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Beryllium, The Criteria Document

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Beryllium, along with a few others such as asbestos and mercury, was a substance singled out as especially toxic in industrial use, requiring a standard under the Occupational Safety and Health Act at an early date. These same substances were also singled out under the Clean Air Act and there is a curious parallelism in their treatment under these two laws. Action by the National Institute of Occupational Safety and Health on asbestos came quickly and the draft of the criteria document was given to the Occupational Safety and Health Administration review committee and the standard adopted before the criteria document was published. Beryllium was the next subject for a criteria document and this was actually the first criteria document published. Strangely, although it has been available in final form for at least nine months, no OSHA review committee has yet been appointed to consider it. A somewhat similar course has been followed by the Environmental Protection Agency with respect to beryllium. Proposed

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beryllium emission standards were published in the Federal Register in December 1971 and a draft of a control document was reviewed more than a year ago, but it was not until April, 1973 that the standard was adopted and the control document issued.

Since the beryllium criteria document was the first to be published it was somewhat pioneering and experimental in form and, as a result, there are a few things that may be noted about this document which have been modified in later documents. Its history reflects the criteria and standard making process in a favorable fashion. Having had the opportunity to read two drafts prior to the final one I was impressed with the improvements from one draft to another and the extent to which consideration was given to comments from professional groups and individuals. It is also encouraging that many persons were willing to devote time to making reviews and submitting written comments. Good standards can only come from such broad and willing participation.

Workplace Air Concentrations

When we think of a standard we first consider the Threshold Limit Value or the concentration level to which workers can be exposed on their job. Here the figures are exactly the same as those adopted by the U. S. Atomic Energy Commission in 1949 -- twenty-four years ago. To anyone who has

followed the history of these standards this comes as no surprise and this is one of the reasons there has been no urgency about the formal adoption of an OSHA standard. People who regularly work with beryllium have long been aware of these standards and most have already been observing them.

The question is inevitably raised as to whether these standards are soundly based on experimental data and observations and whether they are realistic. There is even considerable folklore -- only partly apocryphyl -- about their origin. There is good information testifying to the fact where the standards are followed, beryllium disease is essentially non-existant. Whether the standard could be raised significantly and still provide adequate protection is a question which probably never will be answered. The standard when adopted by the Atomic Energy Commission in 1949 essentially demanded full compliance and the Atomic Energy Commission was in a position to require such compliance by its contractors, who were the major suppliers and fabricators of beryllium. Thus, there would be a natural reluctance on the part of any of these contractors to show that their people were working in concentrations in excess of the standard.

The most serious effects of beryllium exposure often come many years after exposure has ceased and this greatly complicates the effort to relate exposure to effect in a

quantitative way. Even if data could be gathered showing prolonged exposure at levels two to five times the standard it would be necessary to follow the exposed workers medically for the rest of their lives to demonstrate an absence of long term effects. The existing standard does require very careful attention to the design and operation of ventilation and other controls. Relaxation of the air concentration standards by two to five times does not greatly reduce the stringency of the control measures required. There is no great incentive to seek this degree of relaxation. The concentration standards have been met in practice and are demonstrably feasible. It is unlikely that these numbers will decrease appreciably in the future while standards for many other materials have decreased and will probably continue to decrease. In the future, the beryllium concentration may not appear so out-of-line with other toxic substances as it has in the past.

Air Concentration Measurements

The standard requires quarterly measurements of the air concentration in the breathing zone and if concentrations in excess of the standard are found, the required frequency is increased to monthly. Monthly sampling is continued until two consecutive thirty day samples are obtained showing time-weighted-average concentrations to be below 2 $\mu g/m^3$. This is a reasonable approach although many employers will sample more frequently than this. 180 days are

allowed to complete the first sampling period following the adoption of the standard. For most installations this is unreasonably long. Practically any plant handling appreciable quantities of beryllium is already sampling and does not require a six months waiting period.

The sampling flowrate of .05 cubic meters per minute is reasonable although it is difficult to see why it is a required minimum rate if the sensitivity of the analytical method is adequate to measure the amount collected. The filter paper specified as the collection medium is Whatman #41 or equivalent and no specifications are given for the size of the paper or the filter holder. Whatman #41 has a low collection efficiency at low sampling velocities and this efficiency varies considerably with the size of the particles being collected. At velocities exceeding 80 feet per minute (24 meters per minute) all sizes are collected with high efficiency. Thus for a sampling flowrate of .05 m^3/min. the filter paper should not be larger than about 5 cm in diameter to attain an 80 feet per minute filter velocity. A suggested method of calibrating the flowrate on the air sampler is given but only by showing a diagram. However, the diagram does not contain enough explanatory information to enable most people to build the system.

For measuring conformance to the requirement that no peak concentration exceed 25 $\mu g/m^3$ a minimum sampling time of 30 minutes is required and this requirement is a part of the standard. Since no maximum sampling time is specified

it could be an hour or more which hardly conforms to the usual understanding of the meaning of peak concentration. Usually a maximum sampling time of 30 minutes is used and the minimum is determined by practical considerations of the plant operation and the sensitivity of the method of analysis. Demonstrating conformance to peak concentration levels is a difficult problem and has always troubled beryllium users. There is no question, however, of the need for this requirement.

The analytical method recommended for the air samples is atomic absorption spectrophotometry although other methods of equivalent sensitivity and accuracy are permitted. If one is already analyzing such samples by the emission spectrometer or by the morin method these can be continued unless there are other incentives to change. Indeed, these are somewhat more sensitive and permit greater flexibility in sample collection.

Medical Recommendations

Medical surveillance of beryllium workers is important as stressed in the standard. In addition to the usual standard preplacement and periodic examinations several specific measurements, principally respiratory, are required. However, no guidance is given to the physician in how to use or interpret these data.

Personal Protective Equipment

Reusable half-mask air purifying respirators are usually approved for use where the air concentration does not exceed ten times the accepted TLV. In the beryllium standard the limit is placed at 25 $\mu g/m^3$ for some reason which is 12 1/2 times the TLV. The difference is insignificant but it may cause confusion by seeming to relate to the peak concentration standard. Specific and useful information is given in this section.

Control Measures

Adequate ventilation is recommended to reduce exposure to beryllium but no specific information is given in the standard or the document for help in designing such ventilation and no references are cited as sources of such information. In some of the later documents Section V has been expanded to include both environmental and control data. This is a real omission here. Good housekeeping is also important in beryllium control and swipe tests are useful in indicating the degree of cleanup required. These could have been mentioned in this section.

Disposal

The standard properly calls attention to the desirability of recycling scrap beryllium and suggests burial as an alternative method of disposal. There is a real need for

the development of a recycling program. When one considers the necessity of importing beryllium ore and the difficulties and hazards of refining beryllium from relatively low grade ores it is hard to see the justification for burying scrap containing a very high percentage of beryllium. Yet economic factors appear superficially to favor burial of this material.

Sanitation

Food preparation and eating are prohibited in beryllium work areas according to the standard. This is probably justified because of the wide variety of other chemicals usually present in such areas but there is no evidence that beryllium is appreciably toxic when taken by mouth. Strangely enough, the standard does not appear to ban smoking in such areas.

Biological Data

The document contains a thorough review of the biological effects of beryllium including both animal studies and retrospective studies on humans. This review illustrates several points which may be applicable to all studies of industrial health hazards. The serious toxicity of beryllium was recognized abroad very early in many countries and numerous articles existed in foreign journals. These were largely ignored in this country and their existance was

unknown to many. The tendency to discount work in other countries still exists and the beryllium experience teaches us that this is done at our peril.

A more important observation is that the data obtained from animal studies are relatively irrelevant to the task of establishing standards. Because the most numerous exposures to beryllium, those in the fluorescent lamp industry and the atomic energy industry, were rather quickly brought under control by the application of engineering controls, information on large scale human exposures and effects generally ceased. Cases of beryllium poisoning still occurred and were recognized but most of these were either the delayed result of earlier exposures or were sporadic cases from a variety of small industries such as neon sign manufacture. Under such circumstances it was difficult to establish a quantitative relation between exposure and the occurrence of illness or to investigate the mechanisms of disease production. Intensive investigations were made of beryllium toxicity using animals and some useful information was obtained concerning the acute disease after long study. Even in this case confusing results were first obtained leading early investigators to doubt the toxicity of beryllium. This confusion persisted for many years with the degree of toxicity being recognized differently in Massachusetts, Ohio and Pennsylvania. The situation was even worse in respect to the chronic disease and even today it is doubtful

whether the true form of human beryllium disease has been reproduced in animals. This same condition prevails with many other substances where animals are used to investigate the possible effects on humans. Even when identical patterns of disease can be produced in animals and humans there is no real way of translating these data into standards.

One of the most serious problems that has arisen from the animal studies comes from the fact that beryllium deposited in the lungs of some experimental animals seems to produce lung tumors or cancer. A cancer producing substance or carcinogen is regarded with great seriousness in assessing a potential toxic hazard. As nearly as can be determined, in spite of persistant study of the data, cancer does not seem to have resulted in humans from beryllium exposure. Apparently at some point there are species differences in the way various animals handle beryllium deposited in the respiratory tract. Had these animal data been obtained before the human data it is likely that beryllium would have been labeled a carcinogen and the course of its use in industry might have been quite different than what it has been. Today the existance of these animal data has a cautionary influence on setting and maintaining beryllium standards but the standards are not based on such data.

To some extent the finding of tumor production has influenced the direction of animal studies and perhaps led

into directions somewhat remote from actual application to industrial exposures. It also remains to be proven whether the potency of a beryllium compound to produce tumors in animals is a valid measure of its ability to produce beryllium disease in humans. The difficulty of interpreting and applying data from animal studies serves to emphasize the very serious need for extensive epidemiological studies. A great deal of time has been lost in applying this to beryllium but difficult as it may seem, it is the method of study most likely to yield useful results.

In the standards in this document detailed records are to be kept by physicians and employers and extensive data collected. However, the directions given are strictly on using these to meet the literal requirements of the standard. This is a good but limited objective. It is frequently noted that the TLV does not represent a fine line separating conditions favoring health from those producing disease and that professional judgement must be exercised to promote the best interests of all concerned. Directions are given in the document for obtaining data but there is little on how to interpret the data in a larger sense. Nor are the qualifications given for the types of professionals who will be able to interpret the data in the best interests of all concerned. This is not a criticism of the document but just a comment on the

limitations of this approach even when well done as it is here.

Compatibility with Emission Standards

This is tne title of the final chapter of the criteria document and it is curious to find it here at all. In some of the more recent documents this subject has been dropped and perhaps deservedly so. The concentration standard promulgated here is an ambient air quality standard to be applied inside an industrial environment and for an industrial population. It is only remotely related to an ambient air quality standard for the general population. In the case of beryllium, an out-plant ambient air quality standard of .01 $\mu g/m^3$ was adopted by the Atomic Energy Commission at the same time as it adopted an in-plant standard in 1949. Both were based on independent observations and measurements and there is no assumption that one is derived from the other or even related to the other.

Emission standards define the rate, in pounds per hour or some similar unit, that a pollutant can be emitted without producing a condition outside where the concentration exceeds the external ambient air quality standard. It is related to the latter through such factors as stack height, terrain factors, meteorological conditions, particle size, etc. Thus it is meaningless to talk of the compatibility between the standard in this document and any emission

standards. They are completely unrelated. The ambient air quality standards and the emission standards should be given and they are given in this Section but the question of "compatibility" cannot be discussed and is not actually discussed in this document.

This is a good document which is a valuable source of information and reveals how scanty is the information on which we must base our standards. Nevertheless, the standards are needed and in the case of beryllium they have amply demonstrated their usefulness. The criteria document can do much to direct attention to the serious need for detailed careful investigation of industrial exposures and associated research. In this discussion most of the points presented refer to omissions or limitations of the document. This is the nature of such presentations but many of these points actually refer to our own lack of knowledge and are illustrative of the difficulties of the standards making process. Indeed, it may well be that these documents find their most useful applications by demonstrating our needs for additional information.