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MEMO TO FILES

FROM R E Cunningham

SUBJECT STATISTICAL BASIS FOR AIR SURVEYS CONDUCTED BY VANADIUM CORPORATION OF AMERICA

> One purpose of the visit to the VCA mill at Durango, Colorado on June 22, 1961, was to obtain details about the criteria used for sampling airborne radioactive material to determine exposure of personnel. The University of Colorado Medical Center, Department of Industrial Medicine, has established a sampling program which apparently has a sound statistical basis. This program was explained to me by Mr. James Gilliland, consultant to VCA, during the mill visit.

Mr. Gilliland has no written description of the sampling program. Since the University of Colorado acts as consultants for a number of uranium mills and since they plan to utilize this procedure at these other mills, the explanation is attached as an Appendices to this memo. It was suggested to Mr. Gilliland that he submit this procedure in writing.

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A STATISTICAL BASIS FOR SAMPLING AIRBORNE RADIOACTIVITY ESTABLISHED BY THE UNIVERSITY OF COLORADO MEDICAL CENTER FOR USE AT VANADIUM CORPORATION OF AMERICA, DURANGO, COLORADO

OBJECT

Having established the criteris for the sampling program, the object for the following procedure is to establish the frequency it is necessary to sample for airborne radioactive material at each job operation throughout the mill to determine exposure of personnel. Also, the following procedure relates the significance of one sample taken at a specific job operation in terms of exposure of personnel working in the same area conducting other jobs.

CRITERIA

The criterie of the program is to establish with 95% confidence (2.6) that any sample taken at a specific location will reflect conditions there, assuming that the instruments used and methods of analysis and other errors inherent in the sampling system will be accurate to \pm 20%.

PROCEDURE

1. The first step is to divide the mill into general areas, each of which are sources of airborne contamination and where the contribution of airborne contamination from other general areas in the mill is minimal. At the Durango mill areas are classified as roaster area, uranium plant area, No. 1 crushing and grinding circuit, etc. Personnel working in one general area do not ordinarily work in any other area of the mill.

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Procedures - continued

Within each work area, the work performed by each operator is 2. broken down into specific operations performed throughout the work day or week. Typical operations in the roaster area include cleaning arms, checking weight of feed, clasning quenched tanks, etc. Since many of these jobs are performed in the same general location and exposure while performing one job stems from the same source as it does while performing another job, it is practical and valid to establish a sampling relationship (within the criteria mentioned above) which shows that a sample taken during the performance of one specific operation will be the same as a sample taken during performance of a different job.

(a) The first step in establishing such a relationship is to obtain the average concentration to which personnel are exposed while performing each specific job operation from all sampling data available for that job. To do this, of course, it is necessary to have sampling data for each job within the general area. The average concentration is expressed as follows:

 $\overline{X} = \sum_{n=1}^{\infty} x = \sum_{n=1}^{\infty} \sum_{n=$

where S= small sumple variance

The next step is to determine the standard deviation for (b) the average concentration in a small sample system. The standard deviation is as follows:

 $5^{2} = \sum x^{2} - \underbrace{\left[\sum x\right]^{2}}_{n} \qquad \sigma = \underset{\text{deration from which}}{\sigma}$

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Procedures - continued -

 $\sigma^2 = S^2\left(\frac{n}{n-1}\right)$

(c) Once the standard deviation for each specific job is established, it is we then necessary to determine the variance of differences between sample means for samples taken of different job classifications within the same general area. The variance of difference between the means is as follows:

 $\vec{\sigma}_{\vec{x}_i - \vec{x}_k} = \left[\frac{\sigma_i^{\perp}}{\eta_i} + \frac{\sigma_k^{\perp}}{\eta_i} \right]^{k_k}$

X, - X2 2 2 58. - 32 they do not a one for the same population; 48% confident

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Procedures - continued

3. Having established the relationship to one another of samples taken for each job within a general location, it is necessary to classify them so that specific operations where exposure appears similar (presumably exposure stems from same source are grouped together). Therefore, we have in each general area, such as the roaster area, the following type of breakdown:

Roaster Area

GROUP I			GROUP II	GROUP III	GROUP IV
1.	Clean	pipe	1		
2.	Weigh	feed	2		
3.	Clean	tanks	3		

As established here, it is assumed that any sample of a job performed within any group will reflect the exposure to airborne concentrations during all jobs being performed within that same group. The purpose of establishing such relationship is to assure that representative samples will be obtained from all different groups without spending too much time sampling in one group at the expense of another.

4. Having established groups within a general area and knowing the time spent at each job and within the group, it is necessary to determine the relative frequency each group must be sampled to obtain a reliable astimate of parsonnel exposure within a general area, (such as the reaster area).

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Procedures - 4 - continued

As stated in our Criteria, an allowable error of \pm 20% of MPC for personnel exposure in the general area has been established. If the overall error is \pm 20%, the error within each group may be greater than \pm 20%, depending on the total time spent in that group. Therefore, error (e) in each group is expressed as follows:

 $\left[\left(\overline{X}_{enqu}, \left(\underline{T}_{e}, \underline{T}_{f}, \underline{T}_{f}\right)\right]_{e_{i}} + \left[\overline{X}_{enqu}, \underline{t}_{i}\right]_{e_{i}} + \cdots = \left[\overline{X}_{e_{i}}, \underline{T}\right]_{\mathcal{T}}_{e_{i}}$

e. = [(xoundary)] + 20% where y = number of Group. (Xoung)(t) y

Having obtained the error within each group, the number of samples to be made in each group to obtain a reliable estimate of exposure within the general area is as follows:

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Procedures - continued

5. VCA has chosen a 13 week period to complete a sampling cycle. This means that each group within a general area will be sampled N times in the 13 week period. From this it is permissible to say within our established criteria that the exposure during any one week is reflected by the average exposure established during the 13 week period.