Is That Regulation Really Necessary?

A comprehensive examination and commentary regarding the proposed regulation on occupational exposure to ammonia, from an industry viewpoint

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Some serious questions need to be raised with regard to the proposed new federal regulations on occupational exposure to ammonia.

This article consists of a response to the proposal, and concludes that no new Health Standard is needed. If, however, a new one is issued in spite of impressive evidence that it is not needed, then the appropriate segments of the industry ought to be consulted in its development. Other conclusions are brought out in the following detailed discussions.

In cold, black type, the Federal Register of Tuesday, November 25, 1975, spelled out another area of concern for the ammonia industry. This eleven-page section was titled, "Ammonia-Proposed Standards for Exposure."

In the Preamble, the first thing to be noticed was that this would be a new Occupational Safety & Health Standard governing exposure to ammonia, identified as No. 1910. 1031, and that it would delete the present standard for ammonia exposure limits contained in Table Z-1 of 29 CFR 1910. 1000. It was also noted that the Standard would apply to all employees in all industries covered by the Act, including "General Industry," but would not apply to agricultural operations or to operations covered by 29 CFR 1910. 111.

It wasn't until we read paragraph 4 that we found the real thrust of the proposed standard. Paragraph 4 began by stating "The proposed standard contains a requirement limiting employee exposure to ammonia to a ceiling concentration of 50 parts per million (ppm) of air. The proposal also provides for employee exposure measurements, methods of compliance, personal protective equipment and clothing, training, limited medical surveillance, and record keeping."

This proposed standard was recommending changing the present 50-ppm. time-weighted-average (TWA) to a 50-ppm. ceiling limit based on a 5-min. sampling period. Careful scrutiny of the remainder of the Preamble did not appear to provide any reasonable basis for this change in exposure limits.

Living with proposed standard very problematical

The proposed standard itself was then read and re-read many times, each time relating it to the effect it would have on our own company's operation as a nitrogen fertilizer manufacturer and distributor. It became very clear that the standard as written would be next to impossible, if not impossible, to live with. At this time, corporate management was then appraised of the problems the proposed regulations would cause, and it was recommended that a Corporate reply be made during the period open for comment. This recommendation was agreed upon as the best approach.

Next, a plan of action was decided upon. First, all our manufacturing installations were requested to provide input for this Corporate reply. We also contacted friends and associates with other companies in the industry for any help they could provide. Copies of HEW Publication No. (NIOSH) 74-136, "Criteria for Recommended Standard - Occupational Exposure to Ammonia" were obtained. This was the principal document referred to in the Preamble of the Proposed Standard.

Because the expertise for preparing a physiological response was not available within the company structure, we were fortunate in having a local consultant who could do this job for us. Dr. Jerome Martin was asked to review the references given in the NIOSH publication as well as to research the literature for any other references which may have a bearing on the proposed new exposure limit. He was also asked to look at the standard as written and to comment on any portions on which he felt qualified. This excellent report was sent in its entirety as part of our comments to the Department of Labor.

Sampling programs had begun in our other manufacturing facilities, and data started to come in covering results of

sampling, methods of sampling, plant medical histories, and any other information pertinent to commenting on the proposed standard. We were also pleased to hear from contacts with other companies. As we began to assemble and read the huge volumes of information beginning to collect, the paramount question became the development of the most forceful method of projecting this information.

Since the evidence was strong that the proposed standard would not add significantly to the health and safety of employees and that it would be grossly inflationary, it was recommended that no new standard was required. This recommendation alone with all of the supporting data was not enough.

If the decision were made by OSHA to issue a new standard, despite the impressive evidence against it, it was necessary that we provide recommendations on how the standard would be written.

For this reason, a two-column presentation was used. Each sub-section of the proposed standard, exactly as it appeared in the Federal Register of November 25, 1975, was displayed in the left-hand column. A version, rewritten in a manner to incorporate our proposals, was displayed in the right-hand column. At the end of the two-column display for each sub-section, detailed explanations, arguments, and references to supporting data were presented in support of proposed changes in that sub-section. By this method, the final result was a complete standard rewritten to incorporate all of our comments. A sample of this two-column format is shown in Appendix 1.

With this background established, the intended purpose of this article can be explored: "Is the Proposed Regulation On Occupational Exposure To Ammonia Really Necessary?" My answer must be an unequivocal "No!"

The CF Industries, Inc., supply system includes eight U.S. production plants in which ammonia is produced, used, stored, or transported. Data on the amount of ammonia handled in these plants during the five year period 1971 through 1975 were collected along with a tabulation of the number of respiratory cases attributed to ammonia. These data show that nearly 8 million tons of ammonia was handled and that some 900 workers were exposed for approximately 9 million hr. to ammonia concentration governed by a time-weighted-average (TWA) of 50 ppm. Not a single respiratory case was reported involving exposure to ammonia.

In one series of 301 samples taken, the following concentrations were found: 249 samples at less than 50 ppm.; 27 at 50 to 100 ppm.; 19 at 100 to 400 ppm.; and 6 above 400 ppm. With these results, it is apparent that some employees were exposed to ammonia concentrations of over 50 ppm.

Medical records are excellent

Two of the eight facilities surveyed had excellent medical records going back farther than the period 1971—1975. One plant had records back to 1960, which meant that from 1960 to 1963 they were operating under a maximum allowable concentration (MAC) of 100 ppm. and from 1963 through 1975 they were operating under the present standard of exposure of 50 ppm. TWA.

In this facility, all employees were given a pre-employment physical examination, and were re-examined approximately every two years. These examinations had been conducted by the same two doctors at the same place during the entire 15-yr. period. Each examination included a spirogram test of respiratory function.

The doctors were asked to comment on the exposure of employees to low levels of ammonia. One stated "There has not been one case of complaints or irritation of the conjuctiva of the eyes, nasal mucosa, or chronic nasal drainage, sore throat, or cough which has been attributed, either by myself or by the employee, to the inhalation of ammonia."

The spirograms revealed just one case of decrease in respiratory function. This single case was a man who smoked a pipe heavily and inhaled the smoke. When the subject stopped smoking, his respiratory function improved. The doctor's opinion was that the trouble experienced by this man was not related to his work. The doctor also stated, "There is also no evidence that levels as high as those now permitted, or those which have been permitted, causing any significant health problem or illness in the workers. Our evidence supports this contention."

This medical history is from a nitrogen fertilizer complex which has been in operation for over 15 yr., and for which there was 3,440-yr. of employee exposure to ammonia.

Another one of the plants had medical records dating back to 1965. During this period, approximately 460 man-yr. had been worked by employees under the present exposure limit of 50 ppm. TWA. The doctor who had examined these employees during their yearly physicals stated that he had no instances of complaints from the personnel regarding symptoms of excessive inhalation of ammonia fumes, i.e. irritation of the eyes, nasal mucous, chronic nasal discharge, sore throat, or cough.

He concluded "that the level of ammonia which is normally seen in this facility is not causing illness or disease, loss of work, or health hazard to the employee. It is obvious, of course, that an inhalation of a very high ammonia level could cause permanent damage to the eyes or respiratory track or could be fatal. It is interesting, however, that lower levels of ammonis are actually only extremely irritating, and the effects dissipate as soon as the patient is removed from exposure to the agent. There is no evidence of lasting damage. There are no long term toxic effects including production of cancer, etc., associated with prolonged low ammonia dose levels. There is no evidence that levels as high as those now permitted, or which have been permitted, cause any significant health problems or illness to workers."

Medical data such as these firmly support the view that it is not necessary to replace the present exposure limit of a TWA of 50 ppm. with the more stringent ceiling limit of 50 ppm. to protect the safety and health of employees. In addition, these medical reports gave no *credibility* to the unsubstantiated report of Bittersohl *(1)* which implied ammonia was carcinogen.

NIOSH points not seen as persuasive

The U.S. Department of Labor and OSHA relied on the NIOSH Report No. 74-136 for presentation of data to support their contention that a ceiling limit of 50 ppm. for ammonia was necessary to protect the safety and health of workers involved in the production, storage, handling, and transportation of this chemical compound. The NIOSH Report is far from persuasive that it is necessary to change from the present TWA of 50 ppm. to a ceiling limit of 50 ppm., not only because of the character of the data presented, but also because of the kinds of data on which the Report is silent.

The reasons for this view of the NIOSH Report are given in the following paragraphs.

1. No cases have been cited in which employees of a U.S. ammonia plant have suffered bad effects from exposure to ammonia in concentrations allowed by a TWA of 50 ppm. or even of a TWA of 100 ppm., the second of which was in effect for several years after 1943. The lack of such citations is especially significant in view of the fact that ammonia has been made on a large scale in the United States for over 50 years; and that thousands of employees have spent thousands of man-years in its production during this period.

The data presented earlier showed that employees of eight CF Industries, Inc. plants had spent some 7,400 man-years in the period 1971 through 1975, and that the employees of another plant, which furnished data to us, had logged some 8,000 man-years in its operation and no ill effects on the health of employees was reported by either company as the result of exposure to ammonia governed by a TWA of 50 or 100 ppm.

2. The Epidemiologic section of the NIOSH Report cites a reference, El-Sewefy *(2)* which gives results from an Egyptian ice plant, and these showed no statistical difference in medical histories between employees of the plant and a control group. Since this report lacks data on the ammonia concentrations to which the workers were exposed, the only conclusion to be drawn is that at some unknown concentration of ammonia, the health of the workers was not impaired. This report *cannot* be used in support of a ceiling of 50 ppm. Neither can it be used in support of a TWA of 50 ppm.

3. The next reference cited in the Epidemiologic section is that of Bittersohl *(1)*, who claimed that cancer morbidity and mortality in two East German ammonia plants were higher than in the population at large. The details in this reference are so sparse, however, that it was denigrated in the NIOSH Report in these words, "the validity of this single report cannot be evaluated." The NIOSH document No. 74-136 gave a brief summary of Bittersohl's report *(1)*, and on the basis of this summary a number of deficiencies in his work are pointed out.

These deficiencies are shown below along with additional deficiencies which became apparent after the text, although much blurred in sections, became available to us.

(a) Most German ammonia plants use coal as a primary raw material and such plants are notable for polluting the air with dust and with aromatic hydrocarbons. We assumed that the "mineral oil" feed stock mentioned by Bittersohl arises from a Fischer-Tropsch unit fed with a carbon monoxide-hydrogen mixture made from the gasification of coal in, for example, a Lurgi apparatus. This assumption seems reasonable since Bittersohl speaks of a "gas plant" and he mentions that the employees in this plant have a high incidence of cancer. The preparation of a $CO\text{-}H_2$ mixture from coal inevitably contaminates the air with aromatic hydrocarbons, and many aromatic hydrocarbons are, of course, potent carcinogens.

(b) The Findings of Bittersohl are not confirmed by the large German chemical encyclopedia Ullmanns *(3)*. This reference gives a list of chemicals implicated in occupational illnesses in Germany, but ammonia is not included in the list.

(c) Among the chemicals which are implicated in occupational illnesses is methanol *(3)* and Bittersohl states that the German complex contains an amine plant where ammonia and methanol are reacted to form di- and trimethylamines. Since the units in German chemical plants are built close together, it is quite possible that methanol is an airborne pollutant in both the amine plant and in the ammonia plant.

(d) Carbon monoxide is another chemical listed in Ullmanns *(3)* which is inimical to the health of employees. It is produced as part of the non-condensible gas stream which arises from a methylamines synthesis unit. Carbon monoxide could be present, therefore, in the air of the amine plant and in the air of the ammonia plant. Other sources of carbon monoxide would arise from: 1) the exit gas from the coal gasification plant, and 2) the gas mixture fed to the methanol plant. The latter mixture would have a composition of about 32% CO, 64% H_2, and 4% CH_4 plus H_2.

(e) Chromium compounds are also listed in Ullmanns *(3)* as a cause of occupational illness, and Bittersohl states that cancers have been found among workers in the "chromium catalyst" unit. Presumably, this is the unit where methanol synthesis catalyst is made. These catalysts generally have a composition such as $ZnO{\cong}Cr_2O_3$. Dusts from the preparation of such catalysts could easily contaminate the air.

(f) Bittersohl states that the tar fraction of the mineral oil produced in the chemical complex is a carcinogen, especially if it gets on the skin and is then exposed to heat or light. These carcinogenic tars in the form of dust could also be airborne and be carried to other units in the factory.

(g) Bittersohl states that in the large chemical plant, of which the ammonia unit is a part, mineral oil is converted to petrol, plastics solvents, and some other organic substances. He does not state what monomers are used in the manufacture of plastics, but one of the monomers could very well be vinyl chloride which has recently been shown to be a powerful carcinogen. If the incidence of cancer among employees of this plant is as high as stated by Bittersohl, there must be some powerful carcinogen at work, and vinyl chloride is such a substance. There is no evidence that

ammonia could produce such a dramatic increase in the incidence of cancer.

(h) In the following sentence, Bittersohl states that polycyclic hydrocarbons come from the hydrogenation unit (Fischer-Tropsch plant). "It is possible that ammonia as a syncarcinogenic substance is of effect together with polycyclic hydrocarbons coming from the hydrogenation unit and provable in the air of the factory." He then postulates that ammonia is a synergistic agent which amplifies the carcinogenic properties of the polycyclic hydrocarbons which undoubtedly give the mineral oil tars their ability to produce cancer of the skin.

Observations are not applicable

Even if this synergistic action of ammonia had been proven to be true, which it has *not* been, the observations of Bittersohl would not be applicable to U.S. ammonia plants, because none of them, to our knowledge, has a Fischer-Tropsch mineral oil plant nearby.

(i) In the quotation below, Bittersohl gives an egregious reason for the syncarcinogenic or carcinogenic properties imputed by him to ammonia:

"On the other hand, ammonia possesses two free electrons at the N-atom and therefore has the tendency to change to an ammonium ion by absorption of a proton. For that reason one may also comprehend ammonia as a radical. Hence there are connections with the conception of Wattschafter, Cronin and others about the importance of free radicals, as for instance at the effect of some solvents, at the development of carbonium radicals, at the effect of *nitrosamin* and so on."

NOTE: The underlined word was very blurred in our copy of the article and we are not too sure that it is nitrosamin. The exact word, however, does not alter the force of our criticism of Bittersohl's thesis.

Bittersohl seems to be saying that because ammonia forms ammonium ion with a proton, $NH_3 + H^+ \rightarrow NH_4^+ \cdot$ this puts ammonium ion in the class of free radicals, and since free radicals have been postulated as carcinogens and as having other deleterious effects in the body; therefore, ammonia and ammonium ions are carcinogens. *(4, 5)* The following things are patently wrong with his reasoning:

Firstly: neither ammonia nor ammonium ion is a free radical, since a free radical is defined as an atom or group of atoms which has at least one unpaired (odd) electron. *(5, 6)*

Secondly: by Bittersohl's theory, water would also be a carcinogen since it reacts avidly with a proton to give hydronium ion, $H_2 + H^+ \rightarrow H_3O^+$.

Thirdly, if ammonia and ammonium ion were carcinogens, all of the amino acids found in the body would fall in the same category as illustrated below with alanine:

$$\begin{pmatrix} CH_3CH-COOH \\ NH_2 \end{pmatrix} + H^+ \rightarrow \begin{pmatrix} CH_3CH-COOH \\ NH_3^+ \end{pmatrix}$$

It could, of course, come about that the amino group would react as shown in the next equation:

$$\begin{pmatrix} CH_3CH-COOH \\ NH_2 \end{pmatrix} \rightarrow \begin{pmatrix} CH_3CH-COO^- \\ NH_3^+ \end{pmatrix}$$

In either case we have a carcinogenic substance according to Bittersohl's theory.

Fourthly, since the kidneys elaborate ammonia to preserve the base balance in the body, and since urine contains either ammonia or ammonium ions or both of them, every human would be expected to develop cancer of the kidneys and the urinary delivery system. *(7, 8)*

(j) Bittersohl concluded his paper, published in September, 1969, in these words, "We considered these observations worth to be informed though our researches about the problem are not yet finished." It is very strange that there has been no subsequent paper from him in view of the dramatic disclosures made in his original publication.

(k) Finally, the observations of Bittersohl have not been confirmed by data from any other of the many ammonia plants in the world.

The Bittersohl reference was discussed in detail because it was the only one of the numerous citations on ammonia which attempts to associate long-term, low-level exposure with carcinogenic action of the compound. It was therefore concluded that the many deficiencies listed in the discussion of the subject reference render its data completely useless as a support for a ceiling limit of 50 ppm. determined on a sample taken within a time of five minutes or less.

4. Elkins *(9)* stated that an ammonia concentration of 125 ppm. in a mildew-proofing plant was irritating, but that a concentration of 55 ppm. in an electroplating plant was judged not to be excessive. In neither of the statements on these two plants were any details given, particularly with reference to the presence of other chemicals. No statement was made as to whether the concentration of 125 ppm. was detrimental to the health of the workers.

It should be noted that Elkins *(9)* gives 100 ppm. as the MAC for ammonia. This reference gives little or no support for a ceiling limit of 50 ppm. for the following reasons:

(a) Elkins does not disavow an MAC of 100 ppm. for ammonia.

(b) The report from the mildew-proofing plant gives no indication of any bad effect on the health of the employees.

(c) Elkins did not consider 55 ppm. to be excessive.

5. Vigliani and Zurlo *(10)* state that measurements of ammonia concentrations in the synthesis sections for production of ammonia, ammonium nitrate, urea, and illuminating gas indicated that exposure to concentrations of 100 ppm. could not be experienced without irritation of the upper respiratory tract and reddening of the eyes.

As the NIOSH Report No. 74-136 points out, the reference *(10)* is very vague on many details. The most severe defect is that the reference gives no statement about the effect of ammonia at a concentration of 100 ppm. on the health and safety of the workers. The report of Vigliani and Zurlo is concerned only with comfort effects and not with health effects. Vigliani and Zurlo do not even name the country in which the subject ammonia plants were located and they give no indication of the chief raw material used in

the processes. Presumably, since they speak of "Leuchtgaswerken" these plants are based on coal with the attendant air pollution with many aromatic chemicals associated with such an operation.

Some questions as to reliability

The work reported by Vigliani and Zurlo deals with comfort aspects of exposure to ammonia, and it gives no reading on whether a change from a TWA of 50 ppm. to a ceiling limit of 50 ppm. is indicated.

One statement which appears at the bottom of page 529 of their paper casts doubt on the reliability of the work of Vigliani and Zurlo. They define parts per million (ppm.) of compounds in air in the following words: "ppm (parts per million) = 1 mg./liter bei 25°C and 750 mm. Quecksilber Barometerdruck." This definition is obviously wrong in the context intended. It would only be correct for a compound dissolved in a liter of liquid water or any other liquid of specific gravity of 1.0.

6. The Epidemiologic section closes with two unpublished reports by Mangold *(11)* and Pagnotto (no reference number given) which are concerned with a small number of workers in blueprint shops, insole shops, etc.

These reports are deficient in the following ways:

(a) They do not take into account the presence of other chemicals.

(b) They do not consider whether a blueprint operator gets too close to a fresh blueprint on which ammonia is strongly adsorbed and which gives off a high concentration of ammonia in the immediate vicinity.

(c) They do not consider the effect of exposure to ultraviolet light. The reports attributed to Mangold and Pagnotto do not concern themselves with the effect of ammonia in the air on the health and safety of the employees. These reports are concerned with the comfort of the workers. Consequently these two reports do not speak to the question of whether a TWA of 50 ppm. should be replaced by a ceiling limit of 50 ppm. in order to protect the health and safety of employees.

7. The NIOSH Report discusses several references which are concerned with the exposure of humans for very short periods (from 5 to 10 min.) to ammonia concentrations of 30 to 134 ppm. *(12, 13)* The volunteer subjects reported effects such as eye irritation, nasal irritation, signs of lacrimation, and dryness of the nose. These reports are concerned with comfort effects and the reports have nothing to say about the effects of exposure to ammonia on the health of the subjects tested.

In his book *(14)*, Patty wrote with repsect to ammonia, "The maximum permissible concentration is accepted to be 100 ppm. (70 mg./cu. m.). A standard based upon comfort would be somewhat less than 100 ppm."

The data in references *(12)* and *(13)* are of far less value than those of reference *(15)*, because the exposures of the former were only 0.16 hr. compared to those of reference *(15)* of over 100 hr. Furthermore, no medical data were included in the former references; there were also no reasons given to change from a TWA of 50 ppm. to a ceiling of 50 ppm. if our concern is with the safety and health of the employees.

8. As noted in reference *(15)*, the NIOSH Report No. 74-136 (p. 64) states that the Threshold Limit Value (TLV) for ammonia was set at 100 ppm. in 1948 and this value remained through 1962. This TLV was reduced to 50 ppm. in 1963, presumably because of the report of Dalham *(16)* on the effect of very low concentrations of ammonia on ciliary action and the report of Weatherby *(17)* on the effect of ammonia on guinea pigs. It turns out that Dalham *(18)* could not repeat his earlier work, and that his later results indicated that 100 ppm. was the threshold concentration of ammonia for an effect on the ciliary activity in excised rabbit trachea.

Weatherby *(17)* exposed guinea pigs to an average ammonia concentration of 170 ppm. for 6 hr./day, 5 day/week for periods of 6, 12, and 18 weeks. The animals sacrificed at 6 and 12 weeks showed no changes compared sacrificed at 6 and 12 weeks showed no changes compared to the controls. But those sacrificed at 18 weeks showed "relatively mild though definite changes in spleens, kidneys, suprarenal glands, and livers with severity of the changes being most prominent in spleens and least in livers." The guinea pigs sacrificed at 18 weeks had an exposure of 91,800 ppm.-hr.

The later and more extensive work of Coon *et al. (19)* cast serious doubts on the chronic effects reported by Weatherby *(17)* in his guinea pig study. The exposure schedule of Coon is in every case, save one, greater than the 91,800 ppm.-hr. for the 18-week exposure for which Weatherby reported some adverse effects on guinea pigs.

The results of Coon *et al.* do not appear to support a change from a TWA of 50 ppm. to a ceiling limit of 50 ppm.

This review of the same literature reportedly studied by NIOSH fails to support the proposed change to a ceiling limit of 50 ppm. measured over a five-minute period. In fact, nothing in this literature would indicate that a new standard, in any form, is required.

A close review and examination of the proposed standard for exposure to ammonia shows it is deficient in that it lacks accuracy, it lacks clear definition in critical areas, it abounds with amibiguity, and many of the requirements are impracticable.

An attempt will be made to cover only a few of the major points which should be made. Section (b) *"Definitions"* shows the following for emergency:

"Emergency" means any occurrence such as, but not limited to, equipment failure or failure of control equipment which is likely to or does result in an unexpected exposure to ammonia in excess of the permissable exposure limit."

With the proposed exposure to a 50-ppm. ceiling limit there could be so many emergencies in an ammonia plant operation that chaos could result. Looking back on the 301 samples discussed earlier, taken in an actual nitrogen fertilizer plant operation, 52 were over 50 ppm. This would

have meant that there were 52 emergencies in that plant. Such a broad definition as given in the proposed standard destroys the true meaning of the word.

We chose to redefine emergency as follows:

"Emergency" means any sudden, usually unexpected, occasion or combination of events which is likely to or does result in concentrations of ammonia in the air equal to, or above, Emergency Exposure Limits (EEL)."

A formula was worked out relating exposure time to ammonia concentration between 100 and 400 ppm. The EEL was set at 400 ppm. for 40 minutes. This provided a safety factor over that shown in reference *(20)* covering allowable exposure to ammonia in a submarine. In this reference, it is stated that the U.S. Navy in 1962 established 25 ppm. as the maximum limit for exposure during a 60-day dive in a submarine, and 400 ppm. as a maximum allowable concentration for one-hour under operational conditions.

Other definitions also included

We also chose to add definitions for "workplace" and for "work operation" in that they had been used throughout the proposed standard. This was done because one must be prepared for strictest possible interpretation from the compliance officer, who may be a State, rather than a Federal employee. These definitions will be further discussed under the economic impact of the proposed standard.

Determination and Measurement of Exposure, Section (d) of the proposed regulation, had many generalities and impractical features. It was therefore necessary to recommend many changes as part of our comments. Again, due to the different interpretations of regulations by individual compliance officers, it is absolutely imperative that all statements be positive and definitive.

Several places in the standard cover employee complaints of symptoms which may be attributable to exposure to airborne ammonia and certain actions that must be taken. It is interesting to note that in no pl[illegible]n the standard is any reference made to the fact that t[illegible] exposure must have occurred at work. In other words, if an employee was a part-time farmer and had been exposed to ammonia while filling an applicator, or if he had just washed the windows with an ammonia solution before coming to work, he would be covered under these actions which must be taken.

Part (1), *Engineering and work practice controls* which is part of Section (e) *Methods of Compliance,* has some interesting requirements. Paragraph (e) (1) (i) states "The employer shall immediately institute engineering controls to reduce exposures to below the ceiling limit, except to the extent that such controls are not feasible." Paragraphs (e) (1) (ii) and (e) (1) (iii) discuss the use of engineering controls, to the extent feasible, with supplemental work practice controls and also with respiratory protection to reduce exposures below the ceiling limit. However, Paragraph (e) (1) (iv) states "The employer shall establish and implement a program to reduce exposures to below the ceiling limit, or to the greatest extent feasible, solely by means of engineering controls.

The logic of these requirements is difficult to understand. Engineering controls must be installed according to Paragraphs (e)(1)(ii) and (e) (1) (iii), even if they do not accomplish reduction of exposure to below the ceiling limit, but Paragraph (e)(1)(iv) states that it must be done *solely* by means of such controls.

Installation of a control that is known to be ineffective is impracticable, therefore, not feasible. It appears the standard is proposing that engineering controls can be both feasible and infeasible in the same breath.

Section (i) *Medical Surveillance* of the proposed standard would require many changes to make this section practical to live with. For example, it is stated that medical examinations are to be provided by the employer during the employee's normal working hours. With operators on shift work, routine medical examinations are not available on a 24-hr. basis in most areas of the country.

Exception must also be taken to the part of the standard stating that the employer shall provide medical examinations as required by the standard, with no further requirement that the employee is under any obligation to avail himself of the service so provided. This requirement must be placed on the employee as part of any final standard.

There can be no agreement that the employee be allowed to *selectively do those things* which he feels are in the interest of guarding his health while the employer is *told to do all these things* and has no choice but to comply. The need for this requirement is brought out very forcefully in the March 1976 issue of *Job Safety and Health,* published by the U.S. Department of Labor, Occupational Safety and Health Administration.

The article referred to stated that the "OSHA solicitor's office had decided that although the vinyl chloride standard requires employers to make free medical exams available to employees working with or near the carcinogen, workers are not thereby required to submit to the examination." The solicitor further stated "that the w[illegible]er not only has the right to forego the company exam, but he also need not be examined by private physician."

Appearances are sometimes deceiving

Many portions of a standard such as the one we are discussing look innocent and easy to comply with, but under a literal translation they would be very tough problem areas. As an example of this type, Section (j) *Employee Information and Training* states that the employer shall provide a training program at the time of initial assignment to a workplace area as specified. This training shall inform each employee of certain items. Paragraph (j)(1)(ii)(B) states "that the employee must be informed of the quantity, location, manner of use, release, or storage of ammonia and the specific nature of operations which could result in exposure above the ceiling limit, as well as any necessary protective step."

If this wording were not changed and were literally applied to a nitrogen fertilizer complex of even modest size, consisting of the ammonia plant, nitric acid plant, am-

monium nitrate plant, solutions plant, and urea plant, plus all loading areas, the permutations and combinations of events which could possibly lead to an exposure over the proposed ceiling limit could very easily be the number "googol" (10^{100}).

The examples used were but a mere fraction of the items found in the proposed standard which needed clarification or complete revision. Sections such as (k) Labeling (What is a container?), (l) Recordkeeping, (m) Observation of monitoring, and (p) Appendixes, were not discussed.

Before looking into the economic impact of the standard, perhaps one additional comment should be made with regard to a portion of Appendix B, Section IV. This section states that "Laboratories performing chemical analysis should be accredited in Industrial Hygiene Chemistry by the American Industrial Hygiene Association." To my knowledge, only 63 laboratories in the United States have been accredited. These include: only about 10 state or county laboratories; only about 2 NIOSH laboratories units; only 4 national insurance companies; and only 4 universities.

It would be very difficult to get qualified laboratories to run the number of analyses needed.

In formulating the comments to the proposed standard, there was not time to work out and present an elaborate economic impact statement. The approach used was to take a literal interpretation of the standard and to estimate the cost to a hypothetical producer of 200,000 ton/hr. of ammonia and having all the other operating units making up a nitrogen fertilizer complex. A total of 100 employees was used, of which approximately one-half were shift workers.

Costs were estimated for complying with a *literal interpretation* of each section of the proposed standard. This amounted to $1,600,000/yr. The cost to the same producer to comply with our rewritten standard based on the present 50 ppm. TWA would be $40,000/yr.

Assuming that the distribution chain would require handling and compliance efforts equal to at least three times that of the primary producer (and that the non-agricultural users would follow a not dissimilar pattern), the total economic impact would approximate $384,000,000 and $10,000,000, respectively, as order-of-magnitude figures for a U.S. production rate of 16 million ton/yr. Looking at another aspect, the *increased* estimated annual cost per ton of nitrogen becomes $30.00/ton and $0.75/ton, respectively.

Cost estimates made

A conservative calculation of the cost to CF Industries, Inc. to prepare a meaningful response to the proposed standard amounted to $32,000. It is assumed that any producer making comments would have about the same costs and if only a small percentage replied, the total cost would be great. If each of the 400 standards proposed by OSHA entails similar responding costs, the economic impact (which ultimately must be absorbed by consumers) could be cause for alarm.

Another aspect of the impact of the proposed standard should be examined. The NIOSH publication 74-136 in Section IX, Appendix II, pages 94-96 details the analysis procedure for air samples using the direct Nesslerization method. The Nessler reagent requires that 100 g. of mercury (II) iodide (M.W. 545.90) be dissolved in water with the final volume of the reagent being diluted to one liter.

Then, the amount of mercury iodide present in each ml. of reagent:

$$100 \text{ g. Hg. } I_2 \div 1{,}000 \text{ ml.} = 0.1 \text{ g. Hg. } I_2\text{/ml. reagent}$$

Each sample taken requires 2.0 ml of reagent or

$$(2.0 \text{ ml.})(0.1 \text{ g.Hg. } I_2\text{/ml.reagent}) = 0.2 \text{ g.Hg. } I_2\text{/sample}$$

NIOSH, in publication 74-136 on page 24, estimated the number of people affected by the proposal to be approximately 500,000. It is felt that this number is conservative and would be closer to three times this number, or 1,500,000 people. Using the literal interpretation of the standard, as written, the number of samples per week for a work force of 100 was calculated to be 420/week. This figure was used for the estimate of economic impact

If this were applied directly to number of people involved, then:

$$\frac{1{,}500{,}000 \text{ people}}{100 \text{ people/group}} \times \frac{420 \text{ samples}}{\text{group-week}} \times \frac{52 \text{ weeks}}{\text{yr.}} =$$

$$327{,}600{,}000 \text{ samples/yr.}$$

Therefore, the mercuric iodide required would be:

$$\frac{327{,}600{,}000 \text{ samples}}{\text{yr.}} \times \frac{0.2\text{g.Hg.}I_2}{\text{sample}} \div \frac{454\text{g.}}{\text{lb.}} =$$

$$144{,}317 \text{ lb./yr.}$$

This amount of mercuric iodide would probably bedischarged to navigable waters throughout the entire United States because individual small effluents will be randomly, geographically distributed among a great many facilities.

In the EPA proposed rules 40 CFR Part 116, "Designation of Hazardous Substances" page 59965, mercuric iodide was one of the "Materials deleted because of low potential for discharge," for the reasons listed on that page. By increasing the number of samples taken annually and the amount of mercuric iodide used in the sampling, it is most probable that mercuric iodide would have to be added back to the list of hazardous materials.

It is then assumed that mercuric iodide would fall into the same category as the other mercury compounds, i.e. (A) and HQ (in lb.) = 1.

ROP (Rate Of Penalty) = $620/UM (unit of measure). This could then result in penalties of:

$$(144{,}317 \text{ lb./yr.}) (\$620/\text{lb.}) = \$89{,}476{,}540/\text{yr.}$$

to people forced to make measurements and take samples. Relating this amount of money to the total of ammonia produced in the U.S. could result in the following increase per ton of ammonia produced:

$$\frac{\$89{,}476{,}540/\text{yr.}}{16{,}000{,}000\,\text{ton}\,NH_3} = \$5.59/\text{ton}$$

With proper educational measures, effluent discards to navigable waters will be far less than the potential estimated above. Still, prudence dictates that one recognize and acknowledge the magnitude of the problem which could be generated.

Conclusions

Only a small portion of the data and evidence used in preparing a response to the proposed standard has been discussed in this presentation, but I believe enough has been shown that the reader will understand why the following conclusions are presented:

1. The present standard of 50 ppm. TWA (as stated in Table Z-1 of 29 CFR 1910.1000) should be retained and no new Health Standard need be issued.

2. If, despite impressive evidence that it is not needed, a new standard is issued; then it is recommended that it be developed after OSHA has consulted with those appropriate segments of U.S. industry affect by said Regulation.

3. It is believed that NIOSH should undertake more comprehensive investigation and analysis before issuing a Criteria Document to OSHA and the Department of Labor for incorporation into a Health Standard.

4. OSHA should resist pressures calling for immediate action and take time necessary to allow proper considera tion of all factors.

5. In the preparation of Health Standards, NIOSH and OSHA should clearly differentiate between the factors and limits which pertain to health and safety as opposed to those wich relate to comfort. It is our belief that NIOSH and OSHA are not charged with the responsibility of regulating conditions pertaining to comfort.

Let's look at a quotation (author unknown to me) that states: "Not everything we face can be changed, but nothing can be changed unless we face it." Face it we must, with every effort put forth to make those changes necessary to keep us from drowning in regulation. #

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NOTE: In addition to the above specific references to literature cited in the accompanying article, a comprehensive bibliography provides 154 references, including the above 22 citations. It was a part of the original AIChE paper by the

author, presented at the Sept., 1976, meting in Atlantic City, N.J.

Appendix 1

1910.1031 Proposed FR 11/25/75

(b) *Definitions*—"Ammonia" means gaseous[1] or liquified anhydrous ammonia or aqueous solutions thereof.

"Strong aqua ammonia" means aqueous solutions containing more than 10% ammonia.

"Weak aqua ammonia" means aqueous solutions containing 10% or less ammonia.

"Emergency" means any occurrence such as,[2] but not limited to, equipment failure or failure of control equipment which is likely to or does result in an unexpected exposure to ammonia in excess of the permissible exposure limit.

"Director" means the Director, National Institute for Occupational Safety and Health, U.S. Department of Health, Education, and Welfare or the Director's designee.

"Secretary" means the Secretary of Labor, U.S. Department of Labor, or the Secretary's designee.

1910.1031 Proposed CF Industries, Inc.

(b) *Definitions*—"Ammonia" means gaseous or liquified anhydrous ammonia.

"Strong aqua ammonia" means aqueous solutions containing more than 10% ammonia.

"Weak aqua ammonia" means aqueous solutions containing 10% or less ammonia.

"Emergency" means any sudden, usually unexpected, occasion or combination of events which is likely to or does result in concentrations of ammonia in the air equal to, or above, Emergency Exposure Limits (EEL).

"Director" means the Director, National Institute for Occupational Safety and Health, U.S. Department of Health, Education, and Welfare or the Director's designee.

"Secretary" means the Secretary of Labor, U.S. Department of Labor, or the Secretary's designee.

"Workplace" means premises particular to[3] the place of employment.

"Work Operation" means that process, operation,[4] or practice defined by the employer as the main work function of the employee.

Explanation, argument, and references

1. The definition of "ammonia should not be extended to include aqueous solutions snce these are defined specifically in subsequent sections.

2. The definition of "emergency" in the proposed Regulation is so broad and covers so many innocuous occurrences that it destroys the meaning of the word. For example, the following operations would come within the purview of the proposed definition:

(A) A custodian washing windows with a dilute solution of ammonia in water.

(B) A nurse changing diapers in the pediatric section of a hospital.

(C) An ammonia plant operator working on a packing gland leak and noticing the smell of ammonia.

(D) An employee walking by the station where tank cars are being loaded with ammonia and noticing a smell of the chemical in the air.

(E) A patient in a hospital being exposed to smelling salts at 25°C, one of whose constituents is NH_4HCO_3. *(21) NOTE:* Reference *(21)* gives the vapor pressure of NH_4HCO_3 at 25.4°C as 59 mm. Hg. Reference *(22)* gives the ammonia content of the products of decomposition of NH_4HCO_3 as 21.5%. One can then calculate that the atmosphere above solid NH_4HCO_3 contains 16,700 ppm. of NH_3:

$$\frac{59}{760} \times \frac{21.5}{100} \times 10^6 = 16{,}700 \text{ ppm.}$$

(F) An employee of a commercial farm or feed lot working with manure which has stood for a few days.

Making emergencies out of such situations brings to mind Aesop's story of "The Shepherd's Boy" who cried Wolf! Wolf! as a joke and then found that, when the wolf really came, no one paid any attention to his cries for help. There will be so many emergencies in most ammonia plants (under the definition in the proposed Regulation) that employees will not react with proper speed and understanding when a real emergency does occur.

It is believed that the word "emergency" (in the Regulation) should be defined to cover those situations which pose a danger to personnel from high-level concentration of ammonia in air. The discussion here is confined to the definition of "emergency" as it relates to the Regulation and to potential hazards from exposure to airborne ammonia. Nothing herein should be construed to imply that there will not be other types of "emergencies" and consequential actions in an industrial operation. Such emergencies would not necessarily be related in any way to exposure to airborne ammonia.

In reference *(23)* it is pointed out that West Germany defines an Emergency Exposure Limit (EEL) for short-time exposures to certain chemicals. For example, maximum allowable concentration (MAC) for 1, 1, 1-tricholoroethane is 200 ppm., but the EEL values are as follows: 5 min., 2,500 ppm.; 15 min., 2,000 ppm.; 30 min., 2,000 ppm.; and 60 min., 1,000 ppm.

one EEL value for ammonia might well be 400 ppm. for exposures up to 60 min., as suggested in the discussion uner paragraph (c), *Permissible Exposure Limits*, which follows later in this document.

[3,4] "Workplace" and "work operation" are discussed together. As proposed in the Federal Register, without defining the terms "workplace," "work operation," or "inspect," one must be prepared for the strictest possible interpretaion from the Compliance Officer (who may be a State, rather than Federal, Employee).

Paragraph (b) *Definitions*, with the inclusion of additional definitions can avoid such interpretive difficulty and cost. (See Section VII-3 for a more definitive estimate of incremental cost). #

JAMES, R. W.

DISCUSSION

J.G. LIVINGSTONE, Imperial Chemical Industries, Ltd.: I've been relatively quiet this year to my normal performance in this sort of meeting, but this particular subject has really hit and lit off the blue touch paper. We in Billingham wholeheartedly support what is a refreshing approach on the part of the business to put a stop to foolish legislation, and I think there are three things I would like to say first of all before I make some comment about some of the things that are happening in Billingham.

First thing is that legislators are going to have to be forced, and it's going to be bodies like this, that are going to have to play an important part, to act on a much broader basis in approaching these sort of standards. We think that we have to ask the legislators to justify any moves, as you suggested, fully to the public. Last point, and perhaps the most important one, is that the industry and the legislators have a duty to tell the public at large the whole picture. True we can reduce toxic limits. We can reduce them to 5 parts per million if we want to, but who's going to pay? It's the man in the street that's going to pay, not the legislators and not the companies. Because this goes, and has to go, if we are going to stay in the business, on the price of the foodstuffs. We all have to eat to live—we have to pay for it and it is the man in the street who will have to pay.

Now coming back to some of the details in the paper, and I do applaud it as an extremely useful piece of work and a refreshing approach - we at Billingham have been looking through our toxicological department, at some of the records of people involved in the ammonia business going back as far as 1927. And we can find only two cases in all of those employees, who have - suffered illnesses - coronary attacks, that could be in any way - and even that is questionable - associated with exposure to ammonia at the present toxicological limits.

Therefore we see no justification whatsoever for moving the standards, asking us to pay out money which again should be made quite clear to the public, could be much better used, and the return on investment of that money is for the benefit of the public.

JAN BLANKEN, UKF-Holland: During a public enquiry for the construction of a new plant, I was asked by a citizen of the neighbouring village, whether a small amount of ammonia in the air could cause lasting injury to the people of the village.

Trying to get some background information we measured the ammonia content in a cow house of a model farm in North Holland.

It was a properly ventilated well designed cow house and you may be interested in the result, we found 5-8 ppm.

Now this was a model farm, we assumed that the ammonia content in an average cow house and also in piggeries will be considerably higher.

On the basis of this and on the basis of the experience in our own plant which is producing ammonia for nearly fifty years now I am inclined to agree that there is no problem of long term exposure to ammonia at levels below those that cause intolerable acute effects.

RON DYE, UKF, Great Britain. I've listened to the previous paper, I would like to make these comments, and that is like Dr. Livingstone, I sympathize with the cause of the previous speaker, 47a, with effect of government legislation, but then I would ask, as I did the other day, what is the American industry doing, what steps are they taking to counteract this legislation because it's so easy to kick the authorities who are not professional people and understand the problems. They need guidance from the industry and it's far better to get your guidance in first before they open their mouth and speak out from both sides, as the gentleman said.

Because it must also be recognized that unscrupulous industry will put the public at risk. We've just seen this at Servazo in Italy. There's one example to learn a lesson from. Now coming back to this paper on the hose, when are we going to learn about hose? Here we've lost the life of two people, due to an ammonia burst. I can go back to 1957 when a hose

burst, and I happened to be there and it was on a construction site. And it was the unloading of a rail car, 10 tons of ammonia went bang, through a rubber hose.

The same thing happened. People didn't understand that they should run to the leeward side. They ran with the cloud. Fortunately we had no fatalities, but the number of people that fell down pit holes and received injuries - was quite numerous.

Then shortly after that, I can't just remember when but a few years back, a ship arrived on the berth, the hoses that were used were tested. One was found defective, and the ship couldn't be unloaded. So everybody's panicking because of the demurrage charge for the vessel lying on the quay. All pressure was put on the manufacturer to provide a new hose. The new hose came next morning, the ship unloaded, and I think it took about 17 hours use, when this hose collapsed. That was a new hose, made for the duty, marked for the duty, but when it was examined it was found it was the wrong material.

Why was it the wrong material? The manufacturer said well you wanted the hose in a hurry so we had to put the night shift on and the fellow on the night shift didn't know what materials to use. Now, the lesson to learn is dispence with hoses - go to "Chicksan" arms i.e. articulated steel piping. I sit on committees where I hear people telling me, we've unloaded millions of tons of ammonia with hoses and we haven't had one go bang. To me that is just wishful thinking.

JAN BLANKEN, UKF-Holland: I fully agree with the statement just made by Ron Dye, but I received a report of an incident with a Chicksan loading arm in a small independent fertilizer works in England, of which I would like to read the conclusion and recommendation.

The failure of the Chicksan arm at the centre swivel joint was due to loss of all the ball bearings from the ball grooves.

Either the circlips were not fitted, or, more likely, copper alloy circlips were fitted which failed by stress corrosion cracking allowing the ball retaining caps to fall out and subsequently the ball bearings.

A lack of routine inspection and maintenance was a contributory factor.

Recommendations are:

a. To ensure that only austenitic steel circlips are used in the assembly of arms on ammonia duty.
b. To improve relevant inspection and maintenance procedures.
c. Consideration to be given to fitting at least two actuation devices, so that liquid flow can be isolated remotely, or alternatively, excess flow valves be incorporated in the liquid line.

P.A. RUZISKA, Exxon Chemical Co.: I'd like to add to that comment. Our practice in our plants is to issue to each employee entering the plant gate a mask which he has to have in his possession at all times while in the plant. In the event of a problem he can put the mask on quickly and get out. It's not a mask which enables him to work in the atmosphere, but is intended to enable him to get out of a problem area.

M. BADREL DIN, Petrochemical Industries Co., Kuwait: One other safety feature which we have, and I thought it was pretty widespread, is to have an automatic pump trip when the line pressure drops suddenly during ammonia pumping. I don't know whether people in fact have these devices, and they are considered reliable or not.

JAN BLANKEN, UKF-Holland: Having to load tankers coming from all over the world we find it difficult to connect our own trip system ashore with the trip system on board the ship, such that the man on board and the man ashore ;can both close the emergency shut off valve both ashore and on board.

We would very much appreciate if some international body could standardize the trip systems such that they can be connected together.

This coud improve the safety of handling ammonia.