application factor of safety

$N_{AFS} = \frac{F_{DESIGN}}{F_{APPLICATION}}$

6 inch ID pipe with flanges 1040 cold rolled steel 1000 psi pressure

12 bolts around flange 1/2-20 UNF Grade 8 threaded into flange

application factor of safety $N_{AFS} = 2$ to prevent blow-by

application

$F_{TOTAL} = (\text{pressure})\frac{\pi}{4}(D_{BORE})^2 = 28{,}274 \text{ lbf}$

$F_{BOLT} = F_{TOTAL} / 12 \text{ bolts} = 2356 \text{ lbf}$

pre load

$P_i = N_{AFS} F_{BOLT} = 4712 \text{ lbf}$

$F_{DESIGN} = N_{AFS} F_{TOTAL}$

pre-load torque

$P_i = \frac{F_{DESIGN}}{N_{BOLTS}}$

Norton Table 15-11 $k_i = 0.21$

$T_i = k_i P_i d = 494.8 \text{ in.lbf} = 41.2 \text{ ft.lbf}$ Norton Eq. 15.23d

1/2-20 UNF Grade 8 Norton Table 15-1 and 15-6

$d = 0.50$ in

$d_r = 0.4350$ in root

$A_t = 0.1600 \text{ in}^2$

$p = 1/20 \text{ in} = 0.05 \text{ in}$

$S_{PR} = 120$ ksi

$S_{UT} = 150$ ksi

coarse A_t smaller

d_r smaller

p larger

tension in bolt

$\sigma' = P_i / A_t = 29.46$ ksi

smaller for coarse

$N_{PR} = S_{PR} / \sigma' = 4.07$

strip one thread in bolt $w_i = 0.80$ Norton Table 15-5

$A_S = \pi d_r p w_i = 0.05467$ in^2 Norton Eq 15.8a one thread in bolt

smaller

shear area for three threads $A_{3S} = 0.1640$ in^2

$\tau = P_i / A_{3S} = 28.73$ ksi

$\sigma' = \sqrt{3}\,\tau = 49.77$ ksi von Mises

$N_{3S_BOLT} = S_{UT} / \sigma' = 3.01$ smaller

strip one thread in flange (nut) $w_o = 0.88$ Norton Table 15-5 larger

$A_S = \pi d p w_o = 0.06911$ in^2 Norton Eq 15.8b

shear area for three threads $A_{3S} = 0.2073$ in^2

$\tau = P_i / A_{3S} = 22.73$ ksi

$\sigma' = \sqrt{3}\,\tau = 39.37$ ksi von Mises

Norton Table A-9 1040 cold-rolled $S_{UT} = 85$ ksi

similar materials use fine threads

$N_{3S_FLANGE} = S_{UT} / \sigma' = 2.16$

dissimilar materials use coarse threads

this is very close to N_{AFS}

RECOMMEND
use coarse threads OR drill through second flange and use Grade 8 nuts $N_{3S_NUT} > N_{3S_BOLT}$

1/2-13 UNC Grade 8 Norton Table 15-2, 15-5 15-6
$d = 0.50$ in
$d_r = 0.4001$ in
$A_t = 0.1419$ in^2
$p = 1/13$ in $= 0.07692$ in

tension in bolt

$\sigma' = P_i / A_t = 33.21$ ksi

$N_{PR} = S_{PR} / \sigma' = 3.61$

strip three threads in bolt $w_i = 0.80$ Norton Table 15-5

$A_{3S} = 3\,\pi\, d_r\, p\, w_i = 0.2321\ in^2$ Norton Eq 15.8a

$\tau = P_i / A_{3S} = 20.31$ ksi

$$N_{3S_BOLT} = \frac{S_{UT}}{\sqrt{3}\,\tau} = 4.26$$

strip three threads in nut $w_o = 0.88$ Norton Table 15-5

$A_{3S} = 3\,\pi\, d\, p\, w_o = 0.3189\ in^2$ Norton Eq 15.8b

$\tau = P_i / A_{3S} = 14.77$ ksi

$$N_{3S_BOLT} = \frac{S_{UT}}{\sqrt{3}\,\tau} = 5.86$$