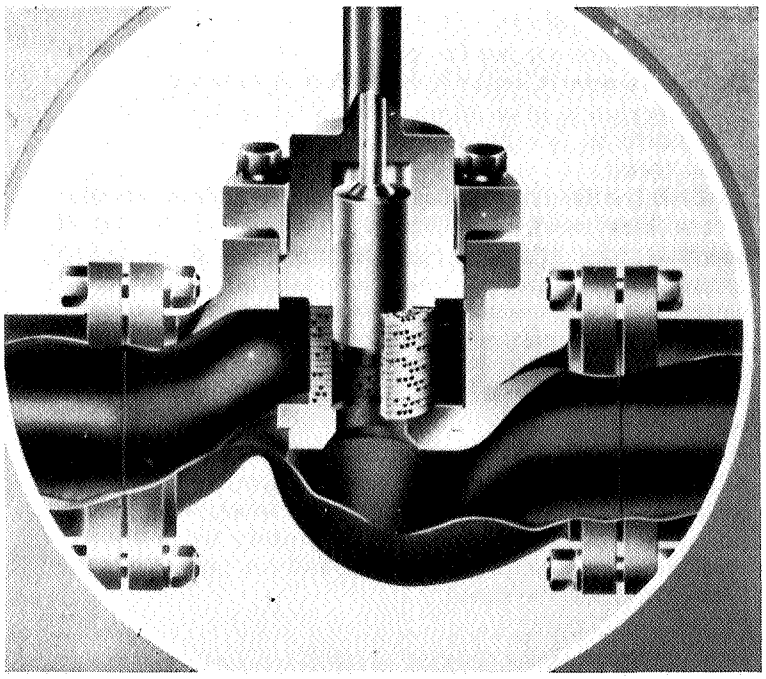

Figure 1. Noise suppressor valve.

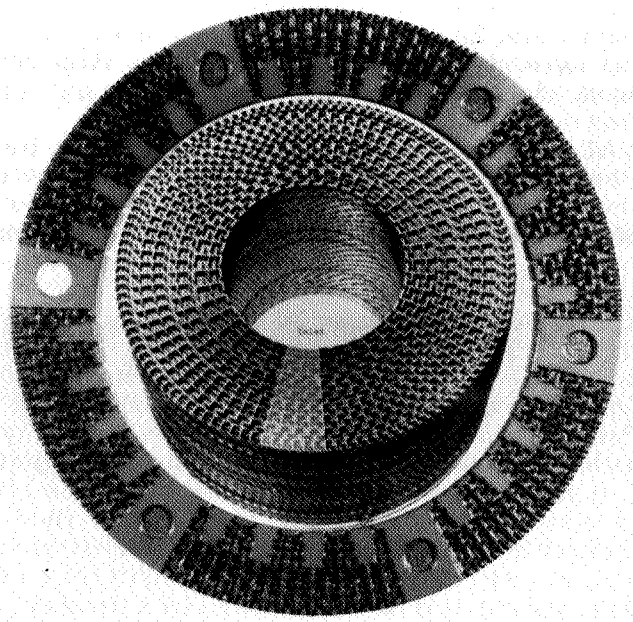

Figure 2. Valve disc.

Noise Abatement in Ammonia Plants

Concurrent with equipment modifications to reduce noise, a plant-wide program was instituted to specify protective measures to be used when work conditions require extended exposure to noise.

L.V. Caserta, American Oil Co., Texas City, Tex.

THE AMERICAN OIL CO. HAS A MODERN, INTEgrated refinery at Texas City, Tex., capable of converting 340,000 bbl./day of crude into finished petroleum products and chemicals at some 22 separate process units. The refinery was begun in 1933 with a handful of units. The first ammonia facility, a 600 ton/day plant completed in 1963, was the world's largest single train plant at birth, and had lots of new and different equipment to challenge refinery personnel. One other thing it had an abundance of was noise. On startups and shutdowns we received complaints from our neighbors in the community, as well as the plant operators. Within a few months silencers were installed at the process vent upstream of shift conversion and at a steam superheating coil outlet vent.

Initial noise abatement efforts

In the instructions to bidders for the second plant, a 1,500 ton/day unit, we specified that silencers be provided to limit the noise level to 95 dBA at grade at the following locations: 1) startup vent upstream of the shift converter, 2) vent upstream of the synthesis compressor, 3) several steam system vents, and 4) at the air compressor startup vent. These were installed and the unit commissioned in December 1968. From the onset certain unit areas were noisy, and the startup vents, in operation, resulted in a general grade noise level of 95- to 105 dBA. The air and process silencers failed structurally within three months of startup. The main process vent failure was noisily spectacular — several hours of intermittent spewing of silencer internals, followed by a nozzle fracture. The noise level was such that an immediate shutdown was ordered. A repaired (and less effective) silencer was used for several months until the redesigned internals could be installed. This period is remembered rather unhappily as a noisy age as other mechanical equipment problems insured a too-frequent exercise of a sub par vent system.

During some startups, and periodically during normal operations, noise surveys were made at approximately 30 locations throughout the unit. The major offenders were:

1. Process vent valves and piping
2. Steam turbine exhaust (expansion joints)
3. Package boiler fan decks
4. Air compressor interstage piping, expansion joints, and coolers
5. Fuel gas regulators
6. Patented-type separators

By far the most intense noise sources are the startup vent controllers. Sound readings up to 126 dBA were obtained in the vicinity of these valves. First, we acoustically insulated the valves and adjacent piping. This afforded some relief, but the vent valves area was still exceedingly uncomfortable when in use. Acoustical insulation is effective in dampening piping noise makers and we have a program underway to insulate our noisy piping.

In 1970, we began looking for a replacement vent valve that would effectively mute the sonic velocity noise, and

still afford good pressure control and tight shutoff. Pressure reduction and the attendant high velocities in the valve innards produce the high noise level. If pressure can be reduced without appreciably increasing velocity, no noise should be made to begin with. For trial, we selected a valve with stacked layers of discs, Figures 1 and 2, which cause the gas to lose velocity head in a series of right angle turns. A plug controls the number of discs in use at any one time so as to maintain pressure control. The valve is less of a noise generator since the velocity through it is lowered. The specs for this valve are impressive:

Inlet Pressure, lb./sq. in. absolute	465
Outlet Pressure, lb./sq. in. absolute	145
Inlet Temperature, °F	450
Flow, std. cu. ft./hr.	14 million
Velocity	Mach 0.52 at disc outlet
Leakage	250 cc./min. water @ 410 lb./sq. in. max.
Size, in.	10 × 14
Weight, lb.	2,000

Figure 3 shows the installed valve. Our experience with the new valve is limited, but substantial noise reduction (in the order of 20- to 25 dB) is obtained. Given a little more time to demonstrate continued good valve serviceability, we plan to install an additional one in a vent valve location.

Hearing protection program

Concurrent with the equipment modifications to reduce noise, we instituted a plant-wide hearing protection program designed to inform our personnel of the noise levels encountered in normal operation, and to specify protective measures to be used when work conditions require extended exposure. The first phase of the program consisted of extensive sound scanning of unit facilities. Our central Industrial Hygiene & Toxicology Department participated in the program. Hundreds of readings were required and obtained. The dBA noise levels were grouped in ranges approximating the Walsh Healy scale, and the sound contours depicted on a color coded plot of each unit. A copy of the plot is posted in each facility control room.

The second phase of the program was an exposure time study of operators and mechanics to help us estimate the cumulative noise exposure potential for our people. A refinery bulletin was issued specifying that all employees entering a unit or work area must familiarize themselves with the maximum exposure time per 24 hr. day permitted in the areas in which they are to work. If they spend as much as the maximum time listed, they must wear approved ear protection. A word about protective devices. For many years we have stocked and issued ear plugs as well as ear muffs. When the refinery-wide program was instituted we decided to use only ear muffs for three reasons: 1) they are superior to plugs for attenuating noise — on an average about 5dB more, 2) to be effective the plugs must be medically fitted and fit tightly (hygienists report that because of the tight fit, plugs tend to become very uncomfortable to some people), and 3) muffs can be more readily replaced since they need not be medically fitted. We have provided some locations with the type muff that is integral with the hard hat, but we mostly use the lighter weight muffs.

In the unit areas of highest noise where minimum unprotected exposure is permitted, we have posted field warning signs in addition to the sound contour map which is in the control room. #

L. V. Caserta is manager of the chemical operations for the Texas City, Texas refinery of the American Oil Co. He received a B.S.Ch.E. degree from Tulane University. He has been employed by American Oil since 1951 and has had assignments in technical and operating groups serving petroleum and refining chemical process units. He is a registered professional engineer in the State of Texas.

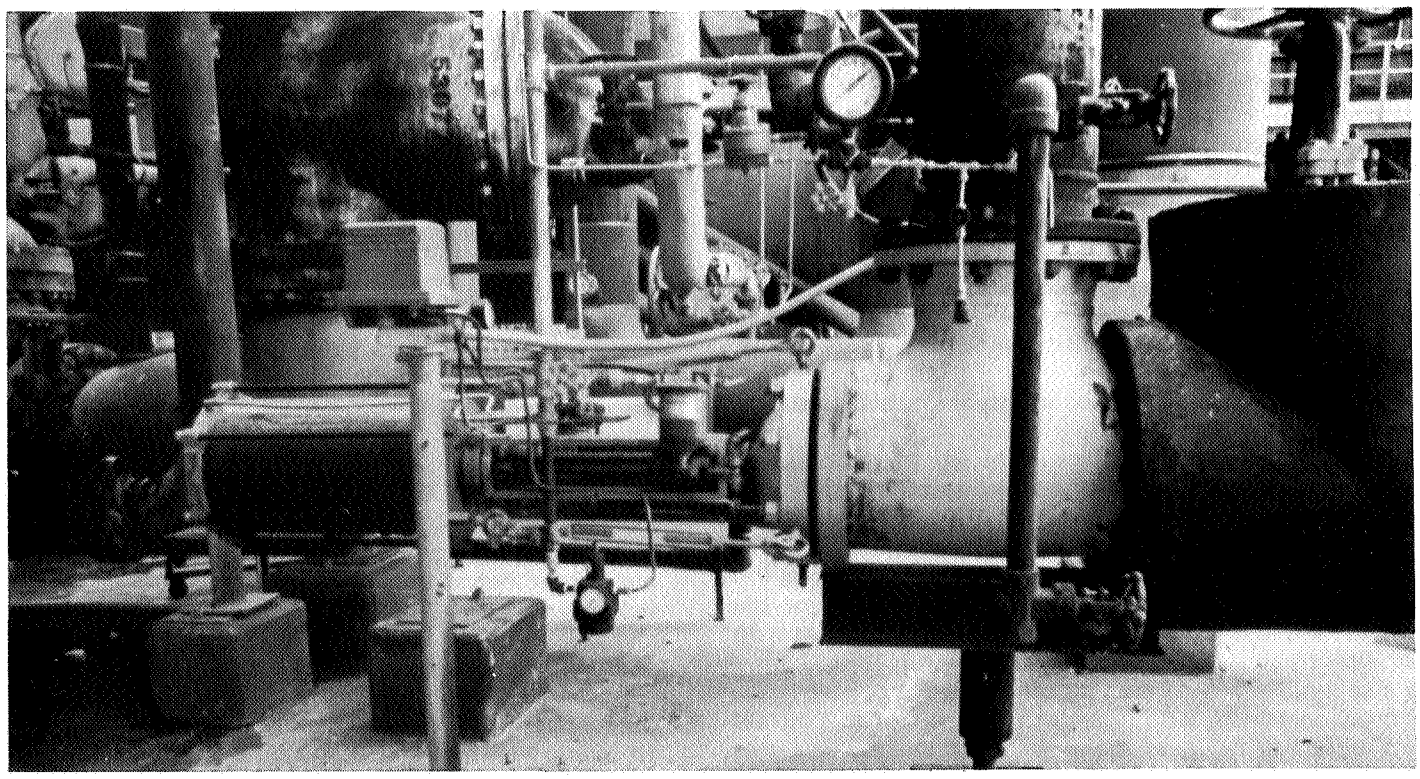

Figure 3. Vent valve installation.

DISCUSSION

Q. On your steam pop valves, have you made any provision for mufflers on there?

CASERTA: Figure 4 showed a pair of silencers in steam service. They are not on relief valve outlets but rather from steam pressure controllers which relieve at a lower system pressure than the relief valves. Generally all our relief valves on the steam systems vent directly to atmosphere. But each steam system has a pressure control scheme that utilizes silencers. On startup or shutdown we occasionally vent through these silencers for short periods at rather high volumes. The silencers were provided and have been effective.

Q. You mentioned in the beginning about using acoustical insulation for controlling noise? Do you use just Fiberglas? Is that the type you've been talking about?

CASERTA: We started up using thermal insulation and it does help, and lately we hve used the acoustical insulation.

Q. And what type of acoustical insulation are you using?

CASERTA: This is a fibrous type - that has I believe some lead in it. I'll provide you with the name of the material we use if you are interested.

ANON: After the startup of our first reformer we realized we had a noise problem. We checked the design of the vent system. It was mainly the vent system downstream of the secondary reformer. We found that during the normal long term vent conditions with about 60 tons of steam, we had sonic velocity at the end of the vent line coming into the silencer. We did some thinking, compared some alternatives, and thought that the simple, cheap solution would be to install a series of multihole orifices inside the silencer itself.

We did that when we designed our second plant. We designed it such that for the total flow downstream of the secondary reformer the pressure drop of the five orifice plates, together, was four atmospheres. We calculated each with a different number of holes, and there was no overcritical expansion over each plate.

We started up that second plant, and we were very happy because we had a very quiet vent system. After that we changed the first plant and we went slightly further. We designed the multihole perforated plates such that a total pressure drop over the four plates was seven atmospheres instead of the four in the second plant and we found that the noise only came down slightly.

My question is, does anybody have any experience with identical system of trying to keep the velocities down in the vent line by installing a series of perforated plates designed such that you have no over-critical expansion across each of the plates?

CASERTA: We have not. Does anyone in the audience have any experience with using perforated plate, orifice plate pressure reduction type devices in the line to reduce noise? This was proposed by some of our engineers. In some cases it would be a rather cheap solution if it works. We never did try it. We did try a scheme once on our first plant to desuperheat the vent. This did not prove too effective. We injected condensate into the startup vent to reduce the volume and cool it down somewhat, but it did not help significantly.

Q. I've kind of a three part question. I may not have heard you say something with respect to one part of it. You had two different types of signs. At least the wording was different. One was "notice" and the other was "danger". Secondly, did you - have you-used any lining method such as lines around areas which have high noise levels and try to identify in any manner how long an exposure the operator can allow himself? And lastly, have you done anything about the difference between startup and shutdown type of noise levels versus normal plant operation as far as designs or lines?

CASERTA: With regard to the first part, there was no significance to the type of signs. We utilized available signs and generally we had either the notice or danger type. If there was a scheme, it was to put the danger signs at the highest noise levels and the notice signs at the ones where perhaps four hours exposure could be permitted without hearing protection.

We thought quite a while about whether or not to paint striping on the units. We decided not to because of the maintenance problem and because the lines may change with weather, as we correct noise sources, etc. The signs are more readily adaptable to changing conditions.

With regard to the third question, we have modified some equipment and improved the flowing arrangement of our vent lines. One failed because of a piping configuration where a sizeable vent entered the system at a right angle. The joint cracked at the weld and began to crack in the vent line. We revised this to make the flow path somewhat smoother by entering at a 30^{o} angle.

Apart from equipment changes we try to get over the worst noise periods in the shortest time.

BILL HAMILTON, Consolidated Fertilizers, Australia: I'd like to know is there any incidence of employees in this country coming forth with civil actions for loss of hearing

CASERTA: I am not aware of any in our particular location.

HAMILTON: Could I explain that under the laws of worker's compensation in our country this is becoming a very big issue, and many employees are coming forward demanding some form of compensation for either sustained or alleged loss of hearing. And I think it might be something that others might care to think about.

CASERTA: In our routine physical examination program for employees which we've done since inception of the plant, we have an excellent hearing test. We're accumulating data from all sections of the plant on hearing changes as operators age and move around the facilities to different units.

JACK MURRELL Shellstar Ltd. United Kingdom: Before putting my question, can I just differentiate between the two types of noise, one being the intense noise for health hazard, of course, the other which is less intense but still a distinct problem, and that is from the public relations point of view.

In our plant we believe we have controlled the intense noise from the health hazard point of view, although we still have some improvements to make. We have pretty well covered the public relations aspect, except for one thing, and that is that on the main gas vent. When this is operating properly as a vent, then, while it is noisy, it's not too noisy and we don't have a public relations problem.

But what happens is that at some times it ignites. When it ignites it creates greater noise and then we do have a public relations problem. One of the things we've tried is to fit a torroidal ring on the top of the vent itself which has given some measure of success.

Now what I would like to know is does anyone else have

this problem, and if so, how did they overcome it?

CASERTA: Our vent silencer, the one that you saw that failed early in the startup, has ignited rather frequently. It seems to ignite more often when we're in the tail end of the startup process, right prior to compression when we have essentially nitrogen and hydrogen. It has ignited in the earlier stages but only infrequently. I'd say perhaps it's ignited 15 or 20 times altogether, but only once or twice in the initial stages of that unit comeup, and generally in connection with some rather severe weather.

The vent stack that you saw is 150 feet in the air, and we have not noted any significant change in noise when it ignites (generally we're over the noisiest steps at the time it has ignited, back in the methanation area). At this location we're venting mainly nitrogen and hydrogen, the steam has condensed, and the CO_2 is removed through a separate vent system. So the volume is down and it hasn't significantly affected noise when it has ignited.

HAYS MAYO, Cooperative Farm Chemicals Assn.: The tunnel burners on the Kellogg reformer produce noise levels in excess of 90 decibels and on maximum firing in excess of 100 decibels. One of the Farmland Industries plants has investigated this area and I would like to ask Louis Pebworth, Plant Superintendent at the Farmland Inds. Dodge City, Kansas, plant for his comments on this subject.

LOUIS PEBWORTH, Farmland Industries, Dodge City, Kansas: We are starting to work on our tunnel burners for noise control. We had three of our people go to a burner school, and from this we developed our noise suppression program. First we installed new crossed orifices for these pre-mix burners that suppresses the high frequency noise developed in the gas-air venturi. This reduced the noise level from this 100 to 105 decibel area to about 90 decibels. Our next step will be to install a muffler or sound suppressor that can easily be attached while the burner is operating and this should reduce the noise level to about 75 decibels. This combination of crossed orifice and muffler installation is said to cut down the noise level to where it is difficult to tell when the tunnel burners are operating.

MAYO: Basically you've put in a piece of felt-like material which is simply attached to the handrail directly in front of the burner?

PEBWORTH: Yes, we did install a shield, and it was some help, but we did not figure this was sufficient, so we have proceeded with improvements by installing the crossed orifices which change the velocity and will quiet them down tremendously. Then, the next state, as mentioned, I think the mufflers will reduce the noise level so low that there will be very little difference in noise level whether they are on or off.