Criterion 4

An alternative criterion is given in ASME STS-1-2011, "Steel Stacks". This standard is written specifically for stacks. The criterion listed in this standard calculates a "critical vortex shedding velocity", V_{zcrit}. This value is then compared to the critical wind speed, V_c, and a decision made.

- If $V_c < V_{zcrit}$, vortex shedding loads shall be calculated.
- If $V_{zcrit} < V_c < 1.2\ V_{zcrit}$, vortex shedding loads shall be calculated; however, the loads may be reduced by a factor of $(V_{zcrit}/V_c)^2$.
- If $V_c > 1.2\ V_{zcrit}$, vortex shedding may be ignored.

Equations are given for calculating all of the associated loads and forces for the analysis. This procedure utilizes the combination of two components of β, one β for aerodynamic damping, β_a, and one for steel damping, β_s. The two values are combined to determine the overall β.

Criterion 5

An alternative criterion is also given in the Canadian Building Code, NBC. The procedure for evaluating effects of vortex shedding can be approximated by a static force acting over the top third of the vessel or stack. An equation is given for this value, F_L, and shown in this procedure.

Dynamic Analysis

If the vessel is determined by this criterion to be unstable, then there are two options:

a. The vessel must be redesigned to withstand the effects of wind-induced vibration such that dynamic deflection is less than 6 in./100 ft of height.
b. Design modifications must be implemented such that wind-induced oscillations do not occur.

Design Modifications

The following design modifications may be made to the vessel to eliminate vortex shedding:

a. Add thickness to bottom shell courses and skirt to increase stiffness and raise the natural frequency.
b. Modify the top diameter where possible.
c. For stacks, add helical strakes to the top third of the stack only as a last resort. Spoilers or strakes should protrude beyond the stack diameter by a distance of d/12 but not less than 2 in.
d. Cross-brace vessels together.
e. Add guy cables or wires to grade.
f. Add internal linings.
g. Reduce vessel below dynamic criteria.

Precautions

The following precautions should be taken.

a. Include ladders, platforms, and piping in your calculations to more accurately determine the natural frequency.
b. Grout the vessel base as soon as possible after erection while it is most susceptible to wind vibration.
c. Add external attachments as soon as possible after erection to break up vortices.
d. Ensure that tower anchor bolts are tightened as soon as possible after erection.

Definitions

Critical wind velocity: The velocity at which the frequency of vortex shedding matches one of the normal modes of vibration.

Logarithmic decrement: A measure of the ability of the overall structure (vessel, foundation, insulation, contents, soil, lining, and internal and external attachments) to dissipate energy during vibration. The logarithmic ratio of two successive amplitudes of a damped, freely vibrating structure or the percentage decay per cycle.

Static deflection: Deflection due to wind or earthquake in the direction of load.

Dynamic deflection: Deflection due to vortex shedding perpendicular to the direction of the wind.

Notes

1. See procedure 3-3 to determine a vessel's fundamental period of vibration (POV).
2. See procedure 3-4 to determine static deflection.
3. Vessel should be checked in the empty and operating conditions with the vessel fully corroded.