FIG. 1 EFFECT OF PRESSURE ON FLEXIBILITY FACTORS
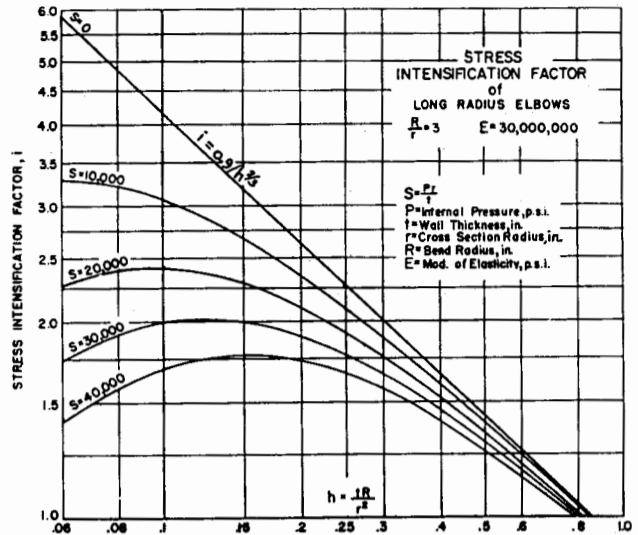

FIG. 2 EFFECT OF PRESSURE ON STRESS-INTENSIFICATION FACTORS
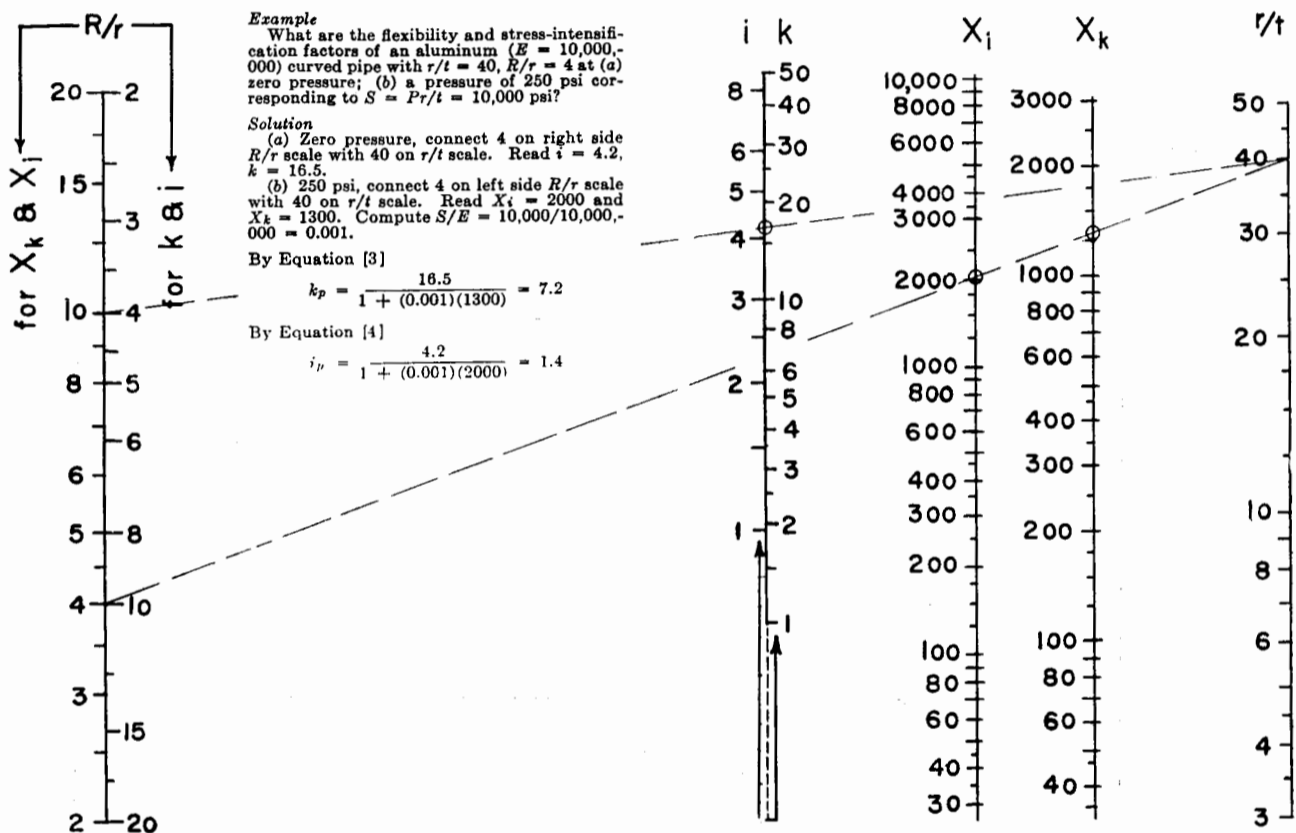

Example

What are the flexibility and stress-intensification factors of an aluminum ($E = 10,000,-000$) curved pipe with $r/t = 40$, $R/r = 4$ at (a) zero pressure; (b) a pressure of 250 psi corresponding to $S = Pr/t = 10,000$ psi?

Solution

(a) Zero pressure, connect 4 on right side R/r scale with 40 on r/t scale. Read $i = 4.2$, $k = 16.5$.

(b) 250 psi, connect 4 on left side R/r scale with 40 on r/t scale. Read $X_i = 2000$ and $X_k = 1300$. Compute $S/E = 10,000/10,000,-000 = 0.001$.

By Equation [3]

$$k_p = \frac{16.5}{1 + (0.001)(1300)} = 7.2$$

By Equation [4]

$$i_p = \frac{4.2}{1 + (0.001)(2000)} = 1.4$$

FIG. 3 NOMOGRAPH FOR OBTAINING k, i, k_p, and i_p

The effect of internal pressure on reducing the flexibility and stress-intensification factors on a curved pipe is illustrated in Figs. 1 and 2, respectively. The example covers long-radius welding elbows ($R/r = 3$) of r/t-ratios ranging from 3 to 50 and the range of internal pressures which produce up to 40,000 psi stress in steel pipe. When h is small the effect of pressure is significant. For example, without internal pressure a 24-in. standard-weight long-radius elbow ($h = 0.094$) has a flexibility factor of 17.5; with in-

ternal pressure corresponding to a stress of 10,000 psi the flexibility factor drops to 13.3, and at 40,000 stress to 8.2. The stress-intensification factor drops from 4.3 ($S = 0$) to 3.1 ($S = 10,000$) and to 1.7 ($S = 40,000$).

It is quite understandable that the effect of the internal pressure on thick-wall curved pipe was overlooked because, for values of the characteristic h covered by thick-wall pipe the change in

flexibility and stress intensification with usual pressures is of the same order as might occur due to commercial variation in pipe-wall thickness.

To provide the engineer with a means for readily calculating the factors, a simple nomograph is given in Fig. 3 for obtaining k, i, X_k, and X_i as defined in Equations [1], [2], [3], and [4], respectively.