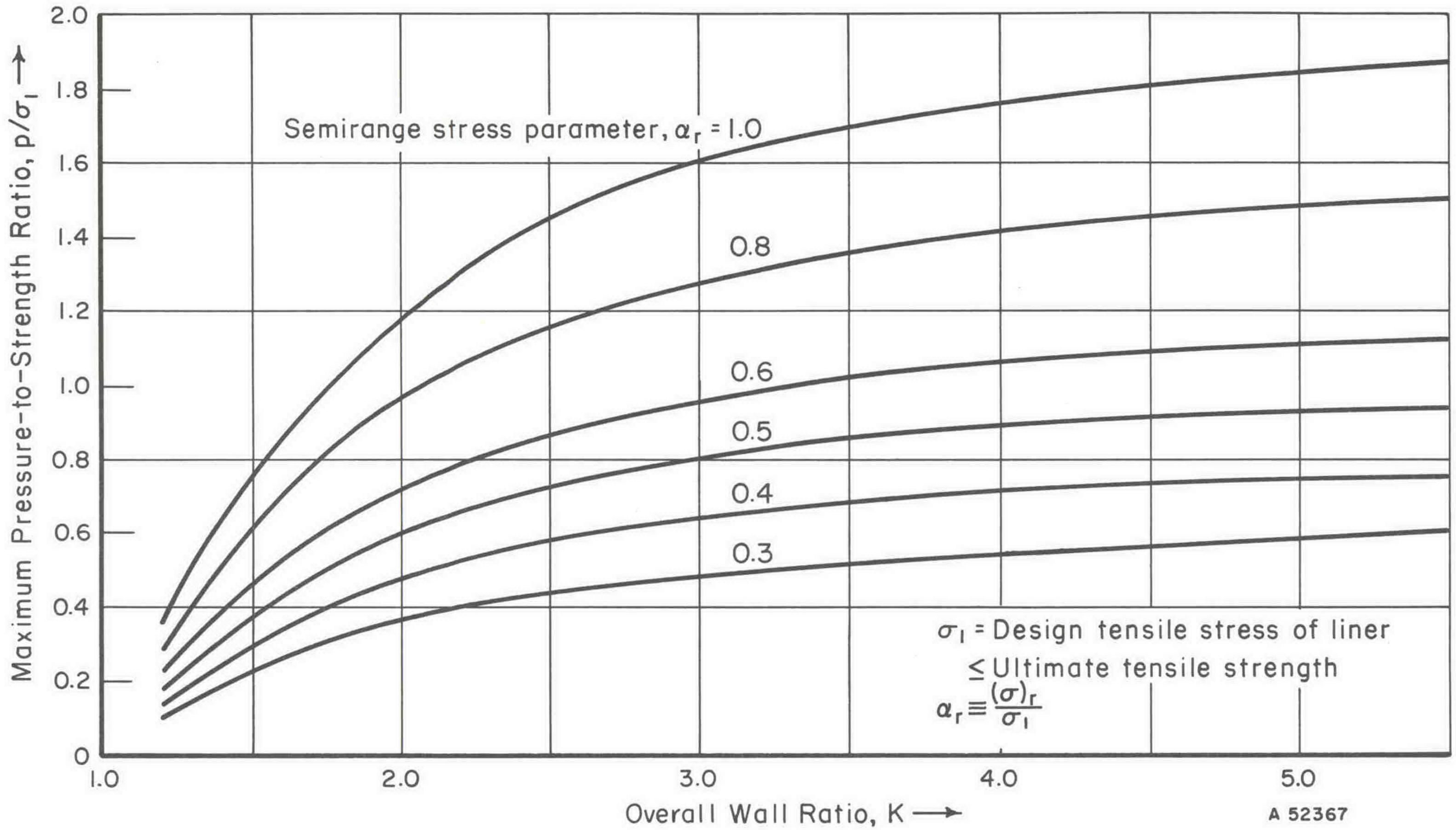

FIGURE 12. MAXIMUM PRESSURE-TO-STRENGTH RATIO, p/σ_1, IN MULTI-RING CONTAINER WITH HIGH-STRENGTH LINER BASED ON THE FATIGUE TENSILE STRENGTH OF LINER

The k_n, $n \geqq 2$ in Equation (50) are equal as shown by Equation (48). Whereas, p/σ_1 depended only upon α_r and K (Equation (47)), p/σ depends on N, k_n, and α_m in addition.

The ratio p/σ can also be limited by the requirement on Relations (9) and (12) that the mean shear stress S_m in cylinder No. 2 at r_1 obeys the relation $S_m \geqq 0$. $S_m = 0$ gives

$$\left(\frac{p}{\sigma}\right)_{limit} = \frac{2}{3} \frac{(K^2 - 1)}{K^2} \; k_1^2 \qquad (51)$$

The limit curves are plotted in Figure 13. As evident from Figure 13, the pressure limit for the outer rings can be increased by increasing k_1. This means that the liner has a great effect on p. The strength of the liner, σ_1, influences p in Equation (47). The size of the liner, k_1, limits p in Equation (51).

Whether or not p/σ can be allowed as high as the limit, however, depends on the other factors N, α_r, K, etc., as shown by Equation (50). This dependence is rather complicated. Example curves of p/σ are plotted in Figures 14 and 15 for $\alpha_r = 0.5$ and $\alpha_m = -0.5$. As shown by these curves p/σ increases with N and also increases with k_1 for N = 5, $K \geqq 6.5$.

Suppose p = 300,000 psi as determined from Equation (47) for $\alpha_r = 0.5$ and $\sigma_1 = 300{,}000$ psi. Then from Figure 15, K must be 9.0 for $k_1 = 1.75$ and N = 5 if $\sigma = 210{,}000$. Thus, the multi-ring cylinder must be quite large in size to support maximum repeated pressures.

The interferences Δ_n and residual pressures q_n have yet to be determined for the multi-ring container. Since the liner and the outer rings are assumed to be made from two different materials, thermal expansions must be included in the interference calculations. It is assumed that no thermal gradients exist; all components reach the same temperatures uniformly. Therefore, the interference required between the liner and the second cylinder is expressed as

$$\frac{\Delta_1}{r_1} = -\frac{u_1(r_1)}{r_1} + \frac{u_2(r_1)}{r_1} - \alpha_1 \Delta T + \alpha_2 \Delta T \qquad (52)$$

where

Δ_1 = manufactured interference

$u_1(r_1)$ = radial deformation of liner at r_1 due to residual pressure q_1 at r_1

$u_2(r_1)$ = radial deformation of cylinder No. 2 at r_1 due to residual pressures q_1 at r_1 and q_2 at r_2

α = coefficient of thermal expansion at temperature

ΔT = temperature change from room temperature.