Noise Control in Ammonia Plants

How modern designs are incorporating means for reducing noise levels to comply with federal regulations imposed by the OSHA of 1970

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New high-capacity ammonia plants for construction in the U.S. are now being designed by M. W. Kellogg with several standard noise control features to comply with the Occupational Safety and Health Act (OSHA) of 1970. Even more stringent requirements could be imposed because of community noise or other client requirements. The other requirements would call for engineering controls in addition to those to be described here.

The OSHA regulates excessive in-plant noise exposure of employees as shown in Table 1. The National Institute for Occupational Safety and Health (NIOSH) recommended in 1972 that OSHA lower the acceptable exposure levels by five decibels, and these levels are also presented in Table 1. Current proposed revisions to the OSHA noise regulations retain the original exposure limits. However, there is considerable pressure on OSHA from the EPA to lower the levels to those proposed by NIOSH. It is possible that future regulations will utilize the lower exposure limits proposed by NIOSH.

Since this Act regulates worker exposure and not the noise produced by a source, it is not always necessary for the noise generated by every source to be less than 90 dBA. at some prescribed location. Areas within a process plant where noise levels do exceed 90 dBA. must be evaluated for worker exposure, that is, the actual worker exposure time to noise levels that exceed 90 dBA. must be known.

A common misunderstanding of the exposure limits shown in Table 1 is for the case of multiple exposures to various levels of noise. The regulation does not say, for instance, that a worker can be exposed to a sound level of 105 dBA. for 1 hr./day and then to a level of 95 dBA. for 4 hr./day. Either of these exposures constitutes a maximum daily exposure to noise.

The regulation provides a formula for computing the composite exposure where it is composed of various sound levels during the course of the day. This formula, an inequality, follows:

$$C_1/T_1 + C_2/T_2 + \ldots + C_n/T_n < 1 \tag{1}$$

where: C_n = Exposure duration.
T_n = Allowable exposure duration.

The formula says that the sum of the ratios of actual exposure time C, to allowable exposure time T, for the various noise levels, shall not exceed unity.

This formula is difficult to apply to a worker in an ammonia unit because typical daily exposure patterns are not clearly defined. However, the employer is still faced with compliance and the act does require that: 1) administrative controls or 2) engineering controls be used to reduce an employee's exposure where over-exposure exists. The employer must apply administrative controls to reduce his employees' exposure time after the plant is operating. The engineering controls can be designed into new plants by the engineering contractor.

This article discusses the engineering noise control considerations that are part of Kellogg's current plant design.

Exposure, hr./day	Current OSHA regulation	Noise level, dBA. Proposed NIOSH rule
8	90	85
4	95	90
2	100	95
1	105	100
½	110	105
¼	115	110

Note: for composite, see inequality formula in text.

Table 1. Regulations limiting noise exposure

Noise in existing ammonia facilities

In 1966, R. Caputo *et al.*, of M. W. Kellogg reported the "Noise Levels in High Capacity Ammonia Plants" to the AIChE Air and Ammonia Plant Safety Symposium. (*1*) Data from Caputo's paper will be presented here as representative of on-stream sound levels in a high capacity ammonia unit. His data will be supplemented with some of the author's data. The representative sound levels presented here are for an ammonia unit with no special design considerations incorporated for noise abatement. Also, this unit would have had no noise control devices retrofitted at the time the measurements were made. These data then serve as the baseline for an "unquieted" plant.

Figure 1 represents a typical Kellogg ammonia unit plot plan. The circles represent vessels and towers. The various equipment areas are outlined by rectangles. The *a*-weighted sound levels are shown at various measurement locations throughout the unit, with the unit under normal operation. An examination of the plot points up the areas of relatively high sound levels before noise abatement.

The furnace and compressor areas contain the highest sound levels, and they affect a relatively large area. The

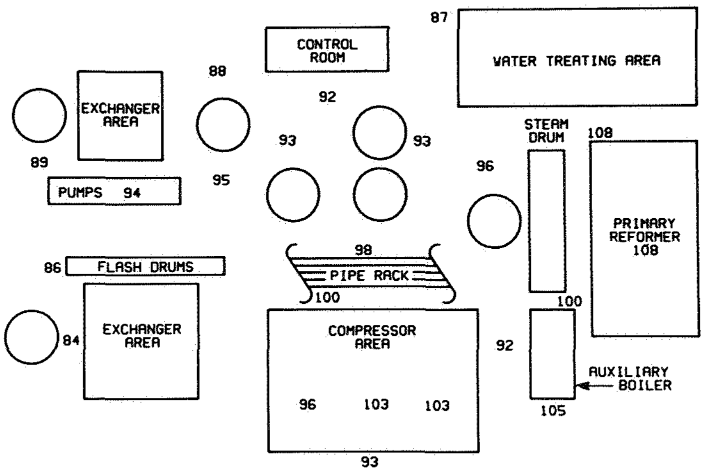

Figure 1. Ammonia plant plot plan with noise levels in dBA.

noise in the pump area is moderately high but is fairly isolated. There is also considerable background noise from control valves. The contributions from all of these sources add together to create sound levels in excess of 90 dBA. over a large portion of the unit. If no engineering noise control were accomplished, severe administrative controls would be necessary to limit employee exposure time.

Design considerations for abatement

Measurements of the noise in existing plants has indicated which areas require special attention in the design phase of new plants. The general approach to noise abatement for each of these areas of high sound levels is described next.

In the furnace area there are three sources of high sound levels: the arch burners, the auxillary boiler burners, and the tunnel burners. Within the reformer penthouse (or burner shack), the arch burners produce the 108 dBA. level shown in Figure 1.

The reformer used on the ammonia units now being designed will incorporate a forced draft blower/air-preheat system that supplies heated combustion air to the arch burners. A representative test furnace was built by Heat Research Corp. to test the air-preheat design. The sound level produced by this test configuration was measured, and extrapolation to the full scale reformer configuration yields a predicted sound level of 92 dBA. This level could be reduced slightly (2 to 3 decibels) by adding a sound absorbent material to the interior walls of the reformer penthouse. However, additional noise reduction is not necessary because this area is one of low operator exposure time.

The auxiliary boiler burners will also be supplied with heated combustion air through air ducts. The sound level on the auxiliary boiler platform for this configuration is expected to be approximately 90 dBA. The sound level at grade and 10 ft. in front of the auxiliary boiler is predicted to be less than 90 dBA.

The untreated tunnel burners that produce the 108-dBA. sound level on the side of the primary reformer will be fitted with mufflers to reduce that level to 80 dBA. per burner (measured at 3 ft.). The aggregate sound level, with all 10 burners operating, is predicted to be 85 dBA. on the side platform at a distance of approximately 3 ft. from the nearest burner.

The forced draft fan on the new air-preheat system is another noise source to be considered. The fan specification calls for 85 dBA. at 3 ft. from the fan. A parallel baffle type silencer is being installed on the blower suction, and 85 dBA. should be achieved.

The noise in the compressor area comes from many sources: compressor noise radiating through the connecting piping, compressor noise radiating through the casing, air compressor suction noise, gear noise, and some turbine noise.

The approach being used on new plants is to install a silencer in the air compressor suction line. All of the compressor piping, both suction and discharge, will be covered with acoustical insulation (2) that will consist of a 2-in. layer of mineral wool pipe covering, followed by a layer of lead-impregnated vinyl (nominal surface density of 1 lb./ft.). Those layers will then be covered with a protective aluminum jacketing. The gear boxes will not be enclosed or insulated unless they are found to be a problem after start-up.

The sound level in the immediate vicinity of the compressors (on the compressor operating platform) is expected to range from 95 to 97 dBA., primarily because of the sound radiated through the compressor casing. This is a relatively high sound level, but operator exposure time can be limited.

The noise in the pump area is produced by the circulation pumps for the CO_2 removal solution and their drivers. This noise has been measured by the author and found in the range of 89 to 92 dBA. at 3 to 5 ft. from the pumps on a new installation. At present, nothing is being done to the pump, and the driver (turbine) is being purchased with an "acoustic lagging" that is predicted not to exceed 87 dBA. This noise is not considered a problem due to its relative isolation in a small area around the pumps.

The other category of noise sources of primary concern is the numerous high-pressure-drop control valves throughout the plant. The noise produced by a control valve can be distributed over large areas of the plant by the piping downstream of the valve. Also, control valves that vent high-pressure gas to the atmosphere are usually an intermittant source of high-level noise.

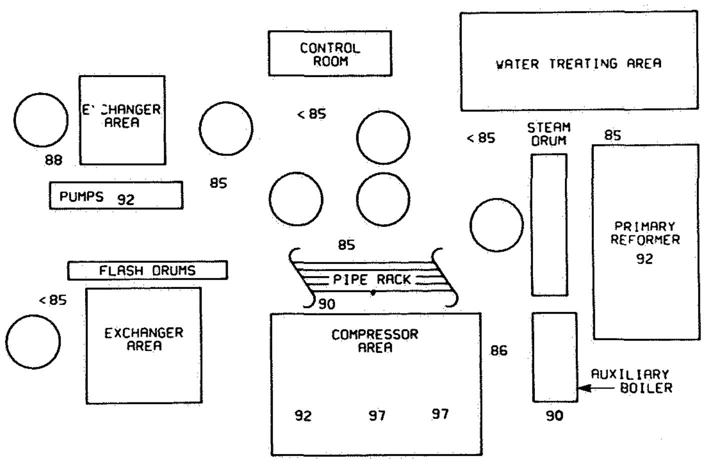

Figure 2. Ammonia plant plot plan with expected noise levels in dBA.

There are approximately 20 control valves (including vents) in a high-capacity ammonia unit that have a predicted sound level in excess of 85 dBA. These valves may be treated in one or both of the following general ways:

1. *Source treatment*. One of the several proprietary low noise trim valves may be selected, so that the actual noise generated is reduced. Often, several valves may be available, offering a wide range of available noise reduction. However, for noise reduction of more than about 10 decibels, the cost can become considerable.
2. *Path treatment*. Acoustic insulation may be used either alone or in combination with one of the low noise valves. Where atmospheric vents are found to be noisy, silencers are used in conjunction with insulation and/or low noise valves.

Generally, the choice of using strictly a modified trim valve or acoustic insulation or some combination of both is based on the most economical solution. There are exceptions to this rule; for example, a low noise trim would not be placed in a high pressure service where its mechanical integrity was questionable.

Conclusions

The approach to noise reduction that was taken by Kellogg was to apply state-of-the-art solutions to the noise problems that were known to exist. These solutions do not restrict or alter the operation of the plant. Figure 2 is a plot showing the expected noise levels with the noise reduction techniques added. The sound levels are not reduced to less than 90 dBA. everywhere in the plant, but this is not necessary for compliance with the OSHA noise regulation. By monitoring operator exposure and using administrative control where necessary, the operating personnel's total exposure to noise can be maintained below that required by OSHA. #

Literature cited

1. Caputo, R., Denmark, E., Heitner, I., and Mayo, H., "Noise Levels in High Capacity Ammonia Plants," AIChE Air and Ammonia Plants Safety Symposium, Atlantic City, N.J. (Sept. 20, 1966).
2. Dear, T. A., "Noise Reduction Properties of Selected Pipe Covering Configurations," Inter-noise 72, Washington, D.C. (Oct. 4-6, 1972).

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DISCUSSION

JAN BLANKEN, UKF-Holland: At the symposium in 1971 the use of crossed orifices for noise suppression was mentioned. I never understood what it meant. As far as I remember it was mentioned that, by using crossed orifices in the burners you could bring the noise level down by something like 10 decibels.

Could you explain what is meant by crossed orifices used for burners and if there are any further developments in this field.

WERCHAN: I think you may be referring to multiport orifices.

BLANKEN: Okay, that's possible.

WERCHAN: Yes, that is one possibility.

BLANKEN: We have two reformers in operation, if we could change e.g. the nozzle of the ejector for the primary air and decrease the noise level we would consider it.

Is that something we could consider or is it out of the question?

WERCHAN: The multiport orifices should be considered if your burners are presently equipped with single port orifices. For the primary air noise you could also consider a silencer. The noise is coming from the primary air register and radiating directly to the receiver. A silencer for the primary air register as well as a multiport orifice could probably be provided by the burner manufacturer. The noise reduction after retrofit of these devices would likely be 10 to 15 dBA.

Incidentally the combustion air on Kellogg's new reformers is forced draft and the noise is greatly reduced.

JIM FINNERAN, Kellogg: I have a question for you. The noise levels which you indicated at the compressor area, is that for compressors enclosed in the building or outdoor installation?

WERCHAN: That is an outdoor installation. We are designing some units with the compressors enclosed, especially in cold climates. These structures are typically weather sheds and none are enclosures for noise specifically. We are putting an acoustically absorbent material such as glass fiber insulation on the inside walls and roof to absorb the sound. If the absorption coefficient is say 90%, which you can achieve, then the incident sound is 90% absorbed. The combination large volume enclosure with acoustically soft walls gives very little reverberant buildup of the sound. As a result, the noise near the compressors will be almost the same as if the weather shed was not there.

JOHN LIVINGSTON, ICI, Billingham: I've always been considered somewhat of a rebel on this question of noise. There's an old English adage, I'm not sure it's over here or it may well have started over here, and that is—if rape is inevitable, just lie back and enjoy it. It's the sort of thing I apply to this question of noise levels. Whilst I appreciate we have to make moves to reduce to some acceptable level, noise levels on plant, we are in great danger of spending money to reduce noise levels to people coming to work, which are much lower in fact than the noise levels they are becoming accustomed to in disco dances and in night clubs, and in places outside.

I think we ought to be giving some publicity to comparisons between the sort of noise levels we do attain on the plants when we spend this sort of money, and on the noise levels that people meet outside. Because I can see this whole question becoming the old snowball and whilst 85 db are accepted for eight hours now, next year it will be 80, and the year after it will be 75. It does raise one question—I'd like your opinion on this—we have had complaints from the public in the vicinity of the Ammonia plants, about noise levels during startup.

Now originally on the make **gas** blowoffs, we had silencers that were packed with **pall rings.** We went to the diffuser type of silencer which, in fact, has made the plant very much quieter in the startup condition than when it was designed. The silencer was designed with a diffuser for startup condition rates. But whenever there is an upset at the plant and we go to the higher rates, the noise level again becomes unacceptable outside, which begins to mean that we are starting to see pressures for people designing plants with a blowoff for startup and a blowoff for full rates to try to accommodate noise levels.

Have you encountered any of this problem at all?

WERCHAN: Not exactly. In our specifications for silencers we do specify both rates and require a certain noise limitation at the startup rate, but the other case is generally considered emergency unless the client specifies otherwise. And, in general, for emergency upsets the higher sound levels are acceptable. There will be some silencing of course. We are using the same type of vent silencer that you use—the diffuser with a packed absorptive section.

JOHNSTON: Perhaps then you'll come back next year with noise levels expected on a Kellogg plant, and compare by the side with noise levels expected in the city outside or whatever conference room it happens to be. It would be interesting to see.

TOM CARROLL, Amoco Oil: We have been quoted up to 50 or 60% extra price for 1500 horse motors to silence them to 85 dba. What does Kellogg specify for motors of this type? What do you consider a reasonable increase in price to offset the noise level you are trying to reach?

WERCHAN: Well I would say 50% sounds excessive.

CARROLL: What noise level do you normally specify now?

WERCHAN: We aks the motor manufacturer to quote us the sound level if his motor is going to exceed 85 dBA. We actually specify 90 dBA. We first state: if the motor doesn't exceed 85 dBA, check the box and return the data sheet. If the motor sound level exceeds 85 dBA, we want to know the sound level and examine the location of the motor; it may be located in conjunction with several other motors. If the level exceeds 90 dBA, then we also want to know what it costs to reduce the sound level below 90 dBA.

That, in general, is how we specify motor noise. I am not that familiar with the total cost of motors, but I am of the opinion that on the larger motors the additional cost is perhaps 15% of the total cost.

CARROLL: We haven't found anything that inexpensive yet.

LIVINGSTON: Sorry that I'm back again, but I am interested in this problem. I wonder if you have any experience at all of figures of monitoring or people's hearing and the effect of exposure at these sort of levels over a ten, 12 sort of years. We really ought to be finding out just whether or not we are accepting these figures as base levels, and if they are still acceptable. Have you any figures at all you can give us?

WERCHAN: I have no figures based on my experience, other than what I've read in some of the publications. Incidentally, you might be interested, or at least the US people might be interested—the proposed change to the OSHA regulation would require: monitoring of the plant noise levels, monitoring the exposure levels of all the exposed employees, audiometric testing of those employees and maintaining records that would be available to the employee. So it's going to get tougher.

E.W.OWEN, Humphreys & Glasgow, Ltd., London: We are engineering one plant at the moment where the client, much to our concern, is insisting on acoustic hoods over his whole compressor house setup. I wondered if there was anybody here who does have a plant with acoustic hoods. Our concern is the problems of maintenance and so on, that inevitably will ensue with acoustic hood assemblies over the top of the machines.

Maybe in a year or two we can report what the outcome of the design is. But that is one instance where the numbers are taking over the engineering, I suspect, and we are getting into tighter and tighter designs. Which will probably prove a considerable nuisance in use.

WERCHAN: I personally don't have any experience with enclosures around the compressors. We are building some large houses around the compressors that enclose the complete platform, but I don't consider that a compressor enclosure for control of noise exposure because you still have the noise exposure problem inside.

Q. With all the time and money that's expended in this field, I have assumed that these noise requirements are irrespective of any ear protection whatsoever. Is that true?

WERCHAN: According to OSHA that's true. According to OSHA you must use feasible administrative controls, engineering controls, or some combination to bring the noise exposures down, and then you can use hearing protection.