AN AMMONIA PLANT OPERATOR'S EXPERIENCE IN BOTH CRISIS AND PREPLANNED NOISE CONTROL

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INTRODUCTION

Most plant managers will have been faced with the problem of trying to pacify neighbours or employees who have been upset by noise. Depending upon where the effect of the noise was felt — either inside the factory or in the neighbourhood — so did the problem, and the consequent commitment to eliminate or mollify the plant noise, receive a differing emphasis and attention.

When in the 1950's and early 1960's we made noise which affected our residential or industrial neighbours, then such upsets usually took on the atmosphere of a reasonably friendly 'joust'. The plant manager generally escaped from these indictments fairly lightly — maybe with minor plant modifications and a recital of various platitudes and assurances. However, the later 1960's have seen a pronounced change in attitudes of residents, local government and statutory bodies. No longer do platitudes and assurances satisfy an annoyed public or a regulating body. Nor do they preserve an operator's hearing for the whole of his working life.

I suppose we could mark the end of the beginning for us as the time when we commenced start-up of an ammonia/methanol/urea/nitric acid/ammonium nitrate complex on part of an existing 200 acre site operated by Imperial Chemical Industries of Australia and New Zealand (ICIANZ) in a suburb of Sydney, Australia.

During the 1940's and 1950's some incidental noise sources had been highlighted and dealt with. Exhaust silencers were put on the bulldozers handling salt for the caustic/chlorine plant, some screen walls were erected around noisy facilities. Noise, however, was not a serious problem. The level of noise had been growing gradually over the period but there had been few dramatic changes. The neighbours had not been suddenly shocked by a new and different quantity or quality of noise.

But in April 1964 we commenced commissioning an ammonia plant. Not having had any real problems with noise before, virtually no consideration had been given to eliminating noise at the design stage. Proceeding through the commissioning, we reached the stage of commissioning the H.T. shifter and as a result, blew off after this vessel for 36 hours, commencing early on a Saturday morning ! This was the end of our peaceful life. We really jolted the neighbourhood into a very active resistance movement. No longer were there any friendly jousts — we were subjected to bitter recriminations and also to the very close attention of the Local Council and the State Health Department, the local body responsible for administering various environment control laws.

We were then very conscious of and dogged by several classes of noise from a variety of sources — commissioning blow-offs, relief valve operation, continuous or intermittent surplus gas or steam blow-offs, positive displacement compressor suctions, discharge ducts and stacks on large volume fans, electric motor fans, etc. The next few weeks and months brought a comparative avalanche of noise control devices to the plant that was already operating. As each further item of plant was about to be commissioned, we most carefully considered all of the noise implications. Within a relatively short time — weeks only — and with the expenditure of much thought, ingenuity, control and some $A.60-70,000 we were within the grudging tolerance limits of the nearby residents. However, we have never really gone back to the peaceful days. We have an alert neighbourhood, quick to pounce on the slightest transgression.

Within 18 months of the noise control crisis at the Sydney site, Imperial Chemical Industries and several partners decided to proceed with a $A.40,000,000 project at Newcastle, New South Wales. The new Company was to be called Eastern Nitrogen Limited. The plants to be built were a 600 T.P.D. M. W. Kellogg ammonia plant, a 360 T.P.D. C&I/Girdler nitric acid plant and a 535 T.P.D. C&I/Girdler ammonium nitrate plant, along with a 12,000 ton atmospheric ammonia storage tank, storage and despatch facilities for ammonium nitrate and all of the various ancillary services needed for a greenfield site.

Out of the operational and technical experience of 1964 and 1965, ICIANZ and Eastern Nitrogen were in a position to know both what they required and what they needed to avoid at Newcastle.

Parallel with our Australian work on noise control, Imperial Chemical Industries Ltd. (U.K.) had also been involved in extensive work and their findings were summarised in 1965 in a Company report which set down their recommendations for noise levels in and around plants.

The M. W. Kellogg Company had also been involved in the assessment of noise levels and the design and application of noise control devices in their 600 T.P.D. and 1000 T.P.D. ammonia plants and submitted a report[1] to the 1966 A.I.Ch.E. Meeting in Atlantic City.

There was also a growing awarness in the 1960's to the fact that noise produces loss of hearing, although it may take many years of exposure for this to become permanent. The occupational hearing loss becomes even more important as operators age and natural hearing loss is added to occupational hearing loss. The acceptable periods for operator exposure to noise levels above 90 Noise Rating Number had been progressively reduced during the 1960's. More recent knowledge indicates that noise at 85 Noise Rating Number or below will usually not cause permanent hearing loss even with full shift exposure.

Combining these three areas of experience with Eastern Nitrogen's intention to provide work areas which would not result in operator hearing loss, to be acceptable neighbours in Newcastle and the Company's willingness to spend money to achieve these objectives, meant that the Imperial Chemical Industries, M. W. Kellogg and Eastern Nitrogen resources have been able to build and operate an in-city plant which at no time has had any complaints on noise either inside or outside the site. The noise levels are notably lower in all operator locations. One can talk normally on the compressor station operating floor or in any other location where operators are stationed for lengthy periods. We, and the neighbours, consider that we have a quiet ammonia plant.

THE NATURE OF NOISE

Noise is generally defined as any unwanted sound.

Extremely little energy is involved but the human ear is an extremely sensitive device and readily detects the successive compressions and rarefactions of the air.

A sound of 200 microbars is on the threshold of pain (atmospheric pressure is approximately one bar). At the other end of the scale, the ear is so sensitive that a sound pressure of the order of one-five thousandth of a microbar may be detected.

The common scale used to define noise and acoustic conditions is the decibel scale. The following expression relates sound pressure levels in decibels to absolute sound pressure levels.

$$L = 20 \log_{10} \frac{p}{p_0}$$

where L = sound pressure levels in decibels (dB)

p = sound pressure in microbars or dynes per square centimetre

p_0 = reference sound pressure, generally 0.0002 microbars

By adopting this relationship, the large range of sound pressures of 1 to 1 million (1/5000 to 200 microbars) is converted to the range of o to 120 decibels.

A significant increase on the decibel scale is say, 5 dB, corresponding to a sound pressure factor of 2 to 1; 20 dB would represent a 10 to 1 change; 40 dB represents a 100 to 1 change.

FREQUENCY OF SOUND

The frequency of variation in sound pressure has an important bearing on the audibility of the sound i.e. on the sensitivity of the ear.

The ear is most sensitive to sounds in the range 1000 to 4000 c.p.s. and is usually less sensitive above and below these frequencies.

At 1000 c.p.s. the threshold of hearing is on average 0.0002 microbar and this is used as the standardised reference pressure (p_0). This sound pressure thus corresponds to 0 decibels at 1000 c.p.s. At very low frequencies, say 50 c.p.s., a sound pressure of 0.02 microbars would be about the threshold. This would be 100 times the standardised pressure and corresponds to about 40 dB. At higher frequencies of 3000 to 4000 c.p.s. for which the ear has its greatest sensitivity, sound pressures well below the standardised pressure can be detected.

Sound pressure levels **and** the frequency of the sound are therefore the significant parameters in determining the character of the sound. Noise surveys will thus include sound pressure level readings in decibels over the mid-frequencies of eight octave bands in order to provide a spectrum of the sound. This procedure is set down in the International Standards Organisation recommendations[2], and although not describing noise fully, allows for relatively easy measurement and comparison of different noises.

Noise levels are therefore usually determined firstly with an instrument having a fixed response (with regard to frequency) and read out in dBA, from the 'A' scale, weighted for low response to sounds of less than 1000 c.p.s.

Another expression of noise is the Noise Rating Number. This single number attempts to describe and rate the effect of noise on the ear. Each N.R.N. is defined by a series of octave band sound pressure levels corresponding to the mid frequencies, 31.5, 63, 125, 250, 500, 1000, 2000, 4000 and 8000 c.p.s.

These scales were originally devised for use on low level sound pressure levels ('A' scale), medium ('B') and high ('C'). However, it has now become common practice to use only the 'A' scale for most noise surveys.

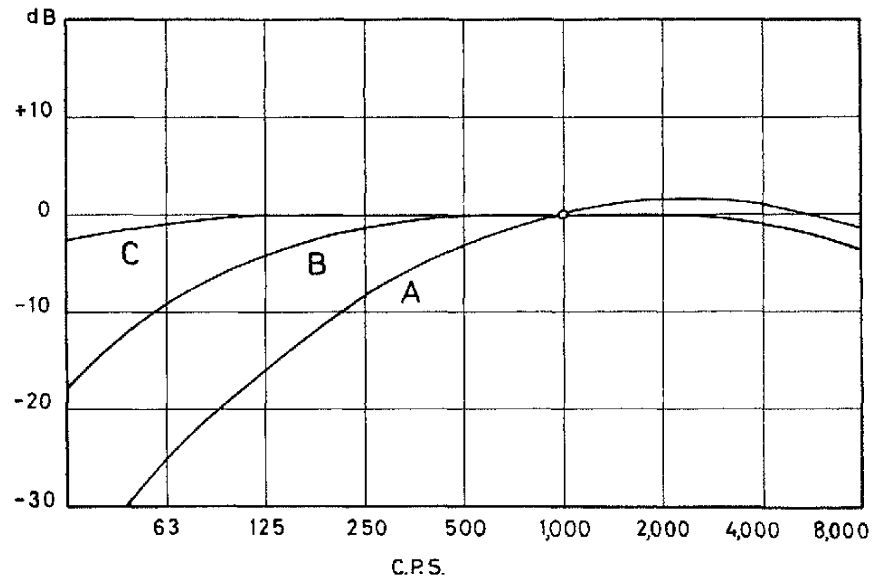

Figure 1.
WEIGHTING SCALES

The N.R.N. curves aim, in part, to represent "contours of annoyance" and reference to Appendix 1 will highlight the point that with a common N.R.N. of 60, the two sound pressure levels of 57 dB at 2000 c.p.s. and 73 dB at 125 c.p.s. represent the same annoyance level.

The N.R.N. for a given noise source is taken as the highest value (usually rounded to the nearest 5 dB) corresponding to the sound pressure level in any of the octave bands. An example is given in Figure 2. The sound pressure levels of a noise source at the various octave band mid-frequencies have

Octave Band Mid-frequency (c.p.s.)	Measured Sound Pressure Level (dB)	Noise Rating for Octave Band from App. 1 (dB)	Noise Rating Number
63	70	45	
125	74	60	
250	72	65	
500	71	70	70
1000	69	70	
2000	68	70	
4000	65	70	
8000	58	65	

Figure 2.

EXAMPLE OF DERIVATION OF NOISE RATING NUMBER

been measured. The N.R.N. for each band can be determined from Appendix 1 and from these the N.R.N. of the noise source can be nominated.

The length of time an operator is exposed to noise will influence the degree of possible impairment of hearing and thus both the level of noise and the period of exposure must be considered in assessing a plant situation.

Present knowledge indicates that a noise source with a Noise Rating Number of 85 will not cause any hearing damage to the average person even under continuous exposure. This rating is accepted by our Company as the maximum permissable level in a position which is manned for more than 25% of the operator attendance time.

This acceptable level has been reducing over the last decade.

Appendix 2 sets down our current range of acceptable levels of noise for various periods of exposure.

1964 EXPERIENCE — ICIANZ AMMONIA FACTORY, SYDNEY. CRASH PROGRAMME FOR NOISE CONTROL

As outlined earlier, we faced a noise crisis in May 1964 during start-up of our ammonia facility at Sydney, Australia.

As we saw the noise sources then, they fell into five main classes :

1. Commissioning blow-offs.
2. Blow-offs from relief valves which, by law, required an unrestricted vent.
3. Blow-offs, which although they were reliefs, could be fitted with some restriction in their vent lines.
4. Suctions of positive displacement compressors.
5. General group — fans, ducts, etc.

Our first move was to restrict the indiscriminate generation of noise by nominating limited periods during which commissioning blow-offs might be initiated, continued and terminated. We also involved the shift managers and shift foremen in monitoring the site from the boundaries and beyond. Shift Managers were required to deal with the actual complaints. The commissioning blow-off problem for catalyst commissioning, etc. was thus drastically reduced.

In the case of vents from statutory relief valves, we had no in-Company experience at that stage in the design or operation of unrestricting silencers. Silencing vents of this type had to wait until we secured the necessary assessments and designs from acoustic consultants.

In the case of vents which could tolerate restrictions, we immediately designed, fabricated and installed ring packed silencers on several of the key blow-offs. These were:

- 350 p.s.i. superheated steam blow-off
- 150 p.s.i. steam blow-off
- Inlet CO_2 removal section blow-off
- Ammonia synthesis loop blow-off
- Methanol synthesis loop blow-off.
- Tail gas stack on the nitric acid plants.

These ring packed silencers (Figure 3) were simple and, at the time, effective. They simply imposed a pressure drop and reduced the velocity of the exit gas. They were, of course, prescriptively designed in order to achieve this condition.

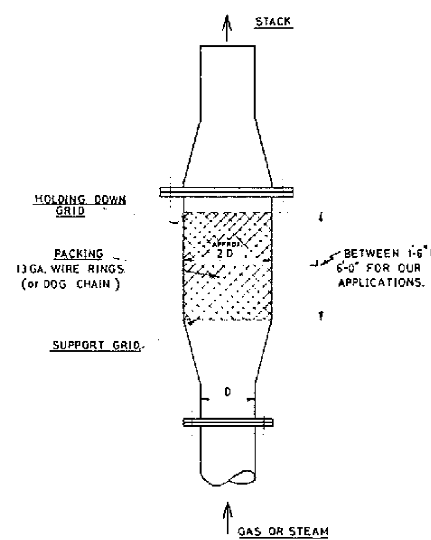

Figure 3.

RING PACKED SILENCER

The noise suppression results with these simple devices were dramatic. Where previously the straight-through vents were literally deafening, the ring packed silencers reduced the noise to an acceptable level. A slight rushing noise was all that could be heard when standing close to them.

This solved the noise problem for the time being, but it was not very long afterwards before we found that rings would fracture and rattle their way through the support grid and then obstruct control valves and other devices lower down the pipeline. In one instance, we blew all the packing out the top and showered the plant with rings. This was caused by a condensate slug. We had not fitted drains at the bottom of the stacks.

These incidents, along with the need to silence some of the relief valve outlets led us to involve Acoustic Consultants[3], to design other types of silencers which did not rely on ring packing.

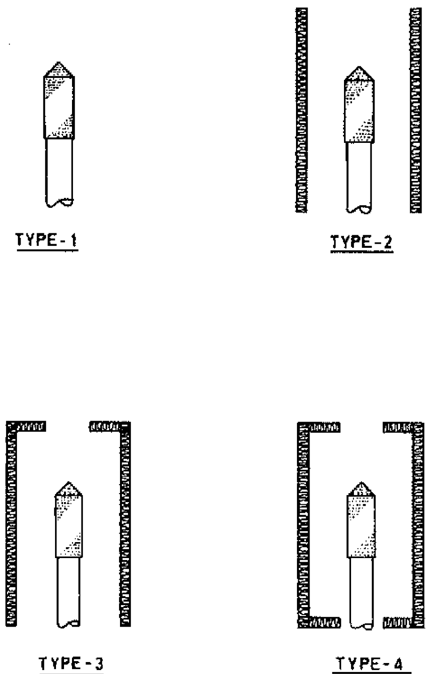

Figure 4.

TYPES OF GAS BLOW-OFF SILENCERS

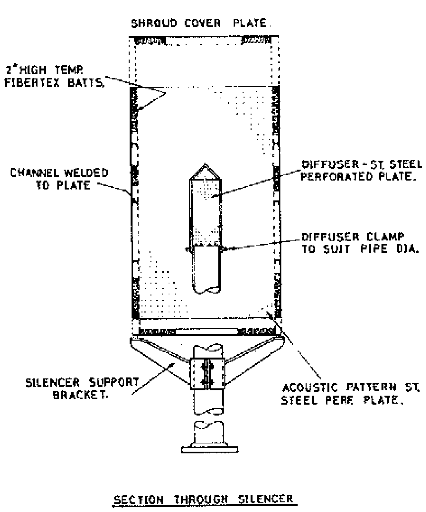

Figure 5.

SECTION THROUGH TYPE 4 GAS BLOW-OFF SILENCER

Silencers of this type shown in Figures 4 and 5 were fitted and all gas blow-off points and provided very satisfactory attenuation.

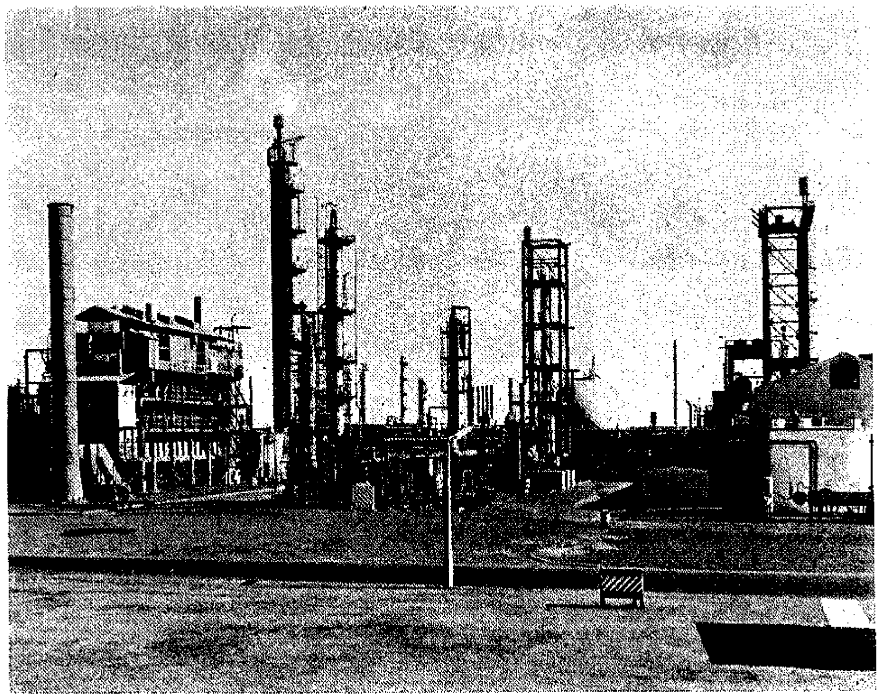

Figure 6.

GENERAL VIEW OF AMMONIA PLANT SHOWING GAS BLOW-OFF SILENCERS FITTED TO VARIOUS STACKS

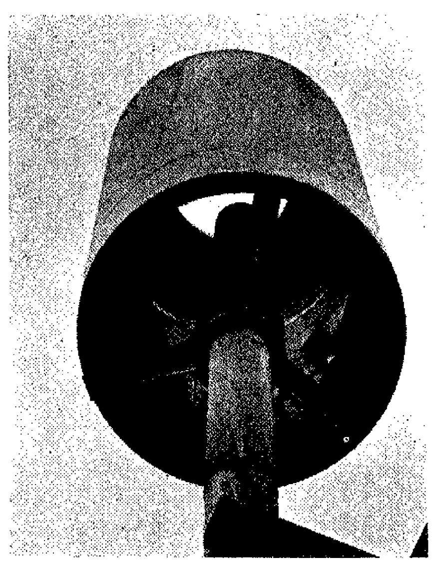

Figure 7.

GAS BLOW-OFF SILENCER SHOWING CYLINDRICAL DIFFUSER, PERFORATED LINER, THE ACOUSTICALLY ABSORPTIVE LINED, SHIELD AND THE TOP SHIELD. THIS BLOW-OFF IS ON STEAM SERVICE.

Figure 8.

A TWINNED GAS BLOW-OFF SILENCER FOR THE AMMONIA AND METHANOL SYNTHESIS LOOP VENT STACKS

POSITIVE DISPLACEMENT COMPRESSORS

Originally our two process air machines (3 stage reciprocators) were fitted with very elementary air intake filters. The noise level near these suctions was extremely high, but of a low frequency.

The instrument air compressors were also noisy, with their suction on the side of the compressor house nearer the residential area. Additionally, these machines being instrument air compressors were intermittent in their operation — on for say 10 minutes and off for 5 minutes.

Both of these noise sources were a nuisance and contributed to our troubles.

The design and installation of pye-type suction silencers removed all of the nuisance. (The name pye [Π] is applied to these silencers because their acoustic circuit is analagous to the circuit of a Π-type electrical filter). The silencers consist of a flat ended cylindrical vessel divided internally by a full baffle. The inlet and outlet chambers are connected by a short length of pipe passing through the centre of the baffle. All dimensions are design nominated.

Figure 9.

PYE TYPE SILENCERS USED ON RECIPROCATING PROCESS AIR COMPRESSOR SUCTIONS

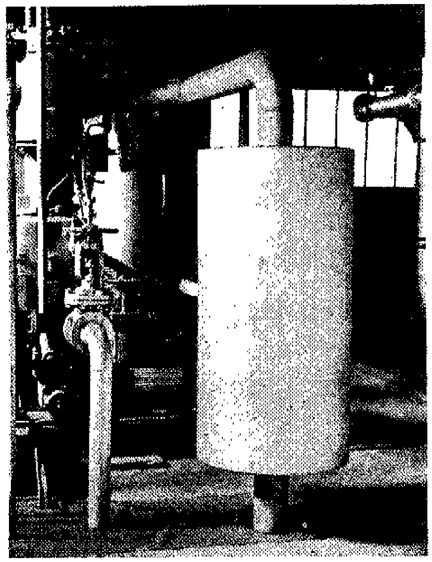

Figure 10.

PYE TYPE SILENCERS USED ON RECIPROCATING INSTRUMENT AIR COMPRESSOR SUCTIONS

FAN STACKS, BLOWERS, MOTORS AND GEARBOXES

The reformer flue gas stack and the urea prill tower fan stacks both constituted nuisances.

The reformer stack produced a low frequency rumble of about 250 c.p.s. Fortunately, this frequency could be handled with an absorptive silencer and this device was lowered into the stack whilst the reformer was on line.

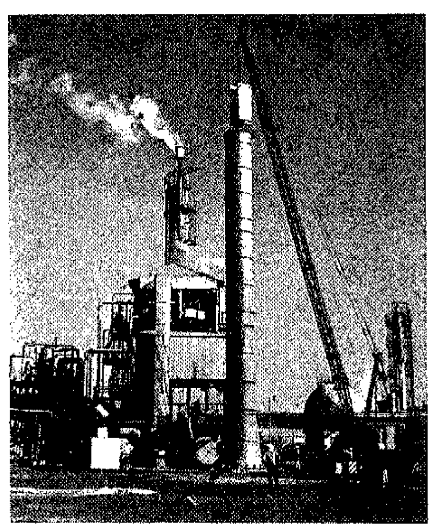

Figure 11.

AN ABSORPTIVE SILENCER BEING LOWERED INTO THE REFORMER STACK WHILST THE PLANT WAS ON LINE. THIS SILENCER EFFECTIVELY QUIETENED A 250 C.P.S. 'RUMBLE'.

The urea prill tower fans were also silenced by using an internal acoustic lining on the outlet side of the fans.

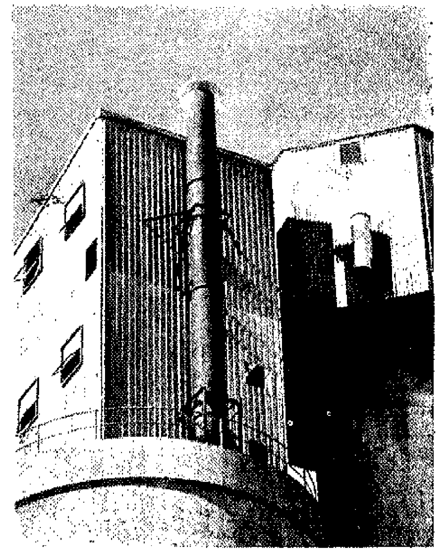

Figure 12.

UREA PRILL TOWER FAN STACK

INTERNAL ACOUSTIC LAGGING USED TO SILENCE THE UREA PLANT PRILL TOWER STACK. STARTING FROM 3 FEET ABOVE THE FAN OUTLET, 12 FEET OF THE STACK WAS INTERNALLY LAGGED WITH 1" THICK FIBRE GLASS HELD IN PLACE WITH ALUMINIUM FLYWIRE, EPOXY RESIN AND SUITABLE MAIN SUPPORTS.

Rotary positive displacement compressors were later used to supercharge the suction of the process air compressors. These are notoriously noisy and they had to be covered on all except one side — the side facing away from residential areas—with an acoustically designed compressor house.

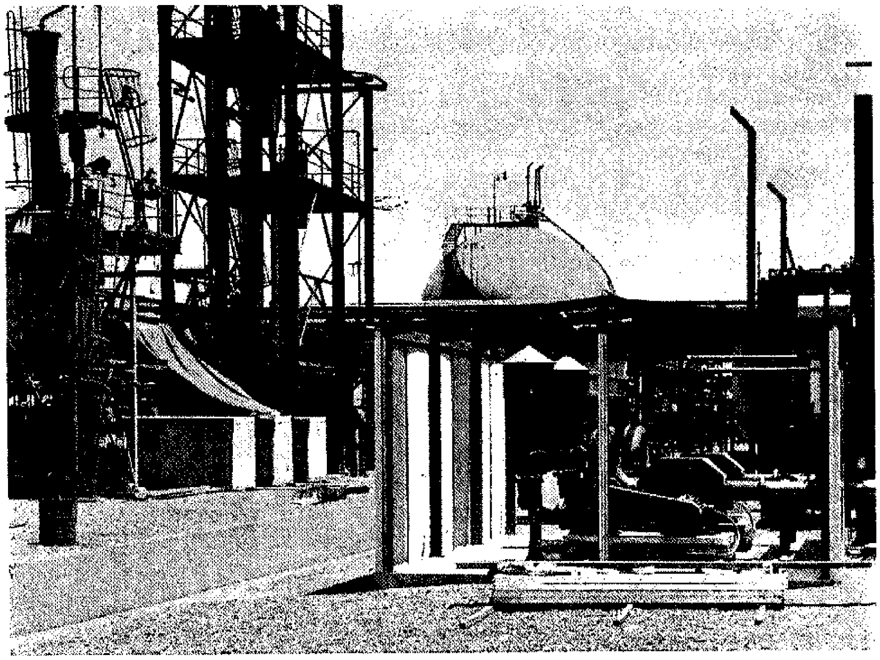

Figure 13.

ACOUSTICALLY LINED COMPRESSOR HOUSE FOR ROTARY POSITIVE DISPLACEMENT BLOWERS. THE NEARER SIDE WAS CLOSED OFF AND FIGURE 14 SHOWS THE FINISHED BUILDING FROM THE FAR SIDE. NOTE THE THREE ACOUSTIC ENCLOSURES AROUND MOTORS AND GEARBOXES OF THE COPPER LIQUOR INJECTORS, AT THE LEFT OF THE PHOTOGRAPH.

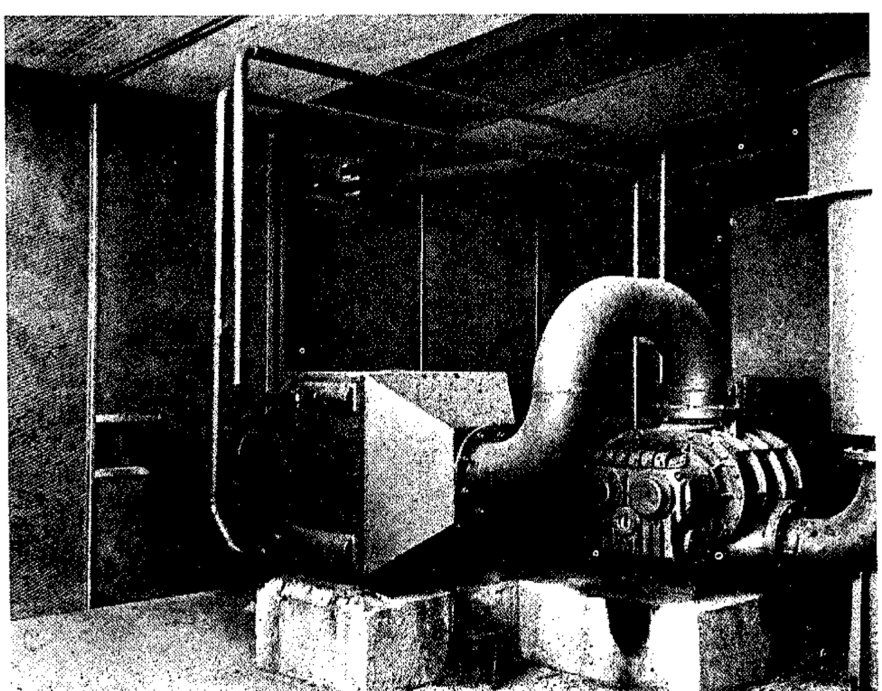

Figure 14.

ROTARY POSITIVE DISPLACEMENT BLOWERS WITHIN AN ACOUSTICALLY LINED COMPRESSOR HOUSE.

PLANNED APPROACH TO NOISE SUPPRESSION

EASTERN NITROGEN LIMITED, NEWCASTLE

The earlier experiences taught us that we would need to start well before plant start-up if noise attenuation was to be accomplished in a preventitive, rather than a crisis fashion.

Our specification of requirements for noise levels was set down in a specification sheet and accompanied our enquiry document. This was sent to prospective contractors at start-up minus three years.

Early operability studies ensured that our concept of an acceptably quiet start-up was introduced at that stage and that facilities were arranged to allow quiet commissioning, start-up and operation.

Engineering concepts were oriented strongly towards quiet operation for individual machines and for larger areas such as compressor houses, and where control, let-down and relief valves were concerned, the material specification of pipework was made suitable for later coping with temperatures higher than those which bare pipe would experience. Such pipework, adjacent to let-down and relief stations, is usually extremely noisy and would probably require lagging.

E.N.L. staff and Contractors' commissioning staff were made thoroughly 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 facilities did not already allow this, then they were to recommend changes or additions to operating procedures or plant facilities.

Parallel to the early work on the project, ICIANZ initiated an extensive in-plant experimental programme[4], aimed at exploring vent behaviour, silencer design and performance under a wide range of operating conditions.

Our ammonia plant contractor, The M. W. Kellogg Company, had had previous experience in vent silencer application and has previously reported[1] on several cases. M.W.K. were therefore both receptive to our noise control philosophy (E.N.L. was prepared to pay the extra cost) and were readily able to interpret and apply our design concepts.

Combined with all of these aspects of our pre-start-up work, we undertook several major surveys of the noise levels at our projected site boundaries and in the neighbouring residential and industrial areas. These were taken before any construction work started, and then successively during construction, commissioning, early operation and finally full factory operation. These datum surveys have enabled us to establish the contribution that we have made to noise levels in any part of the previously existing noise spectra.

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

Our start-up and early running phases have now been successfully completed and we have come through this period without a single noise complaint from either inside or outside the plant. One can carry on a normal conversation alongside the surface condenser 'hogging jet' vent, or near the deaerator vent, or on the main compressor platform. We have planned for and been able to secure a 'quiet' 600 T.P.D. M. W. Kellogg Ammonia Plant and a quiet site.

NOISE CONTROL DEVICES AT E.N.L.

The potential sources of noise nuisance were nominated in conjunction with M. W. Kellogg during the project phase. These again fell into the several classes which were experienced by ICIANZ in Sydney: commissioning blow-offs; relief valve vents; vents for steam or gases under controlled or emergency plant conditions; vents for normal start-up and shutdown; air compressor suctions; (in this case centrifugal machines) and the general group including machine noise, pipeline noise following let-down valves; sundry small but potentially noisy vents such as the hogging jet vent at the surface condenser and the deaerator vent.

The noise attenuation equipment was thus mainly of the following types :

- vent silencers
- centrifugal compressor suction silencers
- acoustically lagged compressor houses
- acoustically lagged pipework

The vent silencers are similar in principle to the devices used in the Sydney plant, but were designed by Randall[1] following the field test work referred to earlier. Figure 15 shows a typical configuration, and Figures 16 through 20 show the disposition of the vents in the plant.

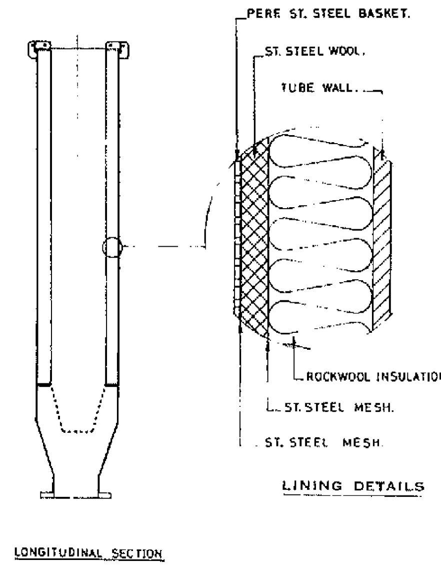

Figure 15.

TYPICAL ARANGEMENT OF A VENT SILENCER

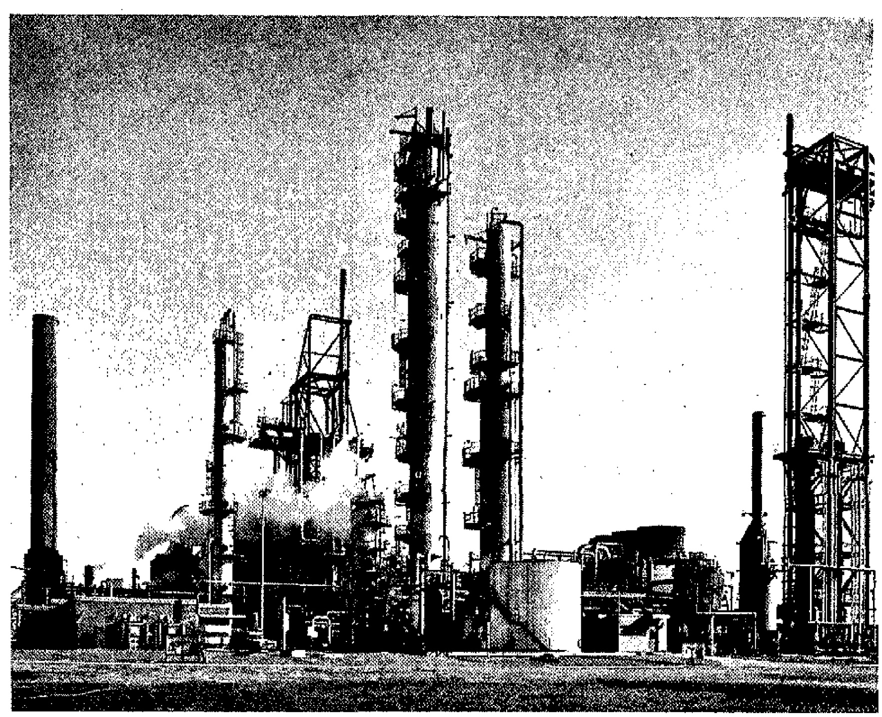

Figure 16.

GENERAL VIEW OF THE 600 TPD M. W. KELLOGG AMMONIA PLANT SHOWING 570 AND 50 PSI STEAM VENT SILENCERS AT LOWER LEFT AND GAS VENT SILENCERS ON THE STEAM DRUM STRUCTURE, AT THE TOP OF THE CO_2·STRIPPER (THE LARGE CENTRE COLUMN) AND ON THE AMMONIA CONVERTER STRUCTURE AT THE RIGHT OF THE PHOTOGRAPH.

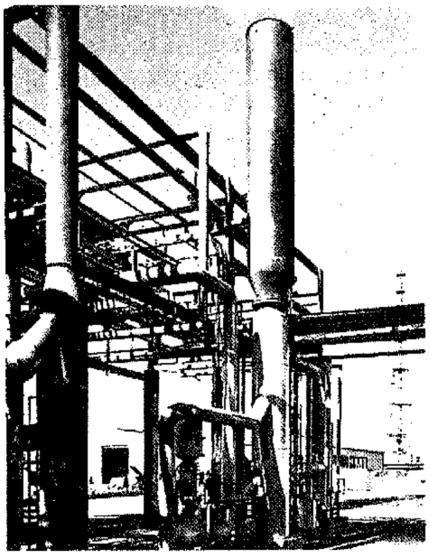

Figure 17.

A CLOSE-UP OF THE 50 PSI AND 570 PSI STEAM VENT SILENCERS. THE LAGGING SHOWN ON THE DOWNSTEAM SIDE OF THE LET-DOWN VALVE, AND ON THE SILENCER SERVES AS ACOUSTIC AS WELL AS THERMAL LAGGING.

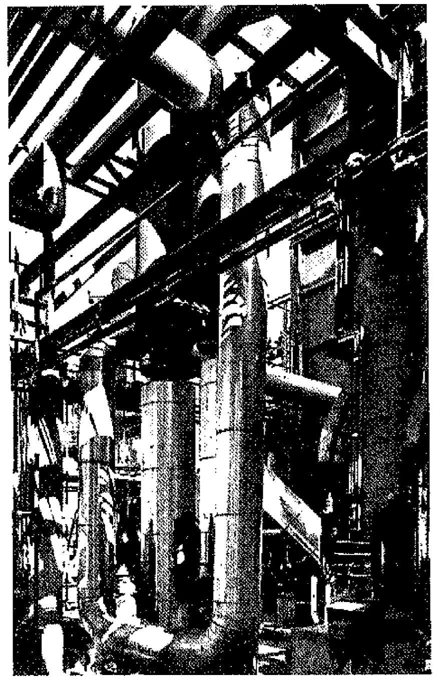

Figure 19.

HIGH PRESSURE (1500 PSI) STEAM RELIEF VALVES LET DOWN INTO SILENCED VENTS.

The suctions of both the process air compressor and the nitric acid air compressors were silenced by using silencers of the type shown in Figure 21. They usually consist of absorptive and re-active chambers arranged concentrically within the vessel.

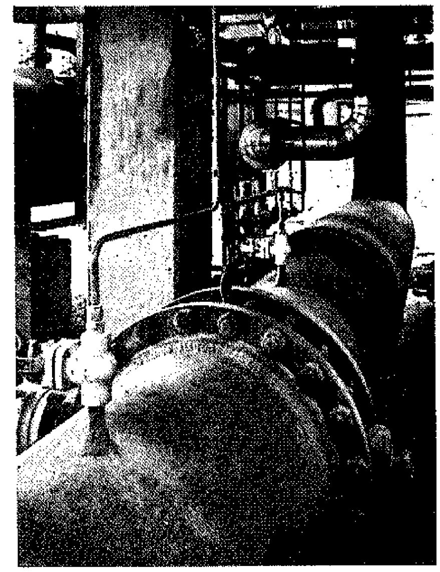

Figure 21.

A COMBINED ABSORPTIVE REACTIVE TYPE SILENCER ON THE SUCTION OF THE CENTRIFUGAL PROCESS GAS AIR COMPRESSOR.

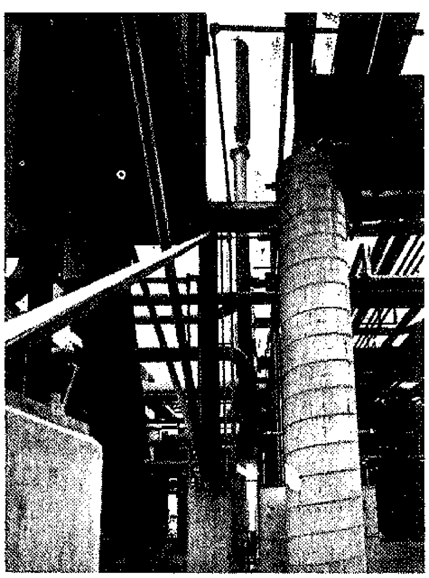

Figure 18.

THE CENTRIFUGAL PROCESS AIR COMPRESSOR HAS A SILENCER FITTED TO CARRY BOTH LP AND HP VENTING. ACOUSTIC LAGGING HAS ALSO BEEN USED HERE TO QUIETEN THE PIPE SCREAM FOLLOWING LET-DOWN.

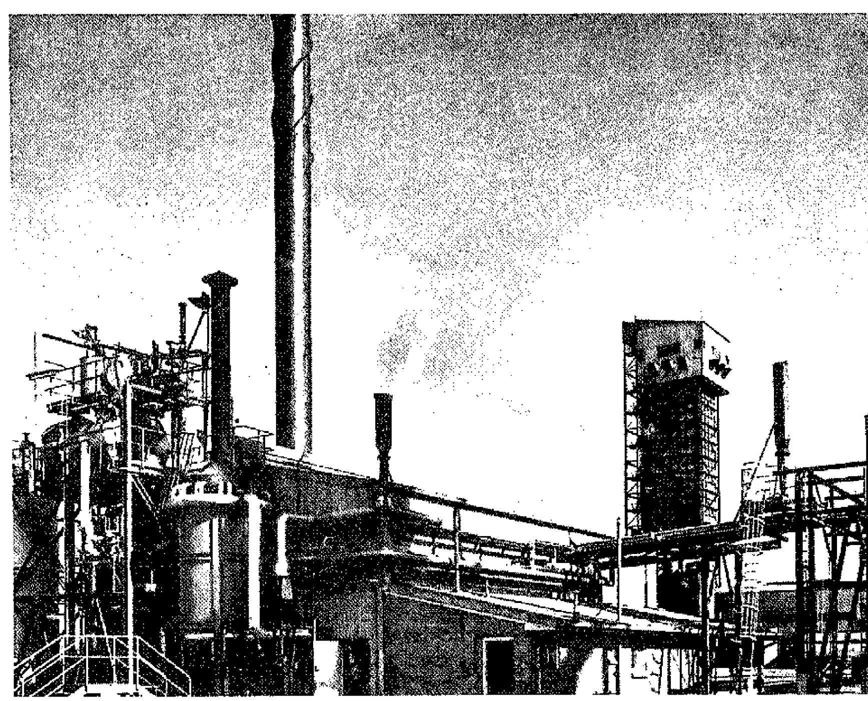

Figure 20.

TWO VENT SILENCERS FOR 250 PSI SATURATED STEAM (R. H. VENT) AND SUPERHEATED STEAM (L. H. VENT) FOR THE OFF-SITE START-UP BOILER STATION.

Both silencers have been effective, particularly on the process air compressor, which during start-up and circulation of nitrogen 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 of Figure 21. The suction silencer successfully attenuates the resultant pipe scream.

The Ammonia Plant compressor house is elevated, uses a checker plate foor and is walled on three sides. It is not roofed (for safety reasons), and the inside of each wall is acoustically lined (Figures 22 and 23). The noise level is low by comparison with similar compressor station. The N.R.N. in operator attendance areas is 80. Normal conversation is quite practicable.

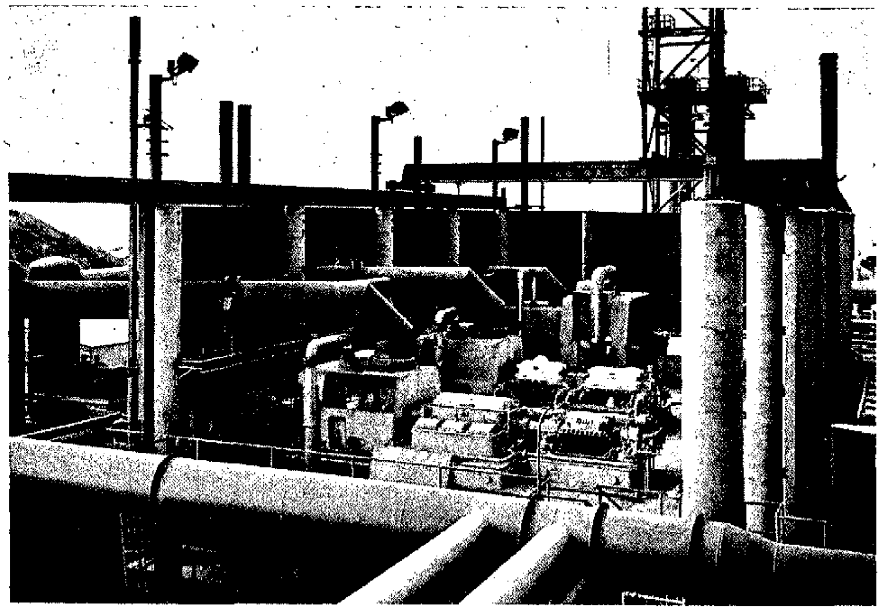

Figure 22.
A VIEW OF THE MAIN COMPRESSOR HOUSE SHOWING THE PROCESS AIR COMPRESSOR IN THE FOREGROUND, THE REFRIGERATION MACHINE CENTRE, AND THE SYNTHESIS GAS COMPRESSOR IN THE BACKGROUND. THE WALLS ARE EXTERNALLY SHEETED WITH ALUMINIUM, ACOUSTICALLY LAGGED AND SHEETED INSIDE WITH PERFORATED LIGHT GAUGE METAL SHEETING.

Figure 23.
A CLOSE-UP OF THE COMPRESSOR STATION SOUND WALL SHOWING THE INTERNAL PERFORATED SHEETING.

COMPARISON OF EASTERN NITROGEN LIMITED RESULTS WITH THOSE REPORTED (1) BY M. W. KELLOGG IN 1966

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, M. W. Kellogg reported noise levels in their 1966 paper[1] and our latest in-plant survey, summarised in Appendix 3, has brought out several comparative points.

1. Our compressor house is quieter with N.R.N's of 80 in the operator attendance areas and 87 N.R.N. between machines. The earlier M.W.K. readings ranged between 87 and 95 N.R.N., presumably in operator attendance areas. Additionally, our machines are closer together than those in earlier M.W.K. 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 more usual naturally 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 octaves.

4. Nowhere in the plant do we experience the very high start-up noise levels nominated in the 1966 M.W.K. report. Our maximum is 100 N.R.N. measured at a normally unmanned point, 14 feet from the vent on the steam drum structure. The earlier M.W.K. plant had start-up sound pressure levels of up to 117 dB and at a frequency of 3600 c.p.s., i.e. an 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, for main operating areas.

In some areas where operators pass between pumps or compressors the level was established as 87 N.R.N.

1. B.F.W. pump area —81 N.R.N.
2. Reformer penthouse —81 N.R.N.
3. Open end of the compressor house —80 N.R.N.
4. Lube oil console and cooling tower area —78 N.R.N.
5. **Between** the refrigeration and synthesis gas compressors —87 N.R.N.
6. **Between** the running and rolling Vetrocoke solution solution pumps —87 N.R.N.

Our operators spend a high proportion of their time actually on the plant, due to both our mode of operation and also to the statutory requirements for operation of our boilers and refrigeration systems. We have been able to provide work areas which are acceptable for long term 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 organisations 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 :

   (i) establishment of desired standards;
   (ii) assessment of existing performance—of either existing plant or a greenfield site;
   (iii) design and installation of 'quiet' machines and equipment;
   (iv) design and installation of noise control devices **before** start-up;
   (v) responsible and informed operation;
   (vi) assessment of the performance of machines and noise control devices.

5. Sufficient expertise is now available within owner, major contractor and specialised consultant organisations to allow objective design of noise control equipment. If owner/operators are to use this expertise effectively, they must know beforehand what they really want and know how to communicate this to the main contractors and thence to sub-contractors. Casual, overall exhortations or even specification sheets will not bring forward the right results if the machine manufacturer sub-contracting 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 neighbour in Newcastle.

REFERENCES

Ref. 1 Noise Levels in High Capacity Ammonia Plants.
By R. Caputo, E. Denmark, I. Heitner, H. Mayo.
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Ref. 2 I.S.O. Technical Committee TC43-314

Ref. 3 Norman & Addicoat, Acoustic Division, Sydney, N.S.W.

Ref. 4 Vent Noise Prediction and Vent Silencer Design.
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Other References :

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The Nature of Noise
By E. T. Weston
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Assessment and Reduction of Noise
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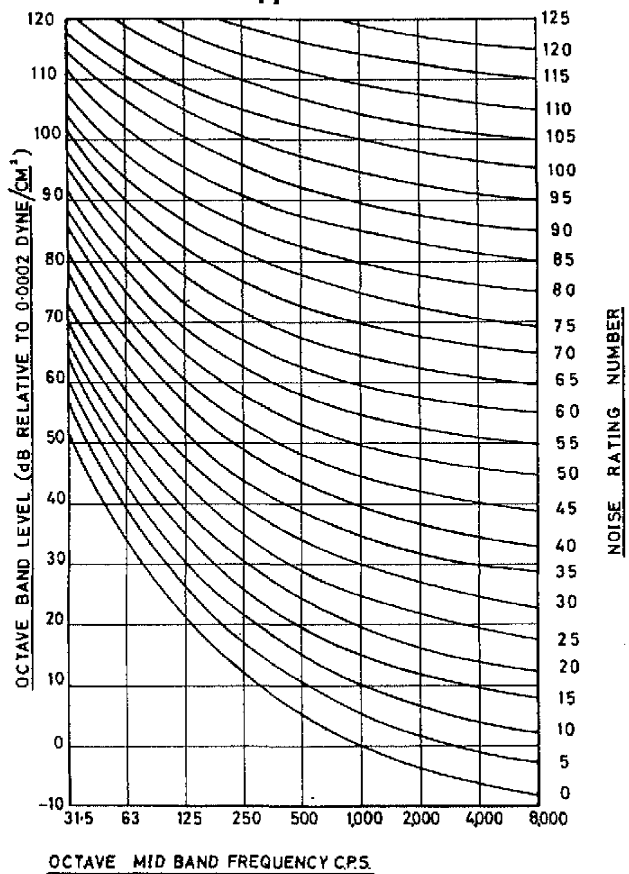
The Steam and Heating Engineer
March 1966

Appendix 1.



NOISE RATING CURVES

Appendix 2.

ACCEPTABLE NOISE LEVELS IN E.N.L. FOR VARIOUS PERIODS OF EXPOSURE

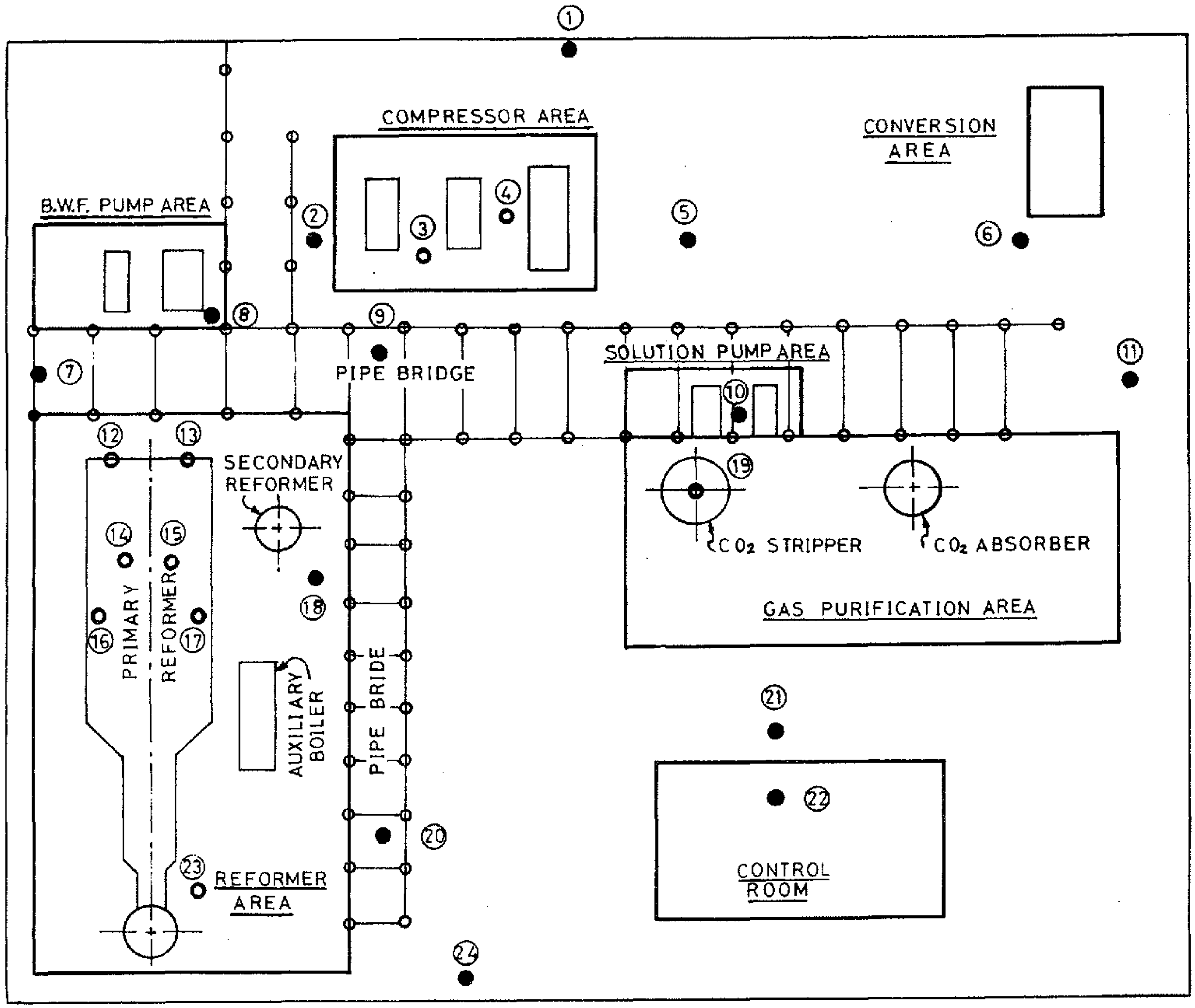
Maximum Permitted Noise Levels Working Areas	* Maximum Noise Rating Numer (Continuous Noise)
Working Areas — noise limited by hearing conversation considerations. Communication between personnel not required.	
(i) Personnel present less than 1% of time	110
(ii) Personnel present less than 5% of time	100
(iii) Personnel present more than 25% of time	85
Working Areas — noise limited by annoyance and speech communication requirement.	
(i) Limited communication required (e.g. workshops, general plant areas)	70
(ii) Speech communication essential (e.g. control rooms)	60
(iii) Plant·officers, laboratories, etc.	55

*** Notes**

(i) For intermittent noise, i.e. noise occurring for less than 10% of the time, the maximum permitted NRN given above may be increased by up to 10 db. for the noise peaks.

(ii) These ~~values~~ apply to broad band noise only. If the noise contains very narrow band or pure tone components, or is impulsive, then these maximum permitted N.R.N's shall be reduced by 5dB.

Appendix 3(1).



KEY

● GROUND LEVEL READINGS

○ ELEVATED READINGS

NOISE SURVEY READINGS.

SURVEY DATE 6-5-70

E.N.L. IN-PLANT NOISE SURVEY

EASTERN NITROGEN LIMITED

600 T.P.S.D. AMMONIA PLANT.

Appendix 3(2).

NOISE LEVELS

Plant Under Normal Operation

No.	LOCATION OF MEASUREMENT	A	C	Recorded S.P.L. (dB) in Octave Band of Mid Frequence (Hz)										N.R.N.
				31.5	63	125	250	500	1000	2000	4000	8000	1600	
1 G	North Battery Limit	82	86		78	76	78	78	77	74	74	72	57	78
2 G	West End Compressor Enclosure	84	87		76	79	78	78	80	76	76	71	58	80
3 E	Compressor Platform Between 101J and 105J	88	90		74	83	84	82	82	81	83	74		87
4 E	Compressor Platform Between 105J and 103J	87	89		73	84	83	79	77	79	83	77		87
5 G	Adjacent to Refrig. Condenser 127-C	86	86		74	75	75	79	76	79	83	81		87
6 G	Adjacent to Converter Structure and 102-B	75	79		71	71	70	69	69	70	67	60		72
7 G	West Battery Limit	77	82		75	77	74	73	73	70	68	62		73
8 G	Adjacent to Boiler Feed Pump 104J	85	88		78	80	78	80	80	79	76	72		81
9 G	Beneath main Pipe Rack	87	88		75	78	77	79	78	80	83	76		87
10 G	Adjacent to Vetrocoke Pumps—Between 107J and JA	91	93		76	78	85	90	84	82	83	80		87
11 G	East Battery Limit	74	80		70	74	72	71	69	68	65	58		70
12 E	Primary Reformer Burner Operating Platform N.W. end	85	90		83	86	84	82	79	74	74	67		79
13 E	Primary Reformer Burner Operating Platform N.E. end	86	91		83	86	85	84	81	76	74	60		81
14 E	Primary Reformer Burner Operating Platform W. centre													
15 E	Primary Reformer Burner Operating Platform E. centre	90	95		90	90	89	89	83	80	78	70		86
16 E	Primary Reformer Burner Operating Platform S.W. end													
17 E	Primary Reformer Burner Operating Platform N.E. end	90	95		85	90	89	87	84	84	81	74		86
18 G	Adjacent Secondary Reformer under Pipe Rack	82	86		80	79	77	75	73	77	76	72		80
19 E	Top of CO_2 Stripper 4′ above Platform	97	100		100	94	96	92	93	94.5	93.5	78		97
20 G	Adjacent 570=//= Steam Vent (S.P.11)	86	90		84	79	80	77	78	81	80	76		84
21 G	Outside Control Room	74	81		75	75	72	68	67	67	66	57		70
22 G	Inside Control Room Door open and Door closed	60	71		69/65	60/57	59/57	56/54	57/54	54/53	52	43		57
23 E	Adjacent I.D. and F.D. Fan Turbines													
24 G	South Battery Limit	76	84		78	80	78	72	68	69	69	61		73
1	Adjacent SP-10 Vent 27′ radius	97	102	95	98	99	93	93	86	90	89	90	79	95
2	Reformer Structure 14′ radius from pipe leading to S.P.8 (A top 101-F)	101	102	94	94	90	83	83	87	96	97	94.5	75	100
3	Stripper column top level with S.P.8 (East Wind)	85	90	83	84	82	78	75	75	79	81	75	55	85