AWWA DESIGN METHOD FOR PVC PIPE CYCLIC PRESSURES

Cyclic design for PVC pipe was included for the first time in the AWWA C900 revision in 2007. The design method uses the number of cycles to failure as the parameter to which a safety factor (SF) of 2.0 is applied. Note that this method uses a DR-based design that is independent of pipe size. Also, it is important to realize that cyclic pressures rarely need to be considered for gridded distribution systems but may govern the design of transmission mains or sewer forcemains.

DEFINITIONS

Cyclic design is complicated because it is a function of three variables:

1. *Average stress* – the hoop stress caused by static working pressure in the pipe
2. *Stress amplitude* – the increase in hoop stress caused by the cyclic surge pressure
3. *Number of cycles provided by the pipe* – this is the value determined in the figure

DESIGN METHOD FOR CYCLIC PRESSURES

1. Check operating temperature to determine if de-rating applies
2. Determine number of anticipated cycles for lifetime of project
3. Calculate maximum design pressure (P_{max}) and minimum design pressure (P_{min})
4. Calculate average stress (σ_{avg}) and stress amplitude (σ_{amp})
5. Determine number of cycles provided by the pipe (using the chart)
6. Compare cycles provided (C_{pro}) to cycles required (C_{req}); must be ≥ SF = 2.0
7. Calculate cyclic design life

DESIGN EXAMPLE - PARAMETERS

Project conditions (as determined by designer):

Pipe = Try AWWA C900 DR18 pipe
Working pressure (WP) = 160 psi
Recurring surge pressure (P_{rs}) = ±30 psi

Design life = 100 years
Number of cycles per day = 55
Operating temperature (F_T) = 60°F

DESIGN CALCULATIONS

- Temperature considerations: F_T = 60°F < 73°F, so temperature de-rating does not apply
- Cycles for 100-year life: (55 cycles/day)(365 days/yr)(100 yr) = 2,010,000 required (C_{req})
- Calculate maximum pressure (P_{max}) and minimum pressure (P_{min}):
    P_{max} = WP + P_{rs} = 190 psi P_{min} = WP - P_{rs} = 130 psi
- Calculate average stress (σ_{avg}) and stress amplitude (σ_{amp}):
    σ_{avg} = (P_{max} + P_{min})(DR-1)/4 = 1360 psi σ_{amp} = (P_{max} - P_{min})(DR-1)/4 = 255 psi
- In the chart: Find the 1360 psi label on the y-axis. Follow the dotted line across until it intersects the 255 psi sloped line. Continue following the dotted line down to the x-axis and find the cyclic capacity = 21,000,000 cycles to failure = cycles provided (C_{pro})
- Compare cycles provided to cycles required:
    21,000,000 provided / 2,010,000 required = 10.8 >> required SF = 2.0
- Calculate expected cyclic life: (21.0 million/2.0 million) x 100 yr / 2.0 SF = 540 yrs

CONCLUSION

AWWA C900 DR18 pipe is suitable for the design conditions, providing enough cyclic capacity for more than 500 years, well beyond the 100-year design life. DR21 pipe would be sufficient for the design conditions, providing an expected cyclic life of (12.0 million/2.0 million) x 100 yr / 2.0 SF = 300 yrs.

References: AWWA C900-07 standard "Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 in. Through 12 in., for Water Transmission and Distribution" (2007)

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PVCPIPE association

Uni-Bell PVC Pipe Association | 2711 LBJ Freeway, Suite 1000 | Dallas, TX 75234
Phone: (972) 243-3902 | Fax: (972) 243-3907 | info@uni-bell.org