NOISE CONTROL IN PLANTS

It is preferable to design noise control into the plant than to wait until an aroused public demands remedial action. The company rarely wins back the goodwill it loses during this sort of confrontation.

N. Horner
Eastern Nigrogen Ltd.,
Mayfield, New South Wales

It is an entirely proper, though nonetheless significant sign of the times, that ICIANZ recently created the post of Environmental Control Manager at its Botany Bay, Sydney, Australia chemical complex. Let there be no mistake that this is seen by the Company as a senior appointment. The present incumbent has had some twenty years production experience.

Since noise, unwanted sound, can properly be regarded as another industrial pollutant, it is entirely appropriate that noise control should come within the purview of this manager.

During the 1940's and 50's ICIANZ's experience at their Botany site, situated in a Sydney suburb, was propably common to much of the chemical industry. Noise was not a serious problem, though noise levels increased gradually-throughout the period. Complaints from neighboring firms and individuals tended to be treated as friendly jousts. Occasionally, noise sources were highlighted and dealt with, but the approach, in general, was haphazard, uncoordinated, and somewhat naive.

In April 1964, with the commissioning of a 100 ton/day ammonia plant, to which virtually no consideration has been given to eliminating noise at the design stage, the situation changed dramatically. From the moment the commissioning reached the H.T. Shifter, and the 36 hr. blow off after this vessel commenced on a *Saturday* morning, there was no longer any room for management complacency. The previously friendly neighborhood was jolted into an active resistance movement and the Local Council and State Health Departments, bodies responsibile for the administration of environmental control laws, were bitter in their recriminations and henceforth, scrupulous in their attention to site activities.

The nature of noise

The human ear is an extremely sensitive device and readily detects successive compressions and rarefactions in the air. Extremely little energy is involved. A sound of 200 microbars is on the threshold of pain (atmospheric pressure is approximately 1 bar). At the other end of the scale the ear is able to detect a sound pressure of the order of $\frac{1}{5000}$ of a microbar.

The decibel scale is commonly used to define noise and acoustic conditions.

$$\frac{L}{P_0} = 10 \log_{10} \quad P$$

L = the sound pressure devel in decibels dB
P = the sound pressure in microbars
P° = the reference sound pressure, generally taken at 0.002 microbars ($\frac{1}{5000}$ microbar)

The use of this scale enables the large range of sound pressure levels of 1 to 1 million to be accommodated in a range of 0- to 120 dB.

Hence a	10:1	sound pressure level change ° 20dB
	100:1	sound pressure level change = 40 dB
	1000:1	sound pressure level change = 60 dB

etc.

The ear is not equally sensitive to all frequencies of sound pressure variation. It is most sensitive to sounds in the range 1,000- to 4,000 cyc./sec., and usually less sensitive both above and below this range. The treshold of hearing at 1,000 cyc./sec. is, on the average, 0.0002 microbars, and this is used as the standardized reference pressure P_0. Because the ear exhibits a frequency response curve, and it is with this organ that human beings both detect and react to sound, it is important to devise a parameter which takes account of this fact. Noise Rating Number (N.R.N.) attempts to quantify the effect of noice on the ear, by relating the sound pressure level to frequency. It can therefore be considered to represent the "annoyance factor." For example, at 2,000 cyc./sec. on the 60 N.R.N. curve, 57 dB are equally annoying as 73 dB at 125 cyc./sec.

Present knowledge indicates that a noice source with an N.R.N. of 85 will not cause any hearing damage to the average person even under continuous exposure. This standard has been accepted by Eastern Nitrogen Ltd. as the maximum permissible level in any part of the plant in which more than 25% operator attendance is required.

Noise control program

To return now, briefly, to the ICIANZ Botany site, Sydney, in April 1964. Management was now forced into a crash program of noise control. This took the following practical steps.

1. Definition of causes and their elimination. These fell into five main classes:
   a. Commissioning blow offs
   b. Relief valve blow boff which by law required an unrestricted vent
   c. Blow off, including some relief valves, which could tolerate some restriction in their vent line
   d. Suctions of positive displacement compressors.
   e. General items - fans, ducts, etc.
2. The restriction of indiscrimate generation of noise by nominating limited periods when commissioning blow offs could occur.
3. The delegation of responsibility for noise control to shift managers who were now required to deal directly with complaints.
4. The personal involvement of junior management in the problem. This was achieved by organizing them to monitor plant noise at the site boundaries and beyond.

The most significant results from the crash program arose from the silencing of vents. In the case of vents that could tolerate restrictions ring packed silencers were immediately designed, fabricated, and installed. These were fitted to on the following key blow offs:

1. 350 lb./sq. in. gauge superheated steam blow off
2. 150 lb./sq. in. gauge steam blow off
3. inlet CO_2 removal section blow off
4. NH_3 synthesis loop blow off

Noise suppression from these simple devices proved quite dramatic. In the longer term, however, problems occurred. Fractured rings fell through the support grid and caused obstructions in the inlet lines and valves. In another instance the plant was showered with rings caused by a slug of condensate. This was due to the failure to fit drains at the bottom of the stacks. As a result, and along with a need for 'unrestricting' silencers, acoustic consultants were involved to design silencers which did not depend on righ packing. One of these devices, a twinned unit for the ammonia and methanol synthesis loop vent stacks, provided very satisfactory attenuation and operated without the problems exhibited by ring packed silencers.

Noise suppression in a fertilizer complex

Within 18 months of the noise control crisis at Botany, Sydney, ICIANZ, in conjunction with other partners, decided to proceed with a $40 million fertilizer complex at Newcastle, New South Wales. This consisted of a 600 ton/-day Kellogg ammonia plant, 360 long ton/day C&I/Girdler nitric acid plant, 500 long ton/day C&I/Girdler ammonium nitrate plant, along with a 12,000 ton atmospheric storage tank, storage, bagging and dispatch facilities for A/N and all ancilliary services needed for a greenfield site. The plant is located within half a mile of a residential suburb, which lies in the direction of the prevailing westerly winds.

Arising from the operational and technical experience of 1964 and 1965, both ICIANZ and E.N.L. were in a position to know both what they needed, but more important, what they needed to avoid in Newcastle. Kellogg had also been involved in the assessment of noise levels and the design and application of noice control devices in their 600-and 1,000 ton/day ammonia plants.

Throughout the world during the '60's there was growing awareness that noise produces loss of hearing, particularly as operators age and the acceptable period of operator exposure to noise levels above 90 N.R.N. has been progressively reduced.

From these three areas of experience combined with E.-N.L.'s determination and willingness to spend money in order to provide work areas that would not result in operator hearing loss and prove acceptable to our near neighbors and the community at large, came a planned approach to noise control.

Vital to this planned approach was the clear realization that is the work was to be accomplished in a preventative, rather than a crisis fashion, it was essential to commence well before start-up. Thus, the following steps were taken between start-up -3 -to -2 yr.

1. Arising from its Botany, Sydney, experience, ICIANZ initiated an intensive in-plant experimental program aimed at exploring vent behavior, silencer design, and performance under a wide range of operating conditions.

2. Maximum tolerable noise levels were set down in a specification sheet which accompanied the enquiry document to prospective contractors.

3. Early plant operability studies paid particular attention to the problems of noise generation and highlighted potential noise sources. This ensured that our concept of an acceptably quiet commissioning, start-up, and subsequent full operation was introduced at this stage.

4. Discussions with Kellogg confirmed that they were receptive to our noise control philosophy and were readily able to interpret and apply our design concepts, for which, naturally, E.N.L. was prepared to Pay!

5. At the mechanical design stage, the potential noise sources were nominated in conjunction with Kellogg. Special attention was paid to ensuring:
   a. Quiet operation of individual machines
   b. Problems of sound absorption in the compressor house
   c. Noise attenuation in let down, relief and control valve piping systems.

Prior to construction we undertook several major surveys of noise levels at our projected site boundaries and in the neighboring residential and industrial areas. These continued progressively during construction, commissioning, early operation, and finally full site operation. The value of these surveys was that they enabled us to establish the contribution that our new plant had made to the previously existing noise spectra of the district.

Prior to commissioning E.N.L. and contractors' staff were made unequivocally aware of the fact that it was their clear-cut, personal, responsibility to pre-commission, commission, start-up, and operate the plant without creating noise nuisances. If the as-built plant did not allow this, then they were to recommend changes or additions to operating procedures or plant facilities.

Finally, we undertook a public relations program in which neighbors were invited to inspect our facilities, and were told what to expect in the way of noise and plumes. We kept the City informed through progressive press reports of our progress and our achievements.

Noice control devices at E.N.L.

As has been previously stated, the potential sources of noise nuisance were nominated in conjunction with Kellogg during the project phase. In broad terms these were:

1. Vent silencers
2. Centrifugal compressor suction silencers
3. Acoustically lagged compressor houses
4. Acoustically lagged pipework.

The vent silencers were similar in principle to the devices used in the Botany, Sydney, plant but were designed by Randall, following the field test work referred to earlier.

The silencers on both nitric actid and ammonia plant air compressors consisted of absorptive and reactive type chambers arranged concentrically within the vessel. Both silencers have proved effective, particularly on the ammonia process air compressor, which, during start-up and circulation of N_2 through the H.P. case, has a small quantity of cooling air bled through an orifice in the blade of the butterfly valve shown in the foreground.

The ammonia plant compressor house is elevated, uses a checker plate floor and is walled on three sides. It is not roofed (for safety reasons(and the inside of each wall is acoustically lined. The noise level is low in operator attendance areas, between N.R.N. 80 = 87, in comparison with other plants and normal conversation is quite practible.

Results

Detailed objective comparisons of noise levels in two plants is scarcely conclusive since plant layout, configurations, and exact locations of test points are not identical. However, Kellogg's report noise levels in their 1966 paper, and out latest in-plant survey has brought out several comparative points.

1. Our compressor house registers N.R.N's of 80 in operator attendance areas and 87 between machines. (The earlier Kellogg readings ranged between 87 and 95. In addition, our machines are closer together than those in earlier Kellogg plants.

2. Our reformer penthouse is notably quieter - 81 N.R.N. compared with 110 N.R.N. This is due to our use of forced draught burners, compared with the more usual finely aspirated natural gas burners.

3. We have a passive total spectrum of noise. The quality of sound is not aggressive in the annoying mid to higher octave bands.

4. Nowhere in the plant do we experience the very high start-up levels nominated in the 1966 Kellogg Report. Our maximum is 100 N.R.N. measured at a normally unmanned point, 14 ft. from the vent on the steam drum structure. The earlier Kellogg plant had sound pressure levels of 117 dB at a frequency of 3600 cyc./sec. i.e., a N.R.N. of 120.

5. In our areas of highest operator attendance we have recorded operator exposure at 81 N.R.N. or less. In some areas where operators pass between pumps or compressors, the level was established at 87 N.R.N. Typical examples are:

a. B.F.W. pump area	- 81 N.R.N.
b. Reformer penthouse	- 81 N.R.N.
c. Open end of compressor house	- 80 N.R.N.
d. Lube oil console and cooling tower area	- 78 N.R.N.
e. Between refrigeration and synthesis gas compressors	- 87 N.R.N.
f. Between running and rolling Vetrocoke solution pumps	- 87 N.R.N.

Due to our mode of operation and the statutory requirements for operation of our boilers and refrigeration systems, our operators spend a fairly high proportion of their time actually on the plant. The foregoing figures indicate the success we have had in providing work areas which are acceptable for long term operator occupancy.

Conclusions

1. Our experience convinces us that it is far more preferable to design noise control into the plant rather than wait until an aroused public or work force compels remedial action. The company rarely, if ever, wins back the goodwill it will have lost during the confrontation.

2. Statutory and health organizations are quite properly continuing to tighten the laws governing residential noise nuisance and operator exposure to noise. What is just good enough now will probably be unacceptable in 1975.

3. Control of noise starts with an understanding of the nature of noise.

4. The steps following an appreciation level understanding of noise involve:

a. Establishment of desired standards

b. Assessment of existing performance, of either existing plant or a greenfield site

d. Design and installation of noise control devices before start-up

e. Responsible and informed operation

f. Assessment of the performance of machines and noise control devices.

5. Sufficient expertize is now available within owner, major contractor, and specialized consultant organizations to allow objective design of noise control equipment. If ow-

ner/operators are to use this expertize effectively, they must know beforehand what they really want, know how to communicate this to the main contractors, and thence to subcontractors. Casual, overall exhortations or even specification sheets will not bring forward the right results if the machine manufacturer subcontracting to the main contractor just doesn't know what it's all about.

6. Different main contractors, by virtue of their differing levels of competence and experience, are likely to bring forward widely differing noise control performance.

7. Eastern Nitrogen's experience has shown that it is possible to achieve acceptable noise levels both during and following commissioning. It has taken a good deal of planning and cost a significant amount of money, but it has certainly simplified our life as an industrial neighbor in Newcastle.

8. Whilst it has proved impossible to isolate all costs associated with the crash noise control program at Botany, Sydney, and the planned programme at E.N.L., Newcastle, we have made estimates of the expenditure on actual hardware on each site.

At Botany, Sydney, the figure was around A$100,000 on a $12 million dollar site. At E.N.L. the total figure for environmental control was $½ million dollars for a $40 million site of which approximately $90,000 went into noise control hardware.