72AE5

BRITISH ACOUSTICAL SOCIETY

SPRING MEETING: 5th- 7th APRIL, '72.

AERODYNAMIC NOISE SOURCES IN INDUSTRY SESSION: University of Loughborough

SILENCERS FOR RECIPROCATING COMPRESSORS

RUPERT TAYLOR, R.M. TAYLOR & PARTNERS LTD.

1. INTRODUCTION

1.1 A compressor intake silencer was designed on classic resonator principles and successfully constructed in order to alleviate complaints from residents close to a new nitric acid plant in a country district. In addition, a side-branch resonator was installed to reduce the level of infra-sonic pulsation.

1.2 The problem was caused by two Belliss and Morcom double acting reciprocating compressors drawing 5000 cfm of free air through a common 24 in. diameter intake duct and delivering compressed air at 80/90 psig. No attenuating device had been incorporated in the intake.

2. PROCEDURE

2.1 A preliminary survey was carried out to assess the extent of the problem which gave rise to the complaints. An octave band analysis taken outside a bungalow 200 yds from the plant showed levels of noise in the 63, 125, 250 Hz bands which were due to the compressor intake, as opposed to the various other sources present.

2.2 It was decided to aim to reduce all noise from the plant to below NR 35 at the bungalow, and in order to achieve this, attenuation of compressor intake noise of 11 dB at 63 Hz 8 dB at 125 Hz and 10 dB at 250 Hz would be required.

2.3 Since rolling and welding facilities were available to the client, they requested that a design be produced to enable them to manufacture their own compressor intake attenuator. It was therefore decided to involve classic resonator principles in a simple design to achieve the required reduction.

3. DESIGN PARAMETERS

3.1 Information was supplied concerning the operating characteristics of the compressors, which were not new, which indicated that the fundamental frequency of the intake pulsation was 8.33 Hz, since the shaft speed of the two-cylinder double acting machines was 250 rpm.

3.2 A simple double-expansion chamber[1] was designed on the basis of the formula

$$TL = 10 \log \left[1 + \frac{1}{4} \left(m - \frac{1}{m} \right)^2 \sin^2 k\ell \right] \text{ dB}$$

This yielded a requirement for a chamber 5 ft in length, with a diameter of 4 ft 6 in to achieve an expansion ratio of approximately 5, the greatest practicable in the available space. The transmission loss in theory would be a peak 8 dB at 57.5 Hz, 170 Hz, and 283 Hz, with pass bands at 113 Hz, 226 Hz etc.

3.3 In order to improve the transmission loss, the final design incorporated two similar expansion chambers, into each of which a 24 in diameter tube protuded half way. According to the formula

$$f_c \approx \frac{c}{2\pi} \left[m \ell_e \ell_c + \frac{\ell_e}{3} \left(\ell_t - \ell_c \right) \right]^{-1} \text{ Hz}$$

the low frequency pass band thus introduced owing to resonance in the connecting tube would be in the region of 2.2 Hz.

3.4 In a further attempt to reduce coupling between the two end chambers, a central expansion chamber 5 ft long was included through which the central 24 in diameter tube passed, locally perforated with ½ in holes to give twenty five per cent open area.

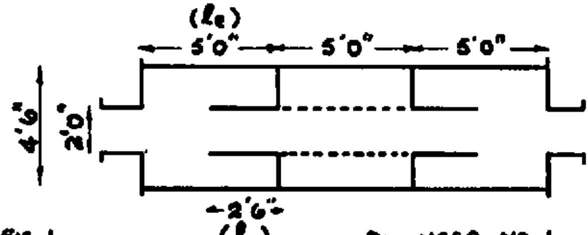


FIG. 1. SILENCER NO. 1

4. INTERIM RESULTS

4.1 After installation of the attenuator, the noise level at the bungalow was reduced to below the target level of NR 35.

4.2 Measurements taken close to the compressor intake louvres indicated an insertion loss had been achieved of 7 dB at 31.5 Hz, 13 dB at 63 Hz and 8 dB at 125 Hz.

4.2 However, further complaints were received from the residents about air vibration causing movement of window panes and large surfaces. The cause of this was considered to be 8.33 Hz, the compressor fundamental, which was too low to be adequately attenuated by a reasonable sized expansion chamber silencer. Consequently it was decided to install a side branch resonator between the first attenuator and the compressors.

FIG 2. INSERTION LOSS OF SILENCER NO. 1.

5. DESIGN OF SIDE BRANCH RESONATOR

5.1 A single chamber side branch resonator was designed on the basis of the work of U. Ingard[2] using the formula

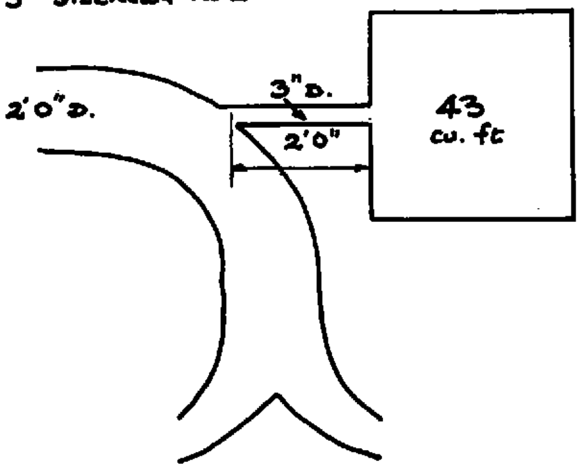
$$TL = 10 \log \left[1 + \frac{\alpha + 1/4}{\alpha^2 + \beta^2 \left(f/f_0 - f_0/f \right)^2} \right] dB$$

5.2 For a peak attenuation at f_o = 8.33 Hz, a chamber of 43 cu. ft. volume would be required, with a connecting tube 2 ft. long 9 in diameter. This was constructed, with a resulting negligible improvement.

5.3 It was then discovered that the problem was in fact occuring at 4.16 Hz, not 8.33 Hz, owing to a sub-harmonic being generated by the double action of the compressors.

5.4 Consequently the neck of the resonator was reduced from 9 in to 3 in diameter.

FIG 3 SILENCER NO 2



6. RESULTS

6.1 Following the installation of the modified side branch resonator, complaints ceased. Accurate measurement of the improvement obtained was precluded by the lack of suitable instrumentation for the low frequencies concerned, but the final linear sound pressure level measured with a Brüel and Kjaer type 2204 sound level meter measured at 3 ft from the intake louvres showed an apparent overall reduction of 7 dB. Subjectively, all trace of structural vibration in the bungalow was eliminated.

7. CONCLUSION

7.1 The project was necessarily of an empirical nature, and was an urgent practical application of theoretical principles, rather than an exact, controlled experiment. The results were eminently satisfactory, particularly in view of the low cost involved, and showed that the formulae used are easily capable of direct practical use.

7.2 Of particular interest was the success of the side branch resonator in view of the simple nature of the design and the often costly means sometimes taken to achieve the same results.

8. REFERENCES

1. Davis, D.D., Jr., G. M. Stokes, D. Moore and G. T. Stevens, Jr., N.A.C.A. Report 1192, 1954.

2. Ingard, U. 'Side Branch Resonators in Ducts', Bolt Beranek and Newman, Inc. (Unpublished).

Note: The subject matter of both references is included in 'Noise Reduction', Leo. L. Beranek , McGraw Hill, 1960.