NASA TECH BRIEF

Marshall Space Flight Center

Predicting Vibrational Failure of Flexible Ducting

A simple technique successfully predicts the occurence of failure caused by flow-induced vibrations in bellows and other flexible hoses. The technique should find direct application wherever liquid or gas is transferred through flexible ducting, and should prove especially valuable in cases involving fluid flow at high velocity.

Application of the technique entails computing the function

$$S_i = \sigma h \rho_f V^2 Q / 2N_p t^2,$$

where
σ is the convolution width of the bellows,
h is the convolution height of the bellows,
ρ_f is the fluid static pressure,
V is the fluid flow velocity,
Q is the dynamic amplification factor of the bellows,
N is the number of plies in the bellows,
t is the convolution thickness per ply, and
S_i is the failure indicator, which is directly proportional to the peak stress on the bellows convolutions, as caused by the dynamic fluid pressure and the vortex-shedding force.

The key to this analysis is the determination of the natural resonance (frequency and quality) of the flexible sections, together with the vortex-shedding frequency of the bellows convolutions. When the two frequencies are in close proximity, vibrational failure becomes probable. This condition is shown by a marked increase in the value of the indicator S_i.

Although insufficient information has been compiled to allow complete definition of the exact value of S_i above which vibrational failure will occur, the following ranges have been determined by testing existing bellows installations and by examining previous cases of bellows failure:

$$S_i < 8 \times 10^4 \quad \text{No problem}$$
$$8 \times 10^4 < S_i < 20 \times 10^4 \quad \text{Uncertain failure probability}$$
$$20 \times 10^4 < S_i \quad \text{Probable failure}$$

Notes:

1. The fluid mechanism responsible for vibrational excitation of free bellows also causes oscillation in flexible hoses. Although the braided covering of the hose restricts its number of vibrational modes, the stress indicator S_i remains a valid indicator of failure probability.

2. S_i indicates dynamic stresses only. Stress caused by static pressure also influences fatigue life of flexible ducting, and must be considered separately.

3. This information may be of interest to the petroleum and chemical industries.

4. Requests for further information may be directed to:

   Technology Utilization Officer
   Code A&TS-TU
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   Reference: B71-10150

Patent status:

No patent action is contemplated by NASA.

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