MnO 25, SiO <sub>2</sub> 75, Cr <sub>2</sub> O <sub>3</sub> 0   | 150                               |
| 23         | FeO 0, MnO 20, SiO <sub>2</sub> 80, Cr <sub>2</sub> O <sub>3</sub> 0   | 100                               |
| 24         | FeO 0, MnO 15, SiO <sub>2</sub> 85, Cr <sub>2</sub> O <sub>3</sub> 0   | 50                                |
| 25         | FeO 0, MnO 10, SiO <sub>2</sub> 90, Cr <sub>2</sub> O <sub>3</sub> 0   | 0                                 |

SiO<sub>2</sub>



FeO-MnO-SiO<sub>2</sub>

1712°



1785°

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

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**6 Conclusion**

The recent trend toward higher grade of small

**References**

1) S. Sugimura, K. Okuyama, T. Fukuda and H. Nakasui.