ALUMINUM COMPANY OF AMERICA
NIAGARA FALLS WORKS
HEALTH SURVEY

Between May 17, 1948 and June 9, 1948, 267 employees of the Aluminum Company of America, at the Niagara Falls Works, were given thorough physical examinations. In the month prior to these examinations X-rays had been taken of the chest and lower spine and pelvis of all who were to be examined. During the course of the physical examinations the atmosphere of the working environment was studied in two five-day periods separated from each other by an interval of fourteen days. The data obtained have been analyzed without reference to any previous examinations of these men, and the conclusions reached are based solely on evidence accumulated during this survey.

Procedure

Physical Examinations. The physical examinations were performed by W. F. Ashe, M.D., Ian Maclachlan, M.D. and Arthur Edwards, M.D. Each included the elicitation of complete occupational history and a complete previous medical history, a review of past or present symptoms or lesions of the organic systems of the body, and a detailed medical and neurological examination. The form used in each case will be found in Appendix B. For convenience the height, weight and visual acuity were measured by O. P. Lowell, R. N. Visual acuity was determined by the use of the American Optical Company's Snellen charts. The histories as given by the individual men are not above criticism because many of them speak little or no English and because many of them were reluctant to give accurate information. Their reticence was based upon the incorrect assumption

that the findings of this survey would be a controlling factor in their future disposition when the Niagara Falls Works is closed. Information, believed to be reasonably accurate, was obtained from the personnel office relative to the duration of employment of each man and the types of tasks he has undertaken during his employment.

For the purposes of this report, hypertension is defined as blood pressure levels at or above 160 mm. Hg systolic or 90 mm. Hg diastolic; anemia is regarded as a state in which there are fewer than 4.5 million erythrocytes or less than 13.5 gm. hemoglobin; leukopenia is considered a state in which there are fewer than 5,000 WBC; and malnutrition is represented by a deviation greater than 15 per cent or more below the so-called normal body weight (Metropolitan height-weight tables).

Urine Analyses. Urine specimens were collected at the time of examination and were analyzed for specific gravity, pH, albumin, sugar and microscopic characteristics. Albumin was detected by the "heat and acetic acid" method; the sugar by the "Clinitest", checked in all positive or questionable cases by Benedict's method; and the microscopic examinations were performed by the examining physicians after centrifugation of the specimens. In addition a gallon jug was delivered to the home of each male employee (a few took them home themselves). Each man was asked to urinate into the jug until it was half full. It was then collected, brought to the plant, measured as to volume, and a 200 cc. aliquot was sent to the Kettering Laboratory of Applied Physiology for fluorine analysis. This elaborate method of handling was carried out to avoid contamination of the specimens by dust in the plant. These samples

are believed to be representative of the average daily concentration of fluoride in the urine of the men at the time of the examination. It is believed that contamination of the samples did not occur in significant frequency or degree.

Hematologic Examinations. Enumeration of the erythrocytes and leucocytes, determinations of the hemoglobin content and of the relative numbers of different types of leucocytes, in the blood of each man were carried out by Dan Duvall of the Kettering Laboratory. Standard techniques were used throughout.

X-ray Examinations. The X-ray studies were made by W. R. Scott, M.D. of Niagara Falls, N.Y. The chest films are six foot teleoroentgenograms and the pelvic films are bucky-flat plates taken at 30". All of the X-ray interpretations were made by Doctor Scott. In cases of fluorosis of bone, he reported only distribution and degree of change in bone density. His classification included "no increase", "questionable increase", "slight increase" and "marked increase" in bone density. The films, together with his interpretation of them, were reviewed by the examining physicians and reclassified with reference to fluorosis of bone, as follows:

1. none
2. questionable
3. slight
4. moderate
5. severe

In general, the classification of Roholm was used in the slight, moderate and severe cases. A few cases marked "questionable" by Dr. Scott have been considered as normal by us after reviewing all available data. Also, a few cases about which Dr. Scott was in doubt have been classified as slight after reviewing

the films, work history, urinary fluoride concentration and atmospheric fluoride contamination data. These problems have been discussed with Dr. Scott, and he is in accord with the procedure adopted.

Atmospheric Examinations. The collection and analysis of atmospheric samples were carried out by J. Cholak, Ch.E. and L. J. Schafer, B.S.E.(Ch.E.) of the Kettering Laboratory. Simultaneous samples were taken by Lester Cradley of the Aluminum Company of America during the first week. The techniques used and the results obtained will be found in Appendix A.

Results

For ease in handling the large mass of data, the general health of each occupational group except pot room employees has been analyzed separately. The findings are tabulated, reference is made in each table to the incidence of certain abnormalities within the group, and this value is compared with the incidence of the same disorder in the whole plant population. All pot room employees were considered together for reasons which will become self-evident. Following a brief summary of the findings in each group we have discussed the overall picture as it appears to us after consideration of all of the assembled observations and data.

POT ROOM WORKMEN

This group consists of 128 men, ranging in age from 21 to 66 years, the average age being 50.3 years. The severity of the exposure of these men to cryolite and alumina has been relatively great. The duration of the exposure of the men employed in the pot room (length of employment in the pot room) has ranged from 2/12 year to 38-1/2 years, averaging 15.5 years.

Classified according to their tasks, these men are crane operators, pot tenders, tapper carbon changers, head tapper carbon changer, line foremen and shift foremen. In the main they have been studied as a single composite group rather than as representatives of a series of separate occupations, first because the working environment of all is similar (the single large pot room), second because an analysis of the data reveals that any given man at different times may have had several different jobs of varying duration within the pot room, and finally because the available evidence indicates that the morbidity rate and severity of the occupational disorder incident to employment in this group is primarily a function of over-all exposure in the pot room.

The health of this group of men is classified as fair. There are few disabling conditions, but many require medical care or follow-up. Seventeen of the men can be considered to be quite healthy; 18 require only dental care; 3 require inguinal herniorrhaphies; 20 show no defects other than some degree of fluorosis of bone. Sixty-five have defects that require supervision or care by their own physicians. These latter have all been so advised. One man [redacted] should be no longer employed because of a large aortic aneurysm.

All of the defects found are listed in the following table.

Defect	Group		Plant	
	Number of Cases	Rate (%)	Number of Cases	Rate (%)
Fluorosis of bone	91	71	120	45
Osteo-arthritis of spine	84	64	95	36
Hypertension	64	50	113	42
Defective vision	63	49	118	44
Gingivitis	56	44	89	33
Dental caries	53	42	94	35
Injected throat	42	33	70	26
Pulmonary fibrosis	33	26	37	14
Skin disorders	20	16	48	18
Varicosities	20	16	37	14
Injected nose	20	16	26	10
Obesity	15	12	27	10
Defective hearing	13	10	34	13
Inguinal hernia	10	8	20	7
Hepatomegaly	10	8	17	6
Albuminuria	8	6	13	5
Asthma	8	6	9	3
H.C.V.D.*	7	6	12	4
Positive Wasserman	6	5	7	3
Pyuria	5	4	6	2
Benign prostatic hypertrophy	3	2	6	2
Undernutrition	2	2	7	3
Ventral hernia	2	2	3	1
? Peptic ulcer	1	1	3	1
Aortic aneurysm	1	1	1	0.3

* Hypertensive cardiovascular disease

Except for osteo-arthritis of the spine, pulmonary fibrosis and fluorosis of bone, the morbidity rates for this group vary little from those of the plant as a whole, and are believed to be similar to those which one might expect to find in any group of laborers of similar racial and economic background, type of work and educational status.

The most outstanding characteristic of this group is the occurrence therein of 91 cases classified as fluorosis of

bone. This characteristic rests upon individual X-ray diagnoses each of which involves the detection of an increased density of one or more of the bony structures, beginning in specific areas and tending ultimately to extend into the whole skeletal system, and each of which has been corroborated by the finding of an abnormally high rate of urinary fluoride excretion together with the occurrence of hazardous concentrations of fluoride in the atmosphere of the working environment.

These 91 cases have been classified as follows:

Questionable cases - those men whose exposure to hazardous atmospheric concentrations of fluoride are similar to that of the more severe cases but are usually of shorter duration, and in whose urine evidence is found of abnormal fluoride absorption, but whose roentgenograms show questionable or very slight alterations in the structure and density of bone which are suspected of going beyond the realm of the normal variations in density seen among large numbers of men. Eighteen (18) such cases were found. In the statistical analysis of the problem these have been considered to be "cases", since on the background of experimental work, it seems evident that large quantities of fluoride can be absorbed by bones, with minute effects comparable to those associated with the production of X-ray shadows before changes in density reach the stage of radio opacity. Hence in those cases in which one encounters suggestive evidence of the occurrence of selective increase in bone density on the X-ray film and in association with which there has been exposure comparable to that of men showing far advanced disease, he must accept the possibility that incipient abnormality is present. Furthermore, there is

the reasonable certainty that borderline cases exist, and it is believed that these "questionable" cases belong in that category.

Slight cases - those in which there is slight but definite evidence of altered bone structure and increased bone density usually limited to the spine or pelvis and without any evidence of new bone formation or ligamentous calcification.

Moderate cases - those in which there is extensive and readily recognizable increase in bone density widely scattered throughout the skeleton. In many of these there is evidence of new bone formation and in some there is evidence of ligamentous calcification.

Severe cases - those in which the bony structure as seen by X-rays, has been greatly altered by the disease process. In these cases new bone formation along the crests of the ilia, and the shafts of the tibia, fibula, radius and ulna, are quite common, and not infrequently there is evidence of ligamentous calcification about the pelvic girdle and spine. Involvement of the long bones and of the skull has been demonstrated whenever films were made of these areas.

The average age of the ninety-one (91) men found to have fluorosis of bone is 55.3 years and the average duration of pot room employment is 20.3 years. The age of the 37 other pot room employees, similarly exposed but showing no evidence of fluorosis of bone, averages 37.5 years, while the duration of their employment in the pot room averages 4.1 years. These facts, on the one hand, suggest that fluorosis is dependent upon the duration of a given severity of exposure, but, on the other, it might be inferred that chronological age has influenced the incidence of the disease. Table 1 shows the relationship

of chronological age to the incidence and severity of fluorosis of bone, and Table 2 the relationship of the number of years employed in the pot room to the incidence and severity of the disease. Table 3 compares the chronological age and employment age of these men and shows that while the two are not separable completely, one of the etiologic factors in the disease is employment age and not chronological age, since old and young cases are scattered about equally above and below the median chronological age whereas the incidence and severity rises with increasing length of employment (Table 2).

Chart I shows the urinary fluoride concentration of all groups of men in the plant. It is apparent that the pot room employees are absorbing and excreting relatively large quantities of fluorides. It is also apparent that, with the exception of those engaged in carbon rodding, no group has abnormal fluoride absorption and excretion which does not have at least intermittent exposure to the pot room. From this evidence we would expect to see cases of fluorosis predominate among pot room employees, and perhaps occur in other groups, if the others have either intermittent exposure in the pot room or if they work in the carbon rodding operation. In Appendix A will be found the analytical data covering the survey of the atmosphere of the working environment. Here again we arrive at the same conclusion. These conclusions are borne out by the facts, as will appear later. Chart 2 indicates the relationship between urinary excretion of fluorides and the atmospheric concentration of fluorides in a number of operations. Unfortunately there is no completely comparable yardstick by which the two can be measured. It will be apparent, however,

that the two are closely related. Chart 3 relates urinary fluoride concentration to fluorosis of bone. From it and Chart 2 it will be readily apparent that urinary fluoride concentration is directly related to the daily fluoride intake from the working atmosphere rather than the extent to which fluorides have been deposited in the bone. These findings are in accord with experimental findings in the study of human fluoride metabolism.

Fluorosis of bone is a disease which alters the form of the skeletal system. Certainly in these cases and those recorded in the medical literature there are no symptoms associated with the early stages of this change in form. As is the case in many disorders which develop insidiously, the extent of the change in the most severe cases is much greater than one would expect from an analysis of the symptomatology produced. In general, the severity of the symptoms of a disease is a function of the rate of organic change (development of the disease process) rather than a function of the quantity of organic change which has taken place. This does not mean, however, that insidiously developing change in form is necessarily unassociated with insidious interference with function. An insidiously developing alteration of function may be either above or below the sensory threshold and hence either symptomatic or asymptomatic. A good, but completely unrelated example, is that of anemia. In the case of acute blood loss a red count of 3.0 million cells may be associated with alarming symptoms and signs, while a count of 3.0 million in a patient with pernicious anemia may limit function somewhat but be essentially asymptomatic, while counts as low as 1.8 million may present a

less alarming symptomatic picture than those described above in the case of acute blood loss.

In general the cases of fluorosis of bone reported herein are asymptomatic. Furthermore, the slight and questionable cases have not developed enough alteration of function to be demonstrable by ordinary methods. In our present state of knowledge they must, therefore, be considered cases of occupational disease which are asymptomatic and free from demonstrable disability as of the date of examination. There is no available evidence to indicate that their expectancy as regards life or productivity has been significantly altered, and there is every reason to believe that if their exposure to fluorides ceases, their bones will return to normal.

Those cases classed as moderate and severe (55 cases) show varying degrees of alteration of function all the way from very slight to complete ankylosis of the spine. A few of these men are aware of limitations of motion either in the back or elbows, but none complained of pain or discomfort from these findings, and only a few are aware of altered function. Blood studies indicate no significant involvement of the bone marrow. All are apparently able to perform their duties at the plant; however, their efficiency at work must be distinctly suboptimal. The degree of dysfunction does not appear to bear a linear relationship to the severity of the disease as measured by increases in bone density. Those showing the most marked increases in bone density are not necessarily those with the greatest limitation of motion, although, in general, there is greater dysfunction demonstrable in severe cases than in those classed as moderate.

One case, that of [redacted] is particularly difficult to interpret. He has a profound increase in bony density. He also shows complete ankylosis of the spine in the lumbar and thoracic regions and nearly complete ankylosis of the neck. It might be argued that he has had ankylosing spondylitis and that the fluorosis is merely superimposed upon it. However, he gives no history of any acute disorder of the back, and if he did, it would still be impossible, during life, to state with certainty which disorder was primarily responsible for his condition. He has bony change in the hips, knees and elbows as well, which may be due primarily to fluorosis or to the combination of fluorsis and arthritis. In spite of the fact that he goes to the plant daily, he is, for all practical purposes, essentially totally and permanently disabled. The burden of proof seems to us to rest with him who says that this condition is not the result of occupational disease, i.e. fluorosis of bone.

Another man, [redacted] has extensive fluorosis of bone. He has a deformity of the spine which one must consider to be an old Potts disease upon which fluorosis has been superimposed. (He has been a "hunch-back" since early childhood.) How much of the present deformity of his back is due to the old lesion and how much to fluorosis cannot be guessed. In addition he has deformity of the hands and right elbow, which may be either traumatic or arthritic, upon which fluorosis has been superimposed. How much of the present hypertrophic structural deformity has resulted from insults other than fluoride absorption is open to speculation. He has extensive fluorosis. He has extensive disability.

Here again, the burden of proof falls upon him who may try to define how much of it is due solely to disease unrelated to occupation. Unfortunately, no large series of human cases of fluorosis of bone have come to necropsy, so as to provide a basis for any judgment as to whether the cases of these two men do or do not follow the natural trends of this disease. In both cases we think we are dealing with two conditions, one occupational, the other non-occupational, but in the case of [redacted] at least, we are wholly unable to prove this clinical opinion.

In other cases one sees hypertrophic changes in bone along the shafts of long bones, along the crests of the ilia, the ribs, and the rami of the ischium, in the form of stalagmite-like excrescences which appear similar to changes seen in experimental animals with bone fluorosis. The inter-osseous membranes are often ossified. These changes, in no way related to arthritic processes, are believed to be due solely to fluorosis and to indicate that changes about joints may be expected in this disease. Therefore, when one finds, in cases of severe fluorosis of bone, limitation of motion of the elbow and the X-ray reveals exostoses of unusual density about the elbow, one is probably entirely justified in concluding that the deformity and dysfunction are due to fluorosis, and that disability exists in association with and because of this disease, whether or not the man is aware of it, and whether or not he continues to do his job at the plant.

There are 29 additional cases of fluorosis of bone in men employed in departments other than the pot room. Some of these men formerly worked in the pot room, one of them never

has, while others are considered to have had intermittent exposure in the pot room. Each of these cases must be considered individually. This has been done in the discussion of the groups of employees in the several operations of the plant.

The roentgenograms show extensive osteo-arthritis of the spine (hypertrophic changes in the vertebrae) in many pot room employees (Table 4). Careful statistical analysis has shown that these cases are etiologically independent of fluorosis, even though there are many men in whom both conditions are seen. This disorder appears to be related to chronological age in association with hard physical work and not to employment age in relation to fluoride contaminated atmospheres (Table 5). Studies in other plants have shown that hard physical work over many years will produce this type of change without regard to fluoride absorption or any other exogenous noxious agent. Most orthopedists consider these findings to be of no significance unless they produce symptoms. No disability attributable directly to this condition was found among the employees of the Niagara Falls Works.

The X-ray films show a rather marked increase in the parenchymal lung markings (read as fibrosis) in 23 of the pot room employees. Since the atmosphere is dusty and contains acid gases, one is inclined to search for a type of pneumoconiosis. Reference to Tables 4 and 6 will show that this process appears to be more related to chronological age than to years of employment in the pot room. Furthermore, the mean vital capacity of men with this finding (3,700 c.c.) is not significantly different from that of the other pot room employees (3,900 c.c.). The mean age and the mean body surface area

of the two groups are not significantly different. We conclude, therefore, that there appears to be an abnormal amount of lung fibrosis among the employees of the pot room, but this lesion does not appear to be of physiological significance as of the date of examination. Further study and, if possible, post-mortem examinations are indicated to rule out with certainty an occupational pneumoconiosis.

The working environment of the pot room is dirty. There exists hazardous exposure to fluorides. The amount of aluminum dust in the atmosphere is excessive. The lighting is inadequate. Satisfactory eating facilities do not exist. There is no evidence of hazardous amounts of carbon monoxide or sulphur dioxide in the atmosphere. At times the temperatures in the pot room are said to be excessive. Minor burns from splashed hot metal are so common that they are not reported by the employees unless they are serious. Almost every pot room employee shows scars of recent and old burns.

UTILITY SERVICE GANG

This group consists of 23 men ranging in age from 19 to 65 years and averaging 53 years. Their duties are numerous. Most of them have or have had some exposure in the pot room. They have been employed for periods ranging from four months to 36 years with the average of 16 years. The average height of the group is 5'6" and the average weight 154 lb. Only three of the group are seriously underweight and only one is considered seriously overweight. None of these men is anemic, one is believed to be polycythemic [redacted] and eight men are definitely hypertensive (systolic above 160 and/or diastolic above 90).

Many of this older group of men have been given lighter and lighter work as their physical ability to perform work diminished. The more important findings of the examinations are listed in the following table.

Condition	Number of Cases	Incidence in Group (%)	Incidence in Plant (%)
Hypertension	8	35	42
Heart disease	5	20	4
Psychiatric problem	2	10	6
Tuberculosis (probably not active)	2	10	2
Varicose veins	5	20	14
Dental caries and/or pyorrhea	7	30	35
Defective vision (not corrected)	11	50	44
Fracture deformity or other traumatic deformity of hands	3	13	2
Epidermophytosis	1	4	18
Gynecomastia	1	4	0.03
Acute pharyngitis	1	4	5
Varicocele	1	4	2
Hernia	1	4	7
Fluorosis of bone	8	35	45
Hydrocele	1	4	10
Osteo-arthritis of the spine	15	65	36
Dupuytren's contractures of hands	1	4	1

The levels of urinary fluoride excretion range from 0.86 mgm. per L. to 4.16 F_2 mgm. per L. Only two men had levels below 1 mgm./L. and only 6 were below 2 mgm./L., the mean value for the group being 2.68 mgm./L. - a level well below the mean of men regularly employed in the pot room but significantly higher than that found among office employees or in the power house. See histogram showing levels of all groups (Chart 1).

The incidence of fluorosis of bone in this group is as follows:

Fluorosis of Bone

Clock No.	Severity
[redacted]	severe
	severe
	moderate
	slight
	slight
	questionable
	questionable
	questionable
Total	5 certain, 3 questionable

The two severe cases had more than twenty years of employment in the pot room prior to their present jobs. Both show extensive bone changes on X-ray films and neither is seriously disabled from this disorder. The other three definite cases, one moderate and two slight, have likewise had considerable pot room exposure. All three questionable cases have had either continuous or intermittent pot room exposure. None show disability from the disease. The urinary fluoride excretion of these cases is believed to reflect largely the magnitude of their present exposure rather than that of the exposure during which they absorbed sufficient fluorides to produce bone changes (See Chart 2).

This group provides excellent evidence of the etiologic independence of fluorosis of bone and osteoarthritis of the spine. There are eight cases of fluorosis, only five of which show osteoarthritis. There are fifteen cases of osteoarthritis of the spine, only one-third of which have any degree of fluorosis.

This group of men constitutes what may be called the "margin land" of the whole group. Many of them should be retired and both they and their employers know it. Often they have been kept on until their service record permits retirement on a subsistence income. This is a commendable and humane practice. There are at least two men, however, whose condition is so unsatisfactory as to lead us to recommend their immediate retirement. They are [redacted], [redacted] and [redacted] both of whom have far advanced heart disease with evidence of failure.

GENERAL REPAIR AND MAINTENANCE PERSONNEL

This group consists of 23 men. They have been employed for periods which range from 3/4 to 34 years and average 13.8 years. Their ages range from 28 to 66 years with an average of 51.2 years. As a group, they cannot be classified conveniently as to exposure to conditions prevailing in the pot room. Seven men have never worked in the pot room; 10 have worked intermittently in the pot room during all of their periods of employment, periods ranging from 2 to 24-1/2 years, and 6 have alternated between periods of intermittent exposure and periods of no exposure. It is significant that all of the cases of fluorosis of bone, reported below, occurred in men who have had either continued or intermittent exposure in the pot room.

The health of the group, in general, is adequate for the type of work done. Four of the men may be considered to be healthy. Three more require dental care or spectacles but are otherwise healthy and 6 men show some evidence of fluorosis of bone but are otherwise healthy. The remaining 13 have defects which require medical supervision. They have all been advised to consult their own doctors. None of these defects is likely to render the man unsuitable for continued employment in the next six months.

These defects, together with others less significant, are set forth in the following table.

Defect	Group		Plant	
	Number of Cases	Rate (%)	Number of Cases	Rate (%)
Hypertension	9	39	113	42
Defective vision	8	35	118	44
Dental caries	7	30	94	35
Edentulous	7	30	50	19
Osteo-arthritis of spine*	7	30	95	36
Fluorosis of bone*	6	26	120	45
Gingivitis	5	22	89	33
Injected throat	4	17	70	26
Psychoneurosis	4	17	17	6
Pulmonary fibrosis*	4	17	37	13
Hemorrhoids	3	13	23	9
Defective hearing	2	9	34	13
Arteriosclerosis	2	9	22	8
Obesity	1	4	27	10
Inguinal hernia	1	4	35	13
Hemiplegia (residual weakness)	1	4	--	--
Skin diseases	1	4	48	18

* X-ray diagnosis

A comparison of the rate of occurrence of fluorosis of bone in this group and that of the whole plant population indicates that the working environment of this group involves an exposure to fluorides, but only if part, at least, of that environment includes the pot room. Their working environment is not otherwise reflected in the rates of occurrence of other defects, with the possible exception of that for pulmonary fibrosis, the background of which is not evident.

GUARDS AND JANITORS

This group consists of eleven men. They have been employed for periods ranging from 2 to 41-1/2 years and averaging 8-1/2 years. Their ages range from 24 to 65 years and average 52 years. The conditions of their employment have been such that they, as a group, have not been subjected to exposure in the pot room. In the past one of the men was employed in the pot room for 12-1/2 years continuously, and for 1/4 year intermittently. Another man was so exposed intermittently for 28-1/2 years.

The health of the group, in general, is adequate for the type of work in which they engage. Of the 11, 3 are perfectly healthy; 5 have chronic disabilities (hypertensive cardiovascular disease, essential hypertension, prosthesis right foot, silicosis, generalized arteriosclerosis) which will not interfere with their effectiveness if they receive medical supervision; 2 have disabilities which do not interfere with their effectiveness at the present time and which can probably be cured by appropriate treatment (inguinal hernia, chronic upper respiratory infection associated with nasal obstruction) while 2 men have pulmonary tuberculosis which is probably active, and who therefore are unsuitable for employment. All of these men have been advised of our opinion of their physical condition and of the medical attention they require. The men suffering from tuberculosis have also been referred to the authorities concerned.

Other defects were discovered during this examination and are set forth in the following table.

Defect	Group		Plant	
	Number of Cases	Rate (%)	Number of Cases	Rate (%)
Osteo-arthritis of spine*	6	54	95	36
Defective vision	5	45	118	44
Edentulous	5	45	50	19
Hypertension	4	36	113	42
Defective hearing	3	27	34	13
Dental caries	3	27	94	35
Gingivitis	3	27	89	33
Arteriosclerosis	3	27	22	8
Skin diseases	3	27	48	18
Inguinal hernia	2	18	20	7
Questionable fluorosis of bone	2	18	33	12
Nasal obstruction	1	9	10	4
Tuberculosis	2	18	6	2
H.C.V.D.	1	9	12	4
Benign prostatic hypertrophy	1	9	6	2
Obesity	1	9	27	10
Pulmonary fibrosis*	2	18	36	14

* X-ray diagnosis

None of these conditions except tuberculosis is considered to be of importance from the point of view of continued employment. There does not appear to be any evidence that the working environment of these men has anything to do with the incidence of any of these conditions. Such rates of occurrence as are significantly higher than the corresponding rates in the general plant population, are due, in all likelihood, to the greater average age of the group.

With regard to the incidence of fluorosis of bone in this group, we are of the opinion, after considering the results of physical, radiologic, and chemical (fluorides in urine) examinations, and after taking account of the environmental conditions associated with their habitual work, that two of the men (18%) show questionable signs of the disease and that the

remainder (82%) are free of it. Both of the dubiously affected men have been exposed to fluorides in the past, one intermittently for 28 years until 13 years ago, and one continuously for 12 years until 12 years ago, and it is possible that they are now exhibiting a phase of the disease characterized by fluoride excretion in excess of fluoride absorption, with progressive reversion of the bone toward a normal structure and radiographic density.

Note to Medical Director:

There is a remote possibility that [redacted] has a pheochromocytoma and should be followed closely. Dr. Stebbins has been notified.

MEN ENGAGED IN POT LINING

Four men work in this department. Their ages range from 27 to 64 years and average 46.5 years. Employment ages range from 3/4 year to 36-1/4 years and average 19.5 years.

Exposure to cryolite is considered as intermittent, though much time is spent in the pot room in a year's time. The values for urinary fluoride excretion range from 0.74 to 1.94 mg./L. and average 1.44.

General health is good. Two men have red blood counts below 5 million with normal hemoglobin.

Only one man shows fluorosis of bone, and he is graded as severe. He has the longest period of employment, 36-1/4 years, and is the only one whose employment has involved continuous work in the pot room (21-1/2 years as TCC, 1-1/4 years at PT).

Defect	Group		Plant	
	Number of Cases	Rate (%)	Number of Cases	Rate (%)
Defective vision	3	75	118	44
Defective hearing	2	50	34	13
Inguinal hernia	2	50	20	7
Varicosities	2	50	37	14
Caries	1	25	94	35
Gingivitis	1	25	89	33
Hypertension	1	25	113	42
Arteriosclerosis	1	25	22	8
Fluorosis of bone, severe	1	25	33	13

MEN ENGAGED IN CARBON RODDING

The fourteen (14) men in this group range in age from 27 to 64 years with an average age of 48.6 years. They have been employed for periods ranging from 1/2 to 47 years (average 12.6 years). The nutritional status of the group is satisfactory. One man is considered too obese and none seriously undernourished. All blood counts were within normal limits. Vital capacities ranged from 2,200 to 5,200 ml. and averaged 4,020 ml. One individual [redacted] gives a history of accident proneness. The abnormal findings of the physical examinations are tabulated below.

Defect	Group		Plant	
	Number of Cases	Rate (%)	Number of Cases	Rate (%)
Hypertension	8	57	113	42
Injected throat	6	43	70	26
Gingivitis	5	36	89	33
Caries	4	29	94	35
Defective hearing	3	21	34	18
Osteo-arthritis of spine*	3	21	95	36
Fluorosis of bone*	3	21	119	45
Defective vision	2	14	118	44
Varicosities	2	14	37	14
Inguinal hernia	2	14	20	7
Obesity	1	7	27	10
Enlarged liver	1	7	17	6
Hemorrhoids and fissures	1	7	26	10
Neurosis	1	7	17	6
Organic neurological disorder	1	7	8	3
Asthma	1	7	9	3

* X-ray diagnosis

Three men show evidence of fluorosis of bone (2 slight, 1 questionable). The levels of urinary fluoride excretion of the group ranged from 1.06 to 3.74 mgm./L. with a mean value of 2.40 mgm./L. All are defintely above normal. The

atmospheric analyses demonstrated the presence of 3.8 p.p.m. of fluoride in the air at the breathing level in the area of the carbon rodding operation. According to their own statements, these three men have worked from 4 to 10 years in the pot room, but this information is not borne out by the data supplied from the employment records of the plant. In the group were two other men without signs of fluorosis, who have worked in the carbon rodding operation for more than 30 years. These men give no history of having worked in the pot room at any time.

The available data of the atmospheric and urinary analyses show that the men in the carbon rodding operation are exposed to, are absorbing, and are excreting abnormal amounts of fluorides. If one accepts the employment records of the plant, he must conclude that the magnitude of the fluoride exposure in this operation is hazardous and will produce fluorosis of bone. However, the data of the plant records are open to question both on account of the statements of the men who exhibit signs of fluorosis and for the reasons that the two men employed for the longest periods of time in the rodding operation (more than 30 years) show no evidence of fluorosis of the bone. If there existed an hazard of the magnitude found in the pot room, these two might be expected to show evidence of the disease. We may reasonably conclude, therefore, that the magnitude of the hazard in the carbon rodding operation is materially less than that in the pot room and may be of no physiological significance.

ALLOY GROUP

This group consists of 5 men. They have been employed for periods that range from 1/2 to 19-1/2 years and average 11.4 years. Their ages range from 18 to 61 years and average 44.8 years. Their conditions of employment have been such that they, as a group, have been exposed intermittently to conditions prevailing in the pot room from 1/2 to 18 years. One man, in addition to 18 years of intermittent employment in the pot room, worked continuously therein for 1-1/2 years prior to his present job. None of the others has worked continuously in the pot room.

The health of the group, in general, is adequate for the performance of their work. Two of the men are healthy, the other three require medical supervision and have been advised to consult their own doctors.

Following is a list of the defects found on the examination of these men.

Defect	Group		Plant	
	Number of Cases	Rate (%)	Number of Cases	Rate (%)
Injected throat	4	80	70	26
Defective vision	3	60	118	44
Gingivitis	3	60	89	33
Varicosities	3	60	37	14
Dental caries	2	40	94	35
Hypertension	2	40	113	42
Skin diseases	2	40	48	18
Fluorosis of bone, slight	2	40	25	9
Osteo-arthritis, spine	2	40	95	36
Pulmonary fibrosis	2	40	37	13
Injected nasal mucous membrane	1	20	26	10
Nasal obstruction	1	20	10	4
Arteriosclerosis	1	20	22	8
Cardio-vascular disease	1	20	12	4

None of these defects is considered to be important from the point of view of continued employment at the present time. The future employability of the men who require medical supervision is dependent, to some extent, on their receiving the medical care they have been advised to seek.

Two cases of fluorosis of bone (slight) are found in this group. Both men had worked in the pot room for at least ten years prior to their entrance upon their present jobs. None of the available data demonstrate conclusively the existence of a serious fluoride hazard in this occupation, but the analytical results on the urine of these men show that they have absorbed abnormal quantities of fluoride.

Conclusion

One of the men in this group [redacted] has limited expectancy because of hypertensive cardio-vascular disease.

In the working environment of the group are potential hazards of exposure both to fluoride and dust. There is, however, no evidence at this time that either is of sufficient magnitude to be harmful.

TECHNICAL CONTROL GROUP

A group of two men, age [redacted] and [redacted] respectively, employed for two years or less, were found to be in excellent health. Neither man had any evidence of fluorosis.

STOREROOM PERSONNEL

Two men, age [redacted] and [redacted] respectively, have been employed in this category for 6 and 12 years, respectively. The younger, [redacted], has rheumatic heart disease with mitral stenosis. His lesion is well compensated, and he is able to perform his duties without hazard to himself or others. He has no evidence of fluorosis. The older, [redacted] has pulmonary tuberculosis which is probably active. It is recommended that he be suspended from work immediately and referred to the proper health authorities for adequate care. He has given no evidence of fluorosis. Since this is a known case of tuberculosis, it is evident that the mechanisms in the plant, whereby such cases are followed up, are in need of careful and thorough review.

ELECTRICIANS

This group of twelve (12) men divides itself readily into two groups of six each, on the basis of the nature of their jobs, as follows:

Clock Number:

one has considerable intermittent exposure to the pot room while group two is rarely so exposed. The two groups differ somewhat in several other characteristics as shown the following table:

		Ht.	Wt.	Av. Duration	Mg. Urine	% Anemic
Group	47 yr.	69"	171#	17.4 yr.	3.52	
Group II	yr.	68"	156#	24 yr.	0.52	50

I

This is the healthier of the two groups, although their exposure to dust and to fluorides is much greater than that of the older group II. The duties of this group include the installation, maintenance and replacement of electrical equipment of all sorts in the pot room, and, when their services are needed, in other parts of the plant as well. They usually eat their lunches in the shop rather than in the pot room.

The illnesses found on examination of this group are tabulated below:

Disorder	Number of Cases	Incidence in Group (%)	Incidence in Plant (%)
Dental caries	2	33	35
Inguinal hernia	1	16	7
Nasopharyngitis	2	33	5
Hypertension	2	33	42
Pulmonary fibrosis	2	33	14
Questionable fluorosis of bone	2	33	12
Definite but slight fluorosis of bone	1	16	9

The urinary fluoride excretion ranged from 1.54 mgm./L. to 5.74 mgm./L. The average for the group (3.52 mgm./L.) is seven times as high as that of group II, the members of which rarely enter the pot room.

None of the disorders found was of sufficient severity to necessitate cessation of employment.

Conclusions

The intermittent fluoride exposure of the electricians of group I in the pot room is of sufficient magnitude to constitute a definite hazard, as indicated by their rates of urinary fluoride excretion and by the incidence of early or questionable fluorosis of bone. The finding of increased bronchial markings in two members of the group may or may not be significant but suggests the existence of some dust hazard.

Group II

This group is employed in the installation, maintenance and replacement of electrical equipment in parts of the plant other than the pot room. It is an older group of men than Group I, and in general the health of these men is distinctly less satisfactory than that of Group I. The abnormalities

found on examination of these men are tabulated as follows:

Illness	Number of Cases	Incidence in Group (%)	Incidence in Plant (%)
Hypertension	2	33	42
Organic Heart Disease	2	33	5
Malnutrition	2	33	3
Hernia	1	16	7
Albuminuria	1	16	5
Dental caries	3	50	35
Defective vision (uncorrected)	2	33	44
Probable herniated intravertebral disc	1	16	37
Otosclerosis	1	16	37
Peripheral neuritis	1	16	3
Anemia (slight)	3	50	1
Questionable fluorosis of bone	1	16	12
Definite fluorosis of bone	0	0	32

There is but one questionable case of fluorosis of bone in this group. This man has been employed as an electrician for 26 years and undoubtedly, during previous years, he has had much intermittent exposure in the pot room. The rate of urinary fluoride excretion is normal in all of the men.

Conclusions

The exposure of these men to fluorides is believed to be sufficiently small as to be negligible hygienically speaking. The general state of health of the men in this group is definitely unsatisfactory.

MEN ENGAGED IN METAL HANDLING

The three men in this section are in satisfactory health, with no serious abnormalities. None has an occupational history of hazardous exposure, nor is there any evidence of fluorosis of bone. The minor clinical abnormalities observed are listed below.

Defect	Group		Plant	
	Number of Cases	Rate (%)	Number of Cases	Rate (%)
Defective vision	1	33	118	44
Hypertension	1	33	34	13
Chronic bronchitis	1	33	18	7

POWER HOUSE AND ROTARY STATION

This group of sixteen men (16) ranges in age from 22 to 60 years with an average age of 38.5 years. They have been employed in the plant from 1-1/2 to 39 years, the average being 13.2 years. These men are tall (average height 70 inches) and heavy (average weight 185 lb.). Five of the group are definitely obese and one is significantly underweight. Their pulmonary vital capacities are all within normal values, ranging from 3,400 to 6,000 ml. and averaging 4,550 ml. The blood counts of all were normal as were their urines. The rates of urinary fluoride excretion of all were normal, except one ([redacted]). The physical defects found on examination are tabulated below.

Defect	Group		Plant	
	Number of Cases	Rate (%)	Number of Cases	Rate (%)
Defective vision	6	38	118	44
Obesity	5	31	27	10
Hypertension	5	31	113	42
Acne	4	25	48	18
Caries	4	25	94	35
Neurosis	3	19	17	6
Tonsillitis	3	19	13	5
Hemorrhoids and fissures	3	19	26	10
Gingivitis	2	13	89	33
Pharyngitis	2	13	13	5
Arthritis	2	13	13	5
Defective hearing	2	13	34	13
Undernutrition	1	6	7	3
H.C.V.D.	1	6	12	4
A.S.H.D.	1	6	5	2
Enlarged liver	1	6	17	6

Three men were considered to have questionable fluorosis of bone. One, [redacted] gave a history of [redacted]

years of electrical repair work before going to work full time in the power house. If his case be accepted as one of fluorosis of bone, it may be assumed that the condition developed during the period in which he was exposed to fluoride in the pot room while working as an electrical repairman, rather than during the period of his present employment when there was no apparent exposure of that type. He has no symptoms or disability from this condition. The other two, [redacted] and [redacted], have no present or recent exposure to fluoride and no prior history of employment that would involve the likelihood of such exposure. Their rates of urinary fluoride excretion are also within normal limits, and in all probability their apparent dubious increases in skeletal density are not due to excessive absorption of fluoride. No other disorders of occupational origin were found.

SALARIED AND OFFICE GROUP

This group comprises fifteen men who work in the office or analytical laboratory. The length of their employment ranges from 4.5 years to 29.5 years, and averages 18 years. Their ages range from 27 years to 55 years and average 43 years.

Their exposure to cryolite has been either negligible or brief at infrequent intervals. They are excreting fluoride in their urine in concentrations that range within normal values, from 0.23 mg. per liter to 1.02 mg. per liter, the average for the group being 0.44 mg. per liter.

Considered as a whole, the physical condition of the group is rated as satisfactory for the work which they are doing. Their vital capacities range from 3,400 to 5,800 ml., and average 4,400 ml.

Their non-occupational diseases are few and non-disabling. Two men have leucopenia, their leucocytes numbering 3,650 and 3,700, respectively. One man had a slight hypochromic anemia with hemoglobin of 13.2 grams. These findings have been called to the attention of the men concerned.

Defect	Group		Plant	
	Number of Cases	Rate (%)	Number of Cases	Rate (%)
Caries	5	31	94	35
Defective vision	4	25	118	44
Defective hearing	3	18	34	13
Skin disease	3	18	48	18
Obesity	2	12	27	10
Fluorosis of bone, slight	2	12	25	9
Varicosities	2	12	37	14
Hypertension	1	6	113	42
Inguinal hernia	1	6	20	7
Hemorrhoids and fissures	1	6	26	10
Tuberculosis	1	6	6	2
? Renal calculi	1	6	2	1

X-ray examinations of the chest show that [redacted] has active pulmonary tuberculosis. This finding has been verified by stereo films.

The X-rays (of chest and pelvis), read without reference to other data, revealed two slight cases of fluorosis of bone, and three questionable cases of fluorosis of bone. [redacted] whose films give evidence of slight fluorosis of bone, is a production supervisor who has had nine years of intermittent exposure in the pot room. [redacted] classified as slight fluorosis of bone, has been employed for 26-1/2 years and has done clerical work during this entire period. He has no known history of exposure in the pot room, and has never lived in an area known to have large amounts of fluorine in the drinking water. His rate of urinary fluoride excretion is, however, twice as high as the mean rate of the office group, and is in the range of men who have intermittent exposure in the pot room or in the carbon rodding operations. It may be properly concluded that some unrevealed activity on the part of the man has subjected him to exposure to fluorides, and the likelihood is that such exposure has occurred within the plant over a period of years.

The three questionable cases are represented by [redacted] and [redacted] who are, respectively, [redacted] and [redacted]. It is certain that the chemists have had some intermittent exposure to fluoride-containing compounds in the form of vapor and dust. The only known exposure of the [redacted] has been associated with his interviews over the past three years with men whose clothes and persons have been

contaminated with dusty fluorides. Since all three of these are questionable cases without evidence of disability, and since the apparent increases in bone density are limited to the ribs (the vertebrae and pelvic bones are normal), and, finally, since the urinary fluoride levels of all three are within normal limits, we conclude that the dubious evidence of the X-ray films is insufficient to justify the diagnosis of fluorosis.

Conclusions

As a group, the health status is satisfactory. One case of pulmonary tuberculosis ([redacted] requires immediate medical handling. Two cases of fluorosis of bone, both slight and non-disabling, were found. One of these is unexplained on either an occupational or non-occupational basis.

FEMALE EMPLOYEES

Only nine (9) of the female employees were examined. The examinations were incomplete in that they did not include pelvic or rectal examinations or the collection of samples of urine and their analysis for fluorides. These women have been employed as clerks, typists and stenographers for periods of time ranging from three months to fifteen years and averaging six (6) years. Their ages range from 21 to 50 years and average 31 years. Their average height is 5'3" and their weight, 126 lb. None is anemic, seriously undernourished or remarkably obese.

In no instance was serious illness found which would contraindicate continued employment. Incidental findings were as follows: Defective vision 3, otitis 1, acute naso-pharyngitis 1, unexplained leucopenia 1, possible early hyperthyroidism 1, hemorrhoids and rectal fissure 1. In all cases these findings were made known to the individuals involved, and they were advised to consult their physicians about them.

X-rays were made of the chest of eight of these women. No active tuberculosis was found. One case of healed tuberculosis was found. No other abnormalities believed to be significant were demonstrated.

No disorders definitely of occupational origin were found among these employees. None of these women has had any known significant exposure to alumina or to cryolite. Their work-quarters are adequately ventilated and lighted, sanitary facilities are satisfactory and adequate facilities for lunch and rest periods are available.

SUMMARY AND GENERAL CONCLUSIONS

The health survey of 267 employees of the Niagara Falls Works of Aluminum Company of America made between May 17 and June 12, 1948 is herewith reported in detail. Three copies of the individual records of each employee examined are submitted. The X-ray films taken on each employee examined are being forwarded to the Niagara Falls Works for permanent storage. The crude data obtained in the industrial hygiene survey are included in the report. These documents and records constitute the entire source material from which the conclusions of this report have been drawn.

Six (6) cases of tuberculosis were found, at least four (4) of which are active. We are informed by Dr. Irwin that the necessary provisions for their medical care have already been made. It is obvious that adequate procedures for following-up the previously known four (4) cases have been lacking.

Seven (7) men had positive Wasserman reactions. In no instance was evidence of contagious syphilis found. Only one of these men is receiving adequate therapy. There is apparently no mechanism whereby the plant physician determines the adequacy of the therapy received. At least one man was known to have had syphilis as long ago as [redacted] at which time he had no symptoms from his disease. He is now suffering from a rapidly expanding aneurysm of the aorta. This could have been prevented if the plant physician had insisted that adequate therapy be instituted and carried out when the positive Wasserman was first discovered.

One hundred eighteen (118) men work daily with uncorrected defective vision in excess of 20/50. Many of these men have glasses at home but do not wear them in the plant. One hundred thirteen (113) men have varying degrees of hypertension of which seventeen (17) have active readily diagnosable heart disease. Ninety-four (94) have seriously decayed teeth which need attention and eighty-nine (89) have extensive gingivitis. Forty-eight (48) were victims of skin disease in one form or another, exoluding burns. More than fifty (50) other abnormalities, non-occupational in origin, which have been elaborated upon in the body of the report, were found to range in incidence from 0.1% to 25%. All of these defects were reported to the men in whom they were found, and the men were advised to consult their family medical and dental advisors about them.

In addition, one hundred twenty (120) cases of fluorosis of bone were found. Of these 34 were classified as questionable, and therefore might be discarded, except for the fact that they cannot be regarded as certainly normal or negative with respect to fluorosis. Twenty-five were classified as slight, 28 as moderate, and 33 as severe. Many of the last group showed evidences of disability ranging in estimated degree up to 100%. It is believed that all of the cases can be traced to exposure to fluorides in the pot room. There is also a definite exposure to fluorides in the carbon rodding operation, but the evidence at hand does not show conclusively that this hazard is of sufficient magnitude to produce fluorosis of bone. Eighty-eight per cent (88%) of the cases occurring among regular pot room employees had at least twelve years of

exposure before the disease became manifest, and no man employed therein continuously for more than 17 years escaped the development of this disease. The data of the industrial hygiene survey (See Appendix A) make quite clear the origin, nature, distribution, and magnitude of the fluoride hazard which produces this disorder. The data of the urinary excretion of fluoride are very useful as a measure of the average daily fluoride intake but do not reflect severity of the disease produced. There can be no exposure to fluorides is (and for years has been) present in the pot room. The control methods are not sufficiently effective. In Appendix C we have made an effort to estimate the degree of disability resultant from fluorosis of bone in the 120 cases herein reported.

Osteo-arthritis of the spine, independent of fluorosis of bone, is a common finding among pot room employees (81 cases in 128 examined) and among other employees who do hard physical work. This disorder is common among men who are required to do extremely hard physical work for a long period of years. The incidence found in this group of men is comparable to that found in stevedores.

Thirty-five (35) pot room employees showed a marked increase in the density of the parenchymatous markings of the lung fields on X-ray without evident interference with respiratory function. It is not known whether or not this has resulted from the dusty acid-gas-laden atmosphere of the working environment. However, the incidence of this finding is significantly greater than that found in a group of common laborers of comparable age and number, selected at random from the

X-ray files of the Cincinnati General Hospital. It, therefore, appears that this lesion too may be related to occupation.

We are informed that the temperature of the working environment is frequently high. This was not observed because of the time of the year during which the survey was made.

Small minor burns are so common among pot room employees that they are rarely called to the attention of the plant physician or plant nurse. These may be attributed to poor lighting, poor eyesight, carelessness, and unsatisfactory operating techniques.

No uncontrolled serious occupational hazards appear to exist in other parts of the plant.

. . . . . .

Recommendations

The above report is believed to provide adequate evidence in support of the following recommendations. It is, therefore, recommended that:

1. All cases of infectious or potentially infectious disease be given adequate continuous medical supervision.

2. The fluoride hazard of the pot room and carbon rodding operations be eliminated.

3. The potential hazards of dust and acid gas in the pot room be brought under control.

4. Programs to provide adequate illumination in work rooms, and provisions for glasses for all those who need them, be instituted.

5. Totally and permanently disabled men be retired at the earliest possible date and that an effective rehabilitation program be instituted for the partially and/or temporarily

disabled.

6. Adequate medical supervision of the health of the employees be provided.

7. That frequent periodic checks be made of all aspects of the working environment by the industrial hygiene department to insure adequate control.

From the Kettering Laboratory of Applied Physiology, College of Medicine, University of Cincinnati, Cincinnati, Ohio.

Signed_____
Wm. F. Ashe, M.D.

Approved_____
Robert A. Kehoe, M.D.,
Director

Date: October 23, 1948

Table 1

The Incidence and Severity of Fluorosis of Bone among Pot Room Workers in Relation to their Chronological Age

Degree	Chronological Age in Years														Total	Severity Rate %
	21-23	24-26	27-29	30-32	33-35	36-38	39-41	42-44	45-47	48-50	51-53	54-56	57-59	60+		
None	4	3	4	5	3	2	3	1	4	2	2	2	1	1	37	28.9
?	-	-	-	-	2	1	1	2	-	1	3	3	4	1	18	14.1
Slight	-	-	-	-	-	1	2	1	1	-	2	3	3	5	18	14.1
Moderate	-	-	-	-	-	-	1	-	1	-	2	6	4	11	25	19.5
Severe	-	-	-	-	-	-	-	-	-	-	1	7	8	14	30	23.4
Total	4	3	4	5	5	4	7	4	6	3	10	21	20	32	128	100.0
Affection Rate (%)	0	0	0	0	40	50	57	75	33	33	80	91	95	97	71	

Table 2

The Incidence and Severity of Fluorosis of Bone among Pot Room Workers in Relation to the Duration of Employment in the Pot Room

Degree	Number of Years Employed in Pot Room														Total	Severity Rate (%)
	0-1	2-3	4-5	6-7	8-9	10-11	12-13	14-15	16-17	18-19	20-21	22-23	24-25	26+		
None	16	9	2	3	1	1	3	1	1	-	-	-	-	-	37	28.9
?	1	5	2	2	-	-	-	-	2	-	-	-	1	5	18	14.1
Slight	-	2	-	-	2	-	2	2	3	2	2	1	-	2	18	14.1
Moderate	-	-	-	-	-	-	2	3	4	1	5	3	2	5	25	19.5
Severe	-	-	-	-	-	-	-	-	-	7	4	1	3	15	30	23.4
Total	17	16	4	5	3	1	7	6	10	10	11	5	6	27	128	100.0
Affection Rate (%)	6	44	50	40	67	0	57	83	90	100	100	100	100	100	71	

Table 3

Association between Years of Employment, Relative Chronological Age, and Incidence of Fluorosis in Pot Room Workers

	Years of Employment								
	0-1	2-3	4-5	6-7	8-9	10-11	12-13	14-15	16-17
Median Chronological Age in Each Rubric (Men Above)	1	3	1	1	1	0	2	3	5
(Men Below)	0	4	1	1	1	0	2	2	4
Incidence of Fluorosis (%)	6	44	50	40	67	0	57	83	90

Of 60 men employed more than 17 years, all had fluorosis regardless of their chronological ages.

Table 4

Showing the Morbidity Rates for Fluorosis of Bone, Pulmonary Fibrosis and Osteo-Arthritis of the Spine in Pot Room Workers in Relation to the Duration of Employment in the Pot Room

Disorder	Number of Years Employed in Pot Room														Entire Group
	0-1	2-3	4-5	6-7	8-9	10-11	12-13	14-15	16-17	18-19	20-21	22-23	24-25	26+	
Fluorosis	6	44	50	40	67	0	57	83	90	100	100	100	100	100	71
Osteo-arthritis of spine	12	44	75	20	67	0	57	67	80	80	82	80	83	85	64
Lung fibrosis	0	25	0	40	33	0	57	50	60	0	36	80	33	18	23
Number of men in each rubric	17	16	4	5	3	1	7	6	10	10	11	5	6	27	128

Table 5

Association between Chronological Age, Relative Years of Employment, and Incidence of Osteo-Arthritis in Pot Room Workers

	Chronological Age													
	21-23	24-26	27-29	30-32	33-35	36-38	39-41	42-44	45-47	48-50	51-53	54-56	57-59	60+
Median Years of Employment in Each Rubric (Men Above)	0	0	0	0	1	1	2	0	1	1	4	8	9	15
(Men Below)	0	0	0	0	0	0	0	1	2	1	3	10	10	13

Table 6

Association between Chronological Age, Relative Years of Employment, and Incidence of Lung Fibrosis in Pot Room Workers

		Chronological Age													
		21-23	24-26	27-29	30-32	33-35	36-38	39-41	42-44	45-47	48-50	51-53	54-56	57-59	60+
Median Years of Employment in Each Rubric	(Men Above)	0	0	0	0	1	1	1	0	1	0	3	4	2	3
	(Men Below)	0	0	0	0	0	0	0	0	0	0	6	3	4	6

Appendix C

DISABILITY FROM FLUOROSIS OF BONE

On October 5, 1948 a conference was held at the Kettering Laboratory of Applied Physiology in Cincinnati, Ohio attended by the authors of this report and by Dr. Dudley Irwin, Medical Director of the Aluminum Company of America, Mr. Lester Cralley (ALCOA) and Dr. W. R. Scott of Niagara Falls, N.Y., roentgenologist. The data of the health survey were critically reviewed. Certain additional facts came to light, and certain points were checked and verified or corrected, so as properly to be incorporated in the report. In addition Dr. Irwin requested that an attempt be made to evaluate the degree of disability found in the 120 cases reported as having fluorosis of bone.

This is a difficult task. Disability from any disorder derives from a number of factors, including the degree and extent of structural change, the extent and degree of functional change, the nature of a man's job and the extent of his satisfaction or pride in it, his will to work, the attitudes of his co-workers, and many others. For example: A man of 58 years with severe Dupuytren's contractures of the hands may have no symptoms, he will not be able to perform many fine movements, but he may feel well, be anxious to work, and may handle a job as elevator operator, guard, inspector, or other, quite as well as anyone else. What degree of disability has he? Based upon a classification of function of his hands in relation to what normal hands are supposed to be able to do, he has perhaps 75% total permanent disability. However, if

having been so classified, he receives compensation for such disability and is thereby prevented from accepting appropriate employment which will provide for his needs far better than does his compensation, he has been dealt with unwisely and actually unfairly.

It therefore appears to us that final decisions concerning the disability of any man in this plant must be made individually in terms of the factors involved at the time the question arises, and that they cannot be made equitably or finally on any other basis.

The following statements therefore are based upon the situation as observed in the Niagara Works at the time of the examinations (May and June 1948) on the assumption that these men would continue their employment at their present tasks where possible and at lighter tasks when indicated and where feasible, if they reject voluntary retirement under the provisions of the then operating company policy. Furthermore, the statements apply only to that portion of any man's disability which can be fairly attributed to fluorosis of bone. (A man with far advanced arteriosclerotic heart disease with congestive failure who has severe fluorosis of bone but no symptoms therefrom and who shows no limitation of normal motion in his bones and joints may be classified as "without disability" - an obvious fallacy.)

A critical review of the 59 cases of questionable and slight fluorosis of bone found on this survey leads us to believe that in no instance was there evidence of disability in any degree therefrom. Furthermore, if exposure to fluorides is stopped, the bony changes may be expected to revert to normal

without the development of any degree of disability. Finally, there is no evidence to indicate that the finding of slight or questionable fluorosis of bone will in any way alter normal expectancy as regards employability or longevity.

The following are the names and clock numbers of men with moderate fluorosis of bone who are given the same disability rating as was given above for all those with slight or questionable fluorosis.

Name	Clock No.
[redacted]	[redacted]

The other men with moderate or severe fluorosis of bone have been carefully studied. It is my considered opinion that from the scientific point of view none of these men has disability in excess of 25% due solely to fluorosis of bone. However, I am aware that in a court of law, under circumstances which may exist after the Niagara Falls Works is closed, the combination of fluorosis of bone plus osteo-arthritis of the spine plus pre-existing conditions which may or may not have been exaggerated by one or the other of these disorders which are related to employment, much greater disabilities may be claimed and allowed. For that reason I have tried to estimate the upper limit of disability which might be claimed from the evidence available.

Estimates of degrees of disability were based on a review of the entire record in each individual case. Persons with moderate or severe fluorosis without any symptoms or signs

and with little or no hypertrophic change about joints or ligaments and who were 50 years of age or older, were arbitrarily considered to have 10% disability. It is assumed that even with the cessation of exposure to fluorides they will not become entirely free from evidence of fluorosis within their expected life span.

Men who have a considerable degree of fluorosis with hypertrophic changes in the areas of increased bone density and who have no physical signs of limitation of motion and no symptoms are arbitrarily defined as having less than 25% disability.

Men with lesions similar to those described above plus some vague symptoms referable to the areas involved but without physical signs of impaired function, are arbitrarily defined as having from 25-50% disability.

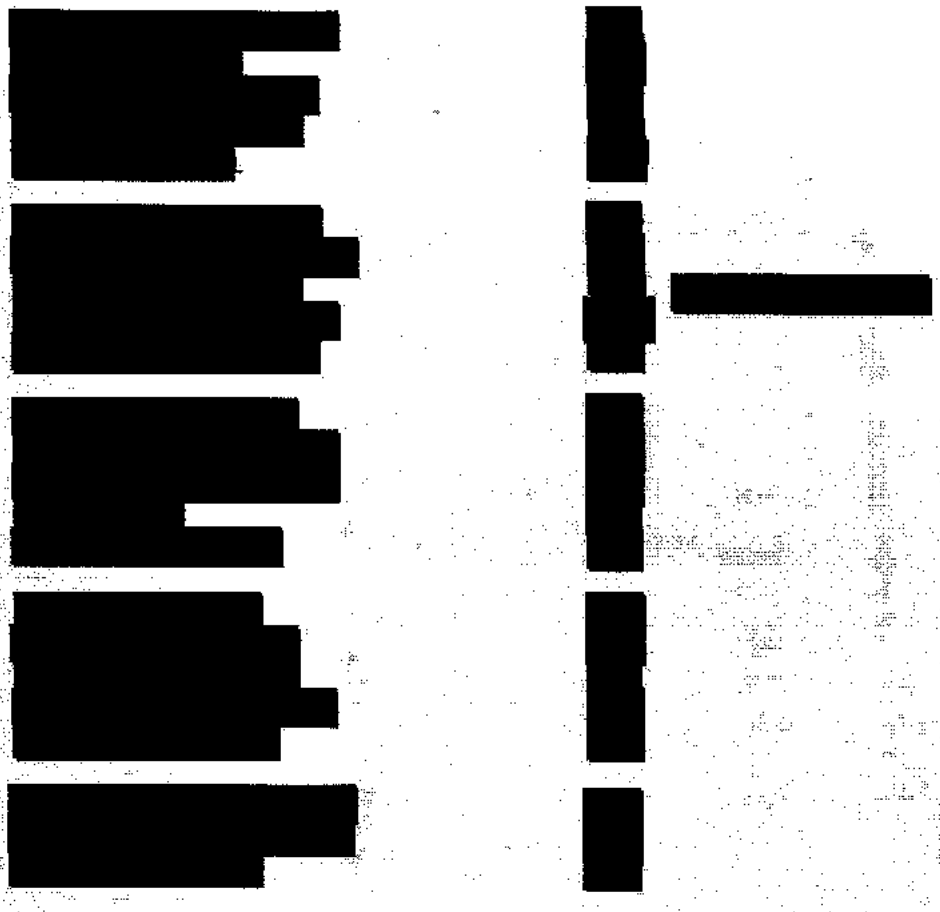
Men of the immediately foregoing type who also give evidence of limited motion of joints or back with or without symptoms and who because of their present age cannot be expected to recover within their expected life span, are arbitrarily considered to be from 50-75% disabled if their limited function is slight or moderate and 100% disabled if it is marked (even though they are still employed).

The names and clock numbers of each group are as follows:

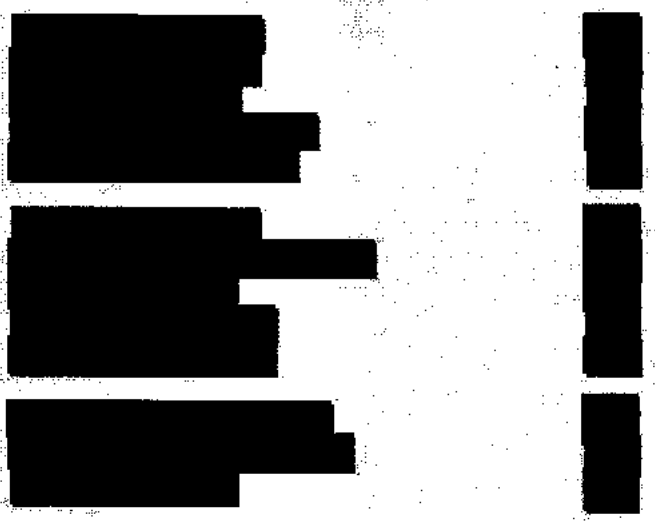
10% Disability

[redacted]

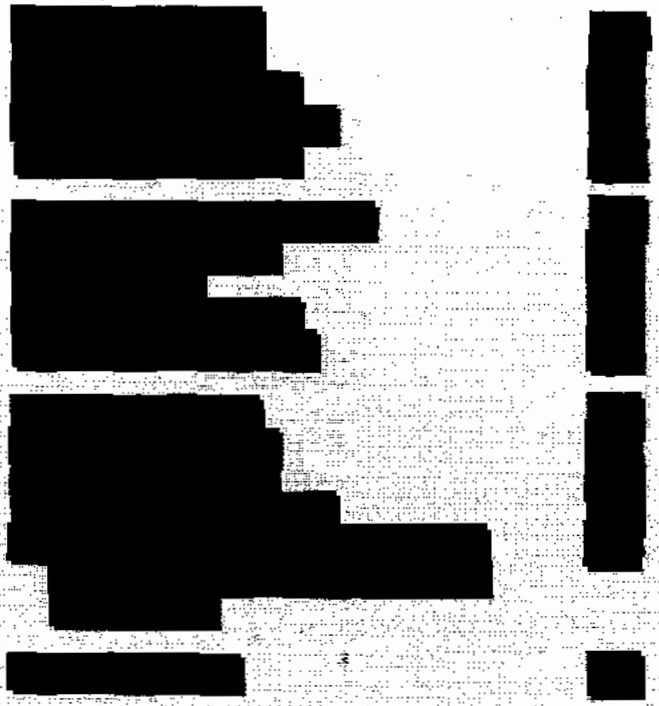
Less than 25% Disability



25-50% Disability



50-75% Disability

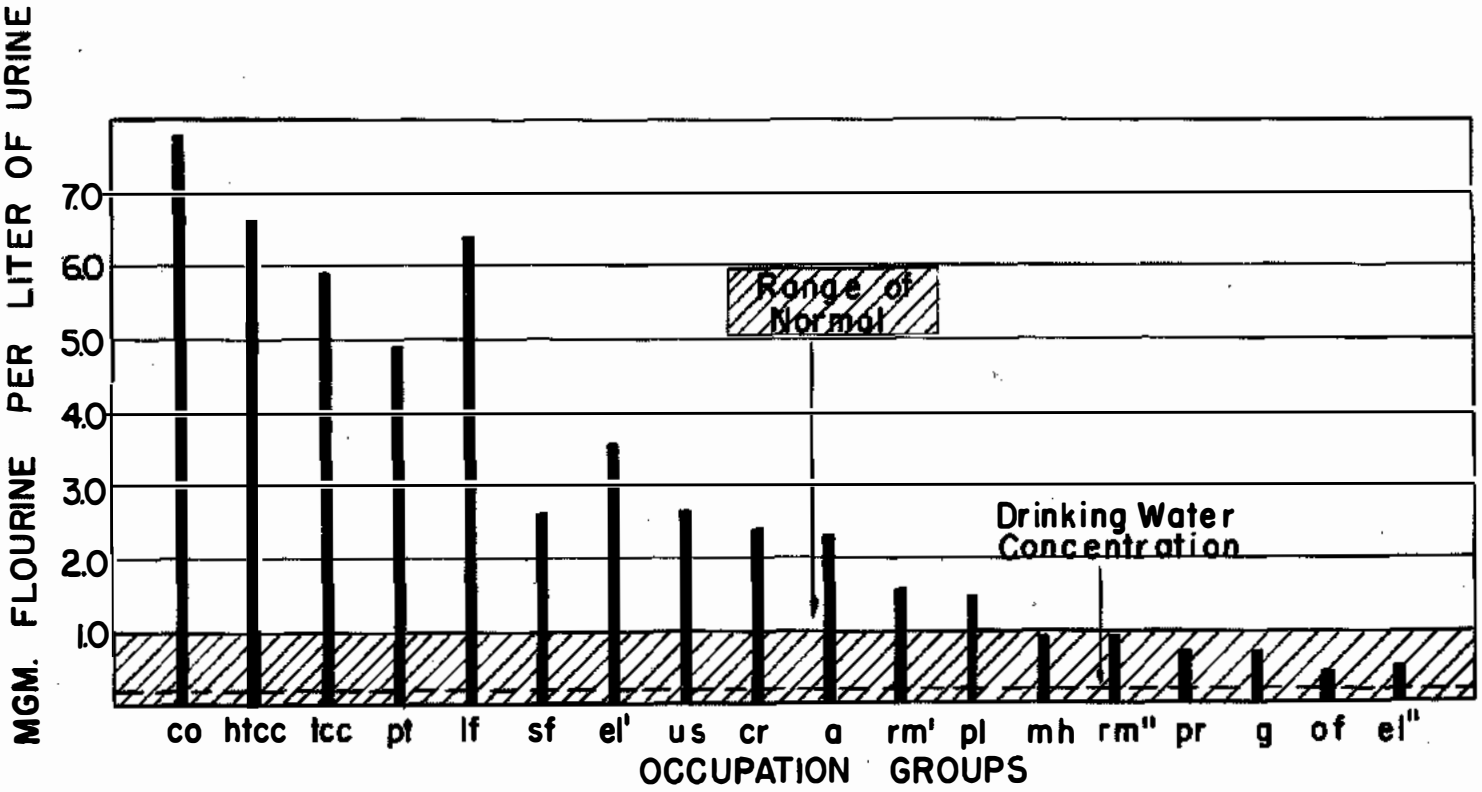


100% Disability

Many of these men have disabilities from other causes in excess of the amounts estimated in relation to fluorosis. Most if not all of the estimates of disability except those recorded as 100% are believed to err on the side of being too high. However, any man with severe fluorosis of bone may claim and be allowed 100% disability if in the course of seeking new employment, he is refused employment because of the changes which may be seen on his chest X-ray. All of the estimates of disability were made by the undersigned and do not necessarily reflect the opinion of the other examiners or of Dr. Scott, roentgenologist.

Wm. P. Ashe, M.D.

THE URINARY FLOURIDE EXCRETION OF MEN GROUPED BY OCCUPATIONS



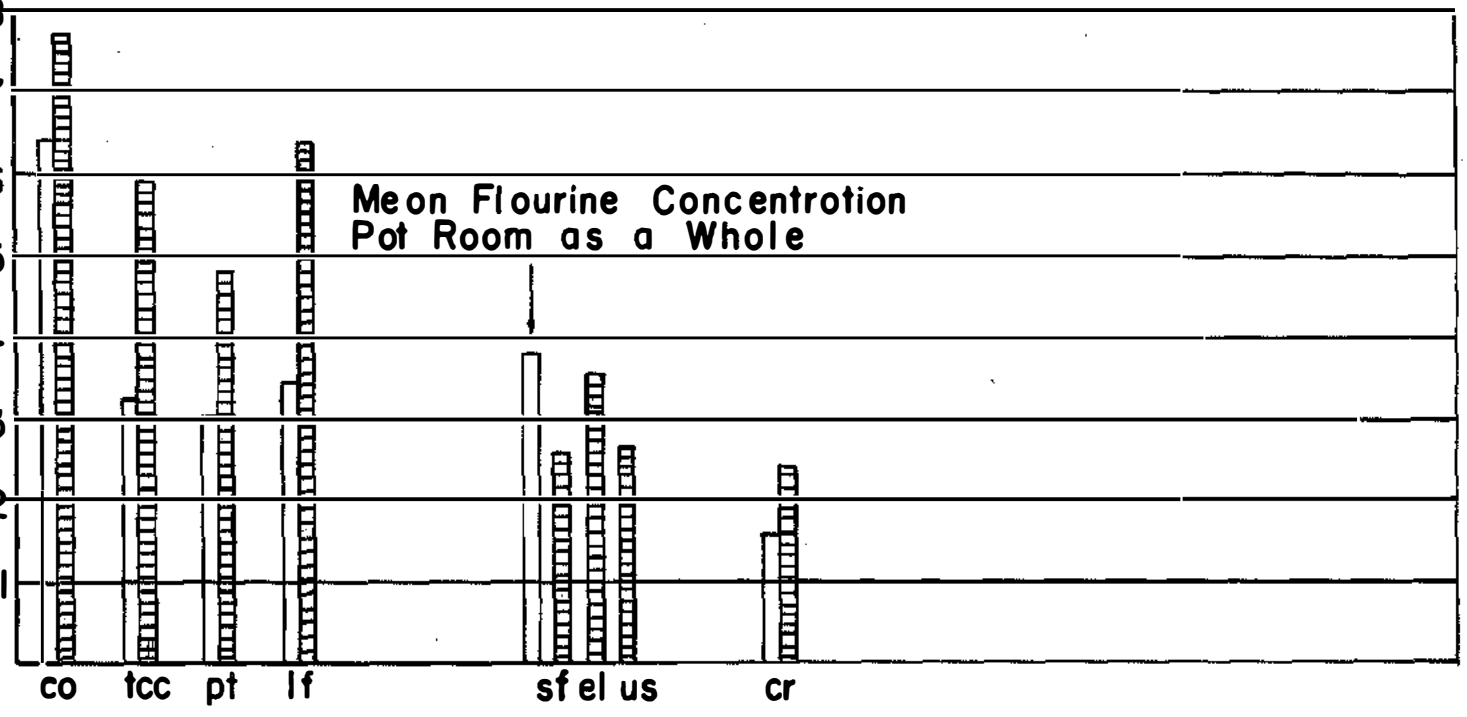
▬ Urinary Flouride Concentration (Group Mean Values)

co = Crane Operators
htcc = Head Tapper Carbon Changers
tcc = Tapper Carbon Changers
pt = Pot Tenders
lf = Line Foremen
el' = Electricians, Group I (Frequent Pot Room Exposure)
us = Utility Service Gang
cr = Carbon Rodders
a = Alloy Group
rm' = Repair and Maintenance, Group I (Frequent Pot Room Exposure)
pl = Pot Liners
mh = Metal Handlers
pr = Power House and Rotary Station
g = Guards
of = Office Personnel
sf = Shift Foremen

CHART 1

CHART 2

THE INTERELATION OF URINARY FLOURIDE EXCRETION OF MEN ENGAGED IN CERTAIN OCCUPATIONS AND THE MEAN ATMOSPHERIC FLOURIDE CONCENTRATION IN THEIR WORKING ENVIRONMENTS



co= Crane Operator tcc= Tapper Carbon Changer pt=Pot Tender

lf = Line Forman sf =Shift Foreman el =Electrician (Pot Room) I

us = Utility Service cr =Carbon Rodding

SHOWING THE RELATIONSHIP OF URINARY FLOURIDE EXCRETION TO THE SEVERITY OF BONE FLOUROSIS IN TWO GROUPS OF MEN WHOSE ENVIRONMENTAL EXPOSURE TO FLOURINE AT THE TIME OF EXAMINATION WAS RADICALLY DIFFERENT (CASES ARE COMPARABLE)

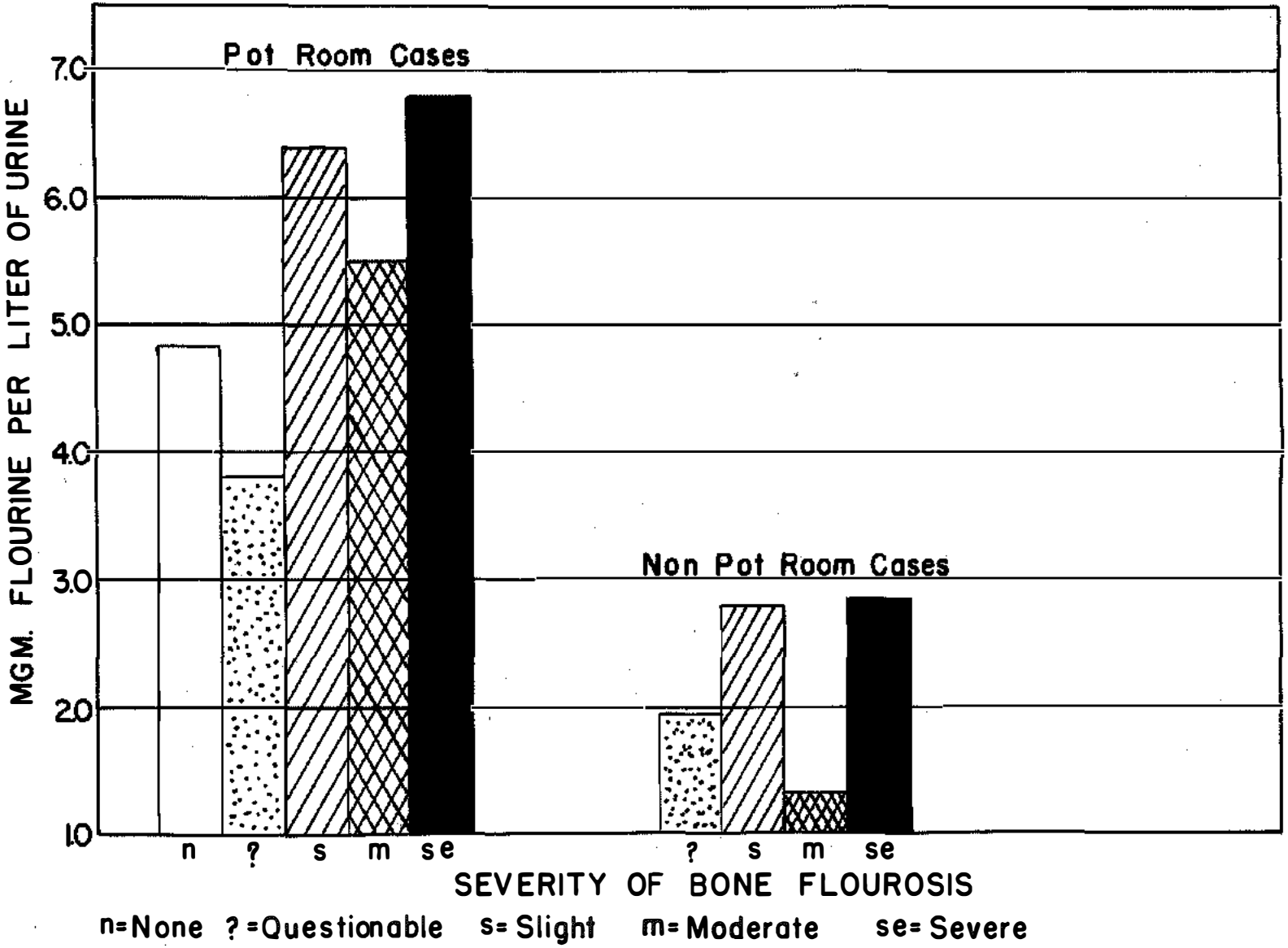


CHART 3

Appendix A

Report on

AIR SAMPLING SURVEY CARRIED OUT AT THE NIAGARA WORKS OF THE ALUMINUM COMPANY OF AMERICA

Report on

AIR SAMPLING SURVEY CARRIED OUT AT THE NIAGARA WORKS OF THE ALUMINUM COMPANY OF AMERICA

Introduction

This report gives the results which were obtained in an air sampling survey that was made for the Aluminum Company of America at the Niagara Works during May and June of this year. The purpose of the survey was to aid in the appraisal of the exposure to fluorine on the part of the employees of the plant. Since there was likelihood of exposure to both particulate and gaseous compounds of fluorine, the representation of these in the atmosphere was examined. In addition, measurements were made to determine the concentrations of sulfur dioxide and of carbon monoxide in the air of the plant. The latter gas occurs as a result of the incomplete combustion of the carbon electrodes which are used in the electrolytic reduction of aluminum ore, while the former is produced by the oxidation of sulfur which may be present as an impurity in the electrodes.

Procedure

The survey was designed to give a cross-sectional picture of the exposure. Air samples, therefore, were taken in locations across the width of the building in the center of each of the three sections in which the pots are arranged. The sampling locations were beneath the centers of the stacks which ventilated the Chippawa and 40-pot sections, and between the two stacks ventilating the center section of the pot room. In the case of the Hall pots (Lines 1 and 2) samples were obtained over the ventilation grills between the pots, at points in front of the pots near the handle of the rabbling iron, and also in the centers of aisles between the

fronts of the pots. In sampling the areas occupied by Niagara pots (Lines 3 and 4), samples were taken on the grills between the back decks of the pots, on the front decks of the pots, and before the pots. In each of these locations, the sampling equipment was set up at about the center of the areas concerned. Samples also were taken in the centers of the aisles between the pots. Other samples were taken in the cabs of cranes, at a number of rest areas in the pot room, and at certain other locations where exposures might be expected to occur. All samples were taken at the uniform height of approximately five feet, in order to correspond to the breathing level of a man of average height. In addition to the air samples, settled dust was removed from one crane in each line in order to determine the fluorine content of this material.

In every case, sampling was carried out with the standard large impinger, through which air was passed at the approximate rate of one cubic foot per minute, a weak solution of sodium hydroxide acting as the trapping medium. Suction was provided by an electrically driven pump. As the impinger collected both gaseous and particulate fluorine, it was necessary, in order to determine the partition of these, to remove the particulate matter by passing the air through an electrostatic precipitator before trapping the gaseous fluorine in the weak sodium hydroxide solution. Therefore, the head of the M.S.A. electrostatic precipitator was attached to the impinger by means of a rubber stopper. A long cable connected the head to the power pack of the instrument. (The precipitators used in this work were revised models of the M.S.A. electrostatic precipitators. The revisions had been made in this laboratory, and consisted chiefly of replacing the original induction coils

with suitable step-up transformers.)

The precipitator-impinger arrangement was used on approximately one-third of the total number of samples which were taken in the pot room. A staggered cross-section of the pot room was analyzed in this fashion. Samples to be used in studying the partition of fluorine compounds were taken for all of Line 1 and for the area between pots 93 and 94 in Line 2 of the Chippawa section. The equipment was next moved to the center section and samples were taken for the balance of Line 2 and all of Line 3. Finally a cross-section of Line 4 in the 40-pot section was sampled. In each section, the remainder of the samples necessary to complete the program of cross-sectional sampling was taken by means of the standard impinger only.

The concentrations of sulfur dioxide were determined only in those samples in which the precipitator was used ahead of the impinger so as to remove any particulate sulfates ($Al_2(SO_4)_3$) that may have been present in the air. A staggered cross-section of the exposure was therefore obtained. The air was sampled for carbon monoxide at numerous locations. Most of the tests were made between the pots in the Hall pot area and on the rear and front decks of the pots in the Niagara section. A sufficient number of tests were also made at other locations to give a good overall picture of the occurrence of carbon monoxide.

The procedure outlined above was used first for a complete cycle, May 17-May 21, and then the program was repeated June 7-June 10, with the exception that the differential sampling (partition of fluorine compounds) was started each time at opposite ends of Line 1. During the two weeks of the survey, certain peaks and

valleys in the concentration were obtained which could be attributed to meteorological variations. During the first week of sampling, outside temperatures were low and there were showers practically every day. Outside temperatures during the second week were slightly higher, and, except for the first day, there was little rainfall.

During the first period of sampling carried out in May, Dr. L. V. Cralley of the Aluminum Company collected a number of samples in parallel with ours in a number of locations. His impinger was set up beside ours on the same stand, the inlets being approximately one foot apart. The samples collected by Dr. Cralley were to be analyzed by the Aluminum Company. The purpose of the simultaneous sampling program was to compare the techniques of the two laboratories so that if the results were in agreement, analytical data available from previous or subsequent observations made by the Aluminum Company might be employed to amplify those obtained in the present survey and to portray the environmental conditions over a more extended period of time.

The fluorine analyses were made by means of the standard thorium nitrate back-titration method which is used in this laboratory for all fluorine analyses. The samples were first evaporated to small volume or to dryness using calcium metal turnings as the fixative for the fluorine. If necessary, a little distilled water was added and the mixture was brought just to the acid side of litmus by adding perchloric acid. The mixture was then rinsed into a distilling flask and the fluorine was distilled out at 135° in the manner described by Willard and Winter. The hydrofluosilicic acid produced in the still was swept out by means of

steam, 250 ml. of distillate being collected in each case. The fluorine in the distillate was then determined by the back-titration procedure, using standardized solutions of thorium nitrate and sodium fluosilicate. Alizarin was used as indicator. The findings were then reported in milligrams per ten cubic meters of air or in parts per million. In the latter case, the molecular volume was corrected to the observed temperature and barometric pressure for the particular day (see Table 11).

Sulfur dioxide determinations were made on aliquots of the solutions which were used to trap gaseous fluorine. After oxidation of the sulfur dioxide to sulfate with bromine water, a few crystals of barium chloride were added and the precipitated barium sulfate was determined turbidimetrically. Readings were made at 500 mμ by means of a Beckman spectrophotometer.

Carbon monoxide determinations were made with the M.S.A. carbon monoxide detector employing the N.B.S. indicating gel.

Results

The individual analytical findings for the respective series of samples taken in May (17-21) and in June (7-10) are listed in Tables 1 and 2. These tables give the location, the temperature, and the volume of air sampled, and under "remarks" are noted particular operations or unusual operating conditions which occurred in the immediate area while sampling. The results have been recorded both as milligrams of fluorine per ten cubic meters of air and as parts per million of fluorine. When data on the partition of fluoride were obtained, the figures "(p)" to the left of the total fluorine value relate to the amounts of

fluoride removed as particulate matter by the electrostatic precipitator, while those designated as "(a)" represent the quantities of gaseous fluorine caught by the trapping fluid in the impinger. The concentrations of sulfur dioxide and carbon monoxide are also listed in relation to the respective locations at which the samples had been obtained.

Charts 1 and 2 locate the samples on the floor plan of the pot room. For convenient reference, the total fluorine content of the samples has also been indicated here, but for the sake of simplicity, the values are expressed only to the nearest tenth of a part per million. The figures in the circles give the findings for the impinger samples, while those enclosed by the diamond record the total fluorine found at that point. The results of the analyses of the samples from the crane, and of those related to certain other specific operations, such as screening and carbon rodding, are not shown.

In Table 3 are listed the average concentrations found at various locations in each line, together with average values for the areas occupied by the Hall pots and the Niagara pots, and the mean value for the entire pot room floor. The averages of results obtained on special samples, such as those taken in the cranes and in certain other areas, have also been given.

Table 4 gives the estimated time spent by the workmen in carrying out their occupational duties, as estimated by the plant superintendent (A.P.D.)

Table 5 gives the average concentrations of fluorides encountered by the various workers in performing their daily work, these being duly weighted on the basis of the data of Tables 3 and 4.

In making these calculations in the instance of the pot tenders and tappers, the type of pot was also taken into consideration. Thus men working at both of these jobs on Lines 1 and 2 (Hall pots) were assumed to have carried out their work in the same locations and under the same conditions. In the area of the Niagara pots, however, the exposure associated with these two types of work is distinctly different, and it has been accepted that only the tappers and carbon changers work on the front and rear decks of the pots. The exposure of the line foremen was assumed to be a composite of that of the area in general. In calculating the average affective concentration to which the technical control group is exposed, the mean concentration in the pot room was used, while the atmosphere of the office was assumed to be free of fluorine. The factor of time in connection with the work of the pot changer was not to be estimated with assurance, but if it be assumed that he spends one-half of his time in the pot room, the average concentration to which he would be exposed in the course of an 8-hour day would not be more than 1.75 p.p.m. The pot digger, when working on a pot, would be exposed to the conditions which characterize the general pot room.

In Table 6 are given the percentages of gaseous fluorine which were found at the different locations in the pot room. The percentages have been averaged for each type of pot and a mean value has been recorded for the entire pot room.

Table 7 gives the analytical data on the settled dusts which were removed from the cranes.

Table 8 gives the average percentage of carbon monoxide found in samples taken at the locations shown. The mean value

for the entire floor (omitting the values for the cranes and the carbon rodding room) has also been recorded.

Table 9 gives data on the concentrations of sulfur dioxide, while Table 10 gives the comparative findings for the samples taken simultaneously by the Aluminum Company and by the Kettering Laboratory. The results obtained by representatives of the Aluminum Company were reported as total fluorine per sample, but since the volumes of the air samples were known, these values were converted to parts per million at the observed temperature and barometric pressure. Finally, Table 11 lists the temperatures and barometric pressures prevailing during the two periods of sampling.

Discussion

Although only two samples were taken at each location, the conditions of occupational exposure as indicated by the mean value would seem to be representative. The mean concentration on the pot room floor was 3.79 p.p.m. (Although the men are said to spend one-half of their time in rest areas, the exposure in these areas is only slightly lower than that prevailing in other parts of the pot room floor.) As would be expected, the crane operators are exposed to the highest concentrations of fluorine, the average for the group being 6.43 p.p.m. with a range of 3.22 p.p.m. to 10.80 p.p.m. The line foremen appear to have the next greatest exposure (3.48 p.p.m.), followed closely by the carbon changers (3.22 p.p.m.) and then the pot tenders (3.03 p.p.m.). The exposure of the technical control group (2.16 p.p.m.) is next in line. The values for the exposure of the other groups as shown in Table 5 are

probably not representative, since they are based either on a single observation, or on an indeterminable working schedule, or both. As an example of this situation, the exposure associated with the carbon rodding operation is portrayed by a single sample taken in the early afternoon when most of the departmental activity had passed its peak.

As may be seen from Table 3, the highest fluorine concentrations were found on Line 1, those of Line 4 being next. The average concentration of fluorine in the areas covered by the Hall pots, however, was practically the same as that for the Niagara pots. The averages of the fluorine concentrations in the two areas (including rest areas) were 3.48 and 3.42 p.p.m., respectively. While the pots themselves were being worked, the highest concentrations in Lines 1 and 2 (Hall pots) were encountered in front of the pots and in the aisles between them. Under comparable conditions, in Lines 3 and 4 (Niagara pots), the highest concentrations were encountered on the front and rear decks of the pots.

Insofar as the type of exposure is concerned, the atmosphere appeared to be about equally contaminated with gaseous and particulate fluorine (Table 6).

Table 7 shows that the particulate matter contained a large percentage of fluorine, the average being 6.62 per cent.

The mean concentration of carbon monoxide on the pot room floor was found to be 0.0026 per cent. The highest average concentration (0.0046 per cent) was obtained in the cranes, the next highest average being 0.0035 and 0.0036, respectively, in relation to the rear and front decks of the Niagara pots. One relatively high result (0.0075 per cent) was obtained on the rear deck of

pot 32 (Table 1). The area immediately over the casting furnace in the carbon rodding room averaged 0.0015 per cent in its carbon monoxide content, while that in the carbon rodding room itself, in which the oil-fired casting furnace is located, averaged only 0.001 per cent. On the whole, the evidence indicates that none of the workmen in any of the areas are being subjected to hazardous exposure to carbon monoxide.

The quantities of sulfur dioxide produced in the process are insufficient to be considered a health hazard, the mean concentration in the atmosphere being 0.63 p.p.m. The highest concentrations on the floor were obtained on the front and rear decks of the Niagara pots. The greatest single concentration (2.24 p.p.m.) was obtained on the rear deck of pot 100 (Table 2).

The results obtained by the two groups (ourselves and Aluminum Company), compared in Table 10, demonstrate that the respective procedures (analytical and sampling) which are used by the Kettering Laboratory and the Aluminum Company are concordant. Although occasional pairs of results differ by as much as 20 per cent, all parallel results are of the same order of magnitude. Moreover, the averages of the two entire series of results are in remarkably close agreement, the difference of the respective averages from the combined average of the two sets being only ±1.75 per cent.

From the Kettering Laboratory of Applied Physiology,
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Work by: J. Cholak, Ch.E.
Lawrence Schafer, B.S.E.
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Elmo Blackston

Approved: Robert A. Kehoe
Robert A. Kehoe, M.D.,
Director

Report by: J. Cholak, Ch.E. Date: September 29, 1948

Table 1

Analytical Results Obtained on Samples Taken in a First Series of Observations Made at the Niagara Plant of the Aluminum Company of America May 17 through May 21, 1948

Sample and Location	Date	Time	Temp. °F.	Sample Ft.^{3}	Mg. F/10 M^3		F in p.p.m.		CO %	SO_2 p.p.m.	Remarks
Line #1											
Between pots 9-10	5-17-48	1:33-2:03 p.m.	85	25.2	21.2(p) 8.3(a)	29.5	2.78(p) 1.08(a)	3.86	0.0025	0.27	Adding AlF_3
In front of Pot 10	5-17-48	2:12-2:42 p.m.	85	25.2	19.3(p) 12.8(a)	32.1	2.54(p) 1.70(a)	4.24	---	0.36	
Aisle between Pots 10-93	5-17-48	2:52-3:22 p.m.	85	25.2	2.95(p) 12.65(a)	15.60	0.39(p) 1.67(a)	2.06	---	0.36	Anode effect #3
In front of Pot 93	5-17-48	3:33-4:03 p.m.	85	25.2	14.0(p) 23.8(a)	37.8	1.86(p) 3.14(a)	5.00	---	0.49	
Between Pots 93-94	5-17-48	4:08-4:38 p.m.	85	21.0	12.3(p) 5.73(a)	18.03	1.62(p) 0.77(a)	2.39	0.001	0.14	Charging pot hoppers; anode effect #9
Between Pots 24-23	5-18-48	9:31-10:01 a.m.	93	30		32.4		4.37	0.0015	--	
In front of Pot 23	5-18-48	10:05-10:30 a.m.	93	30		29.4		3.94	---	--	
Aisle between Pots 23-80	5-18-48	10:39-11:09 a.m.	90	30		31.0		4.15	---	--	
In front of Pot 80	5-18-48	11:46-12:66 a.m.	90	25.2		22.7		3.04	---	--	
Between Pots 79-80	5-18-48	12:18-12:48 p.m.	90	25.2		12.25		1.64	---	--	Anode effect #79; charging ore into hoppers

Table 1 continued

Sample and Location	Date	Time	Temp. °F.	Sample Ft.^{3}	Mg. F/10 M^3		F in p.p.m.		CO %	SO_2 p.p.m.	Remarks
Between Pots 41-42	5-20-48	9:56-10:26 a.m.	88	25.2		13.4		1.78	0.001	--	Breaking in #42
In front of Pot 42	5-20-48	10:30-11:00 a.m.	87	25.2		35.0		4.65	---	--	
Aisle between Pots 41-62	5-20-48	9:25-9:55 a.m.	82	25.2		54.4		7.15	---	--	
In front of Pot 61	5-20-48	11:05-11:35 a.m.	92	25.2		35.0		4.70	---	--	Breaking in #41 and #61
Between Pots 61-62	5-20-48	8:50-9:20 a.m.	90	25.2		33.4		4.47	0.002	--	
Line #2											
In front of Pot 94	5-17-48	3:17-3:47 p.m.	83	30.0		28.0		3.65	0.0005	--	Anode effect #94
Aisle between Pots 8-94	5-17-48	2:46-3:16 p.m.	83	30.0		30.8		4.05	---	--	
In front of Pot 9	5-17-48	2:12-2:42 p.m.	83	30.0		29.4		3.88	---	--	
Between Pots 8-9	5-17-48	1:40-2:10 p.m.	83	30.0		14.7		1.95	---	--	
Between Pots 93-94	5-18-48	2:10-2:40 p.m.	83	25.2	13.05(p) 3.34(a)	16.39	1.72(p) 0.44(a)	2.16	0.0015	--	Anode effect
Between Pots 79-80	5-18-48	9:33-10:03 a.m.	95	25.2		1.37		0.19	0.0015	--	#79 dead; anode effect on #79
In front of Pot 80	5-18-48	10:10-10:40 a.m.	85	25.2	22.8(p) 9.7(a)	32.5	3.02(p) 1.28(a)	4.30	---	0.13	#81 boiled over; sweepings added to hoppers

Table 1 continued

Sample and Location	Date	Time	Temp. °F.	Sample Ft.^{3}	Mg. F/10 M^3		F in p.p.m.		CO %	SO_2 p.p.m.	Remarks
Aisle between Pots 79-23	5-18-48	10:42-11:22 a.m.	84	25.2	11.60(p) 6.45(a)	18.05	1.54(p) 0.86(a)	2.40	---	0.14	Anode effect #24; tapping and moving carbons on Line #3
In front of Pot 23	5-18-48	11:20-11:50 a.m.	83	25.2	9.47(p) 6.60(a)	16.07	1.26(p) 0.88(a)	2.14	---	0.26	Anode effect #22, #25, #76; pouring ingots
Between Pots 22-23	5-18-48	11:45-12:15 p.m.	93	25.2	4.20(p) 3.37(a)	7.57	0.57(p) 0.46(a)	1.03	0.001	0.04	Anode effect #81, #83
Between Pots 61-62	5-20-48	1:50-2:20 p.m.	86	25.2		6.65		0.88	trace	--	Added silicon ore to #61
In front of Pot 61	5-20-48	2:25-2:55 p.m.	92	25.2		35.1		4.70	---	--	
Aisle between Pots 60-42	5-20-48	2:56-3:26 p.m.	87	25.2		33.2		4.42	---	--	Added sweepings on Line #1; ored #60, #62; breaking in #61
In front of Pot 40	5-20-48	3:28-3:58 p.m.	84	25.2		22.2		2.94	---	--	Breaking in #61; oreing up Line 3
Between Pots 41-40	5-20-48	4:00-4:30 p.m.	90	25.2		7.00		0.94	0.0005	--	Changing carbons on Line #3
Line #3											
Front Deck of Pot 5	5-18-48	2:54-3:24 p.m.	86	25.2		13.5		1.80	---	--	Anode effect #47

Table 1 continued

Sample and Location	Date	Time	Temp. °F.	Sample Ft.^{3}	Mg. F/10 M^3		F in p.p.m.		CO %	SO_2 p.p.m.	Remarks
In front of Pot 5	5-18-48	3:25-3:55 p.m.	80	25.2		4.56		0.60	---	--	Breaking in #49; adjusting anodes #48
Aisle between Pots 5-48	5-18-48	2:57-3:27 p.m.	80	25.2		13.6		1.79	---	--	
In front of Pot 48	5-19-48	11:37-12:07 p.m.	73	25.2		8.15		1.06	---	--	
Front Deck of Pot 48	5-19-48	11:00-11:30 a.m.	80	25.2		24.6		3.18	---	--	
Rear Deck of Pot 48-57	5-19-48	10:23-10:53 a.m.	105	25.2		49.5		6.84	0.005	--	AlF_3 added to #47
Front Deck of Pot 12	5-19-48	9:10-9:38 a.m.	72	23.5	6.76(p) 16.00(a)	22.76	0.86(p) 2.05(a)	2.91	---	0.04	Changing carbons #14, #40, #11, #43
In front of Pot 12	5-19-48	9:45-10:15 a.m.	80	25.2	6.66(p) 4.07(a)	10.73	0.87(p) 0.54(a)	1.41	---	0.03	Anode effect #42, #10; adjusting carbons #3, #12; tapping #43
Aisle between Pots 12-41	5-19-48	10:20-10:50 a.m.	79	25.2	7.00(p) 7.15(a)	14.15	0.91(p) 0.93(a)	1.84	---	0.04	Tapping #11, #14; adding AlF_3 to #10, #13
In front of Pot 41	5-19-48	2:52-3:22 p.m.	83	25.2	23.7(p) --	--	3.08(p) --	--	---	--	Added AlF_3 to #42; breaking in #64; anode effect #13, #40; tapping #37

Table 1 continued

Sample and Location	Date	Time	Temp. °F.	Sample Ft.^{3}	Mg. F/10 M^3		F in p.p.m.		CO %	SO_2 p.p.m.	Remarks
Front Deck of Pot 41	5-19-48	11:33-12:03 p.m.	90	25.2	7.70(p) 4.62(a)	12.32	1.02(p) 0.61(a)	1.63	0.001	0.052	Tapping #40; breaking in #12
Back Deck of Pot 41	5-19-48	1:10-1:25 p.m.	85	12.6		8.75		1.14	0.0015	--	Anode effect #64
Front Deck of Pot 21	5-20-48	3:26-3:56 p.m.	84	25.2		16.4		2.16	0.0025	--	Breaking in #19
In front of Pot 21	5-20-48	2:50-3:20 p.m.	69	25.2		3.79		0.47	---	--	Anode effect #35
Aisle between Pots 21-32	5-20-48	2:22-2:52 p.m.	73	25.2		17.5		2.27	---	--	#21, #33 hotter than normal (6V.); anode effect #34
In front of Pot 32	5-20-48	1:50-2:20 p.m.	74	25.2		7.45		0.96	---	--	Breaking in #31; anode effect #23
Front Deck of Pot 32	5-20-48	11:45-12:13 p.m.	82	23.5		18.8		2.44	---	--	Tapping #17; anode effect #20
Rear Deck of Pot 32	5-20-48	11:45-12:10 p.m.	95	21.0		42.0		5.66	0.0075	--	Anode effect #82, #24
North end of Ore Furnaces	5-20-48		--	--		--		--	0.001	--	
Over Furnace, North end	5-20-48	12:00 p.m.	--	--		--		--	0.002	--	

Table 1 continued

Sample and Location	Date	Time	Temp. °F.	Sample Ft.^{3}	Mg. F/10 M^3	F in p.p.m.	CO %	SO_2 p.p.m.	Remarks
Line #4									
Aisle between Pots 57-100	5-18-48	3:30-3:58 p.m.	80	23.5	35.8	4.70	---	--	Anode effect #26; oreing #56, #57, #58
In front of Pot 100	5-18-48	4:00-4:30 p.m.	88	25.2	33.4	4.46	---	--	Anode effect, oreing #57
Front Deck of Pot 100	5-18-48	2:55-3:22-1/2 p.m.	90	23.1	53.8	7.15	---	--	
Rear Deck of Pot 100	5-18-48	2:15-2:45 p.m.	84	25.2	20.2	2.68	---	--	
Rear Deck of Pot 57	5-19-48	10:23-10:53 a.m.	105	25.2	49.5	6.75	0.005	--	Added AlF_3 to #47
Front Deck of Pot 57	5-19-48	9:45-10:15 a.m.	80	25.2	24.7	3.26	---	--	
In front of Pot 57	5-19-48	9:09-9:39 a.m.	85	25.2	18.7	2.48	---	--	Moved to aisle last 3 minutes
Front Deck of Pot 64	5-19-48	1:55-2:25 p.m.	80	25.2	21.0	2.72	---	--	
In front of Pot 64	5-19-48	3:58-4:28 p.m.	80	25.2	29.7	3.84	---	--	
Aisle between Pots 64-93	5-19-48	3:24-3:54 p.m.	88	25.2	31.6	4.15	---	--	Grill partially blocked; oreing up #65,#63,#93
In front of Pot 93	5-19-48	2:40-3:10 p.m.	80	25.2	42.0	5.44	---	--	Grill blocked in aisle
Front Deck of Pot 93	5-19-48	2:06-2:36 p.m.	80	25.2	59.5	7.65	---	--	

Table 1 continued

Sample and Location	Date	Time	Temp. °F.	Sample Ft.^{3}	Mg. F/10 M^3		F in p.p.m.		CO %	SO_2 p.p.m.	Remarks
Rear Deck of Pot 93	5-19-48	1:40-2:00 p.m.	76	16.8		lost		lost	0.001	--	
Front Deck of Pot 73	5-20-48	10:45-11:13 a.m.	90	23.5	14.3(p) 13.5(a)	27.8	1.91(p) 1.80(a)	3.71	0.003	0.43	Breaking in #72, #74; anode effect #77,#86; tapped #88; added ore to #74
In front of Pot 73	5-20-48	10:05-10:33 a.m.	75	23.5	8.65(p) 7.80(a)	16.45	1.13(p) 1.02(a)	2.15	---	0.24	Tapping #70
Aisle between Pots 84-73	5-20-48	9:35-10:05 a.m.	68	25.2	8.76(p) 10.00(a)	18.76	1.15(p) 1.31(a)	2.46	---	0.26	Adding ore to #74,#83; changing carbons #70, #88
In front of Pot 84	5-20-48	8:58-9:28 a.m.	70	25.2	6.30(p) 5.33(a)	11.63	0.81(p) 0.69(a)	1.50	---	0.17	Anode effect #71,#88; breaking in #85
Front Deck of Pot 84	5-19-48	3:58-4:26 p.m.	80	23.5	9.40(p) 8.90(a)	18.30	1.22(p) 1.15(a)	2.37	---	0.14	#84 hotter than normal (6.5V.); changing carbons #70; breaking in #87
Rear Deck of Pot 84	5-19-48	3:20-3:48 p.m.	82	23.5	10.90(p) 7.68(a)	18.58	1.42(p) 1.00(a)	2.42	0.005	0.61	Breaking in #74; anode effect #73 #79; adjusting carbons #83,#84, #85

Table 1 continued

Sample and Location	Date	Time	Temp. °F.	Sample Ft.^{3}	Mg. F/10 M^3	F in p.p.m.	CO %	SO_2 p.p.m.	Remarks
Misc. Samples									
Rest Area Line #4 between Chippawa and Center Section	5-19-48	2:25-2:55 p.m.	70	25.2	14.0	1.78	---	--	
Rest Area Line #3 between Center and 40 Pot Section	5-20-48	4:05-4:34 p.m.	80	25.2	15.7	2.07	---	--	Changing carbons on Line #2
Rest Area between 40 Pot and Center Section (Line #1 front of casting)	5-20-48	11:40-12:10 p.m.	80	25.2	42.0	5.55	---	--	Used carbons moved in front and stored 12 ft. from sample
Rest Area, Pouring Area in front of elevator, Line #1 between Chippawa and Center Section	5-21-48	7:50-8:20 a.m.	92	25.2	22.8	3.08	---	--	
Crane: South end, Line #1	5-21-48	9:00-9:15 a.m.	100	8.8	171.0	23.4	---	--	
Crane: North end, Line #4	5-21-48	7:50-8:22 a.m.	83	26.8	27.2	3.68	---	--	Moving carbons
Crane: North end, Line #4	5-21-48	10:10-10:40 a.m.	98	25.2	38.6	5.25	0.0035	--	Tapping #65, #68, #94
Butt Breaking Line #2 between Center and 40 Pot Section	5-21-48	3:30-4:02 p.m.	70	26.8	13.7	1.78	---	--	Breaking butts

Table 1 continued

Sample and Location	Date	Time	Temp. °F.	Sample Ft.^{3}	Mg. F/10 M^3	F in p.p.m.	CO %	SO_2 p.p.m.	Remarks
Screening	5-21-48	11:00-11:20 a.m.	63	17.0	2.15	0.27	---	--	2 ft. back of workman

(p) -- Precipitator Sample
(a) -- Absorber Sample

Table 2

Results Obtained on Taken in the Second Series of Observations Made at the Plant of the Aluminum of America June 7 June

Sample and Location	Date	Time	°F.	Ft.3	Mg. F/10M3		F in p.p.m.				Remarks
Line #1											
Between Pots 41-42	6-7-48	11:40-12:10 p.m.	97	25.2	22.8(p)	62.8	3.06(p) 5.46(a)	8.52	0.003	1.79	Tapping #46; changing carbons on #39, etc.
In front of Pot 42	6-7-48	11:05-11:35 a.m.	94	25.2	20.0(p) 36.8(a)	56.8	2.69(p)	7.69	---	1.22	Anode effect #60
Aisle between Pots 42-61	6-7-48	10:47-11:15 a.m.	88	23.6	18.1(p)	56.1	2.41(p)	7.51	---	1.01	Tapping #60
In front of Pot 61	6-7-48	10:35-11:05 a.m.	96	25.2	42.1(p)	83.1	5.71(p) 5.60(a)	11.31	---	1.35	Tapping #39, #60; anode effect #41
Between Pots 61-62	6-7-48	10:05-10:30 a.m.	96	21.0	14.7(p) 18.3(a)	33.0	2.00(p)	4.50	0.002	0.68	Pulling carbons on #62; tapping #43, #59
Between Pots 23-24	6-9-48	9:48-10:13 a.m.	91	21.0		26.0		3.45	0.001	--	
In front of Pot 23	6-9-48	9:22-9:47 a.m.	86	21.0		40.0		5.30	---	--	
Aisle between Pots 23-80	6-9-48	8:50-9:20 a.m.	85	25.2		59.5		7.86	0.002	--	Anode effect #24
In front of Pot 79	6-9-48	4:45-5:10 p.m.	95	21.0		30.7		4.13	---	--	Tapping

Table 2 continued

Sample and Location	Date	Time	Temp. °F.	Sample Ft.^{3}	Mg. F/10 M^3		F in p.p.m.		CO %	SO_2 p.p.m.	Remarks
Between Pots 79-80	6-9-48	4:15-4:40 p.m.	91	21.0		10.1		1.35	0.001	--	
Between Pots 8-9	6-9-48	10:20-10:45 a.m.	92	21.0		16.9		2.26	---	--	Anode effect #9
In front of Pot 8	6-9-48	10:35-11:00 a.m.	88	21.0		15.5		2.05	---	--	Breaking in #94
Aisle of Pots 9-95	6-9-48	10:47-11:17 a.m.	87	25.2		25.4		3.37	0.001	--	
In front of Pot 95	6-9-48	11:18-11:43 a.m.	88	21.0		42.0		5.62	---	--	Anode effect #93
Between Pots 94-95	6-9-48	10:05-10:30 a.m.	98	21.0		9.26		1.26	0.001	--	Anode effect #13
Line #2											
Between Pots 60-61	6-7-48	12:10-12:40 p.m.	105	25.2	8.8(p) 19.6(a)	28.4	1.22(p) 2.70(a)	3.92	0.0025	1.02	Tapping #62, #65,#58; anode effect #58
In front of Pot 62	6-7-48	2:05-2:30 p.m.	87	21.0		29.5		3.89	---	--	Anode effect #41, #42
Aisle between Pots 41-61	6-7-48	2:05-2:30 p.m.	87	21.0		19.1		2.55	0.0015	--	Anode effect #41, #42
In front of Pot 41	6-7-48	2:32-2:57 p.m.	96	21.0		41.2		5.6	---	--	Oreing up last 3-4 minutes

Table 2 continued

Sample and Location	Date	Time	Temp. °F.	Sample Ft.3	Mg. F/10 M3		F in p.p.m.		CO %	SO_2 p.p.m.	Remarks
Between Pots 40-41	6-7-48	2:30-2:55 p.m.	100	21.0		15.5		2.12	0.0005	--	Oreing up last 3-4 minutes
In front of Pot 23	6-8-48	4:55-5:20 p.m.	95	21.0	14.40(p) 9.90(a)	24.30	1.94 (p) 1.35(a)	3.29	---	0.71	Oreing up; anode effect #81,#19,#25, #82
Between Pots 23-24	6-8-48	4:20-4:45 p.m.	92	21.0	8.40(p) 8.75(a)	17.15	1.14(p) 1.18(a)	2.32	0.001	0.77	Oreing up; anode effect #27
Between Pots 79-80	6-9-48	3:45-4:10 p.m.	87	21.0		23.1		3.02	0.001	--	Changing carbons in area #79
In front of Pot 79	6-9-48	9:35-10:00 a.m.	88	21.0	11.4(p) 11.1(a)	22.5	1.51(p) 1.47(a)	2.98	---	0.68	Anode effect #21, #22
Aisle between Pots 23-80	6-9-48	8:55-9:25 a.m.	88	25.2	22.60(p) 7.85(a)	30.45	3.02(p) 1.06(a)	4.08	---	0.76	Breaking in #23,#25; anode effect #83
Between Pots 94-95	6-9-48	11:40-12:05 a.m.	98	21.0		4.38		0.59	0.002	--	Anode effect #8; two scoops of ore to #94, #95
In front of Pot 94	6-9-48	1:45-2:10 p.m.	87	21.0		31.4		4.16	---	--	
Aisle between Pots 8-94	6-9-48	2:15-2:45 p.m.	89	25.2		25.4		3.30	0.001	--	Anode effect #6, #11

Table 2 continued

Sample and Location	Date	Time	Temp. °F.	Sample Ft.^{3}	Mg. F/10 M^3		F in p.p.m.		CO %	SO_2 p.p.m.	Remarks
In front of Pot 8	6-9-48	2:45-3:10 p.m.	96	21.0		24.3		3.28	---	--	Anode effect #93
Between Pots 8-9	6-9-48	3:12-3:37 p.m.	99	21.0		9.57		1.30	---	--	Anode effect #9; oreing up
Line #3											
Front Deck of Pot 22	6-7-48	3:05-3:30 p.m.	80	21.0		31.4		4.08	0.004	--	Anode effect #23
In front of Pot 22	6-7-48	3:06-3:31 p.m.	82	21.0		9.3		1.22	---	--	Anode effect #23
Aisle between Pots 22-31	6-7-48	3:33-4:03 p.m.	73	25.2		20.5		2.65	0.001	--	Anode effect #21
In front of Pot 31	6-7-48	3:34-3:59 p.m.	78	21.0		18.9		2.45	---	--	Anode effect #21
Front Deck of Pot 31	6-7-48	4:03-4:28 p.m.	80	21.0		36.8		4.73	0.004	--	
Rear Deck of Pot 31	6-7-48	4:00-4:25 p.m.	96	21.0		27.3		3.63	0.005	--	
Over Fe Melting Furnace	6-7-48	10:00 a.m.	--	--		--		--	0.002	--	
Front Deck of Pot 13	6-8-48	3:40-4:05 p.m.	88	21.0	13.5(p) 10.3(a)	23.8	1.74(p) 1.36(a)	3.10	0.0015	0.69	Oreing up
In front of Pot 13	6-8-48	3:15-3:40 p.m.	85	21.0	4.43(p) 5.24(a)	9.67	0.49(p) 0.70(a)	1.29	---	0.26	

Table 2 continued

Sample and Location	Date	Time	Temp. °F.	Sample Ft.^{3}	Mg. F/10 M^3		F in p.p.m.		CO %	SO_2 p.p.m.	Remarks
Aisle between Pots 40-13	6-8-48	1:35-2:05 p.m.	83	25.2	11.6(p) 8.9(a)	20.5	1.55(p) 1.18(a)	2.73	---	0.47	Anode effect #40
In front of Pot 40	6-8-48	1:55-2:20 p.m.	83	21.0	4.2(p) 15.0(a)	19.2	0.56(p) 1.95(a)	2.51	---	0.22	Dumped wheel-barrow of bath before #13
Front Deck of Pot 40	6-8-48	1:25-1:50 p.m.	98	21.0	10.5(p) 14.7(a)	25.3	1.44(p) 2.02(a)	3.46	0.0025	1.31	Anode effect #15
Rear Deck of Pot 40	6-8-48	1:25-1:40 p.m.	113	12.6	15.5(p) 21.1(a)	36.6	2.17(p) 2.98(a)	5.15	0.001	1.10	Anode effect #15
Front Deck of Pot 5	6-9-48	3:37-4:02 p.m.	96	21.0		29.5		3.96	0.004	--	
In front of Pot 5	6-10-48	9:05-9:30 a.m.	92	21.0		12.3		1.64	---	--	
Aisle between Pots 5-48	6-10-48	11:25-11:55 a.m.	94	25.2		25.2		3.36	---	--	
In front of Pot 48	6-10-48	3:40-4:05 p.m.	91	21.0		9.3		1.24	---	--	
Front Deck of Pot 48	6-10-48	12:17-12:37 p.m.	97	16.8		44.5		6.10	0.005	--	
Rear Deck of Pot 48	6-10-48	12:40-12:55 p.m.	100	12.6		45.5		6.15	0.008	--	Anode effect #5
Line #4											
Front Deck of Pot 65	6-8-48	10:45-11:10 a.m.	84	21.0		56.8		7.57	---	--	Anode effect #93,#64; tapping #94;last

Table 2 continued

Sample and Location	Date	Time	Temp. °F.	Sample Ft.^{3}	Mg. F/10 M^3	F in p.p.m.	CO %	SO_2 p.p.m.	Remarks
Front Deck of Pot 65 continued									10 min. #65 6 V. hotter than normal
In front of Pot 65	6-8-48	10:45-11:10 a.m.	77	21.0	10.1	1.33	---	--	Anode effect #93,#64; taping #94; last 10 min. #65 6 V. hotter than normal
Aisle between Pots 65-93	6-8-48	11:18-11:48 a.m.	83	25.2	20.0	2.64	---	--	Dead carbons cooling 6 ft. from sample; anode effect #66; changing carbons #66; tapping #65
In front of Pot 93	6-8-48	11:18-11:48 a.m.	85	25.2	12.2	1.62	---	--	Dead carbons cooling 6 ft. from sample; anode effect #66; changing carbons #66; tapping #65
Front Deck of Pot 93	6-8-48	10:28-10:53 a.m.	92	21.0	75.5	10.2	---	--	Anode effect #94; adjusting carbons #93
Rear Deck of Pot 93	6-8-48	10:28-10:53 a.m.	89	21.0	65.5	8.8	0.001	--	Anode effect #94; adjusting carbons on #93

Table 2 continued

Sample and Location	Date	Time	Temp. °F.	Sample Ft.^{3}	Mg. F/10 M^3		F in p.p.m.		CO %	SO_2 p.p.m.	Remarks
Front Deck of Pot 73	6-8-48	8:40-9:05 a.m.	77	21.0		41.1		5.40	---	--	
In front of Pot 73	6-8-48	8:40-9:05 a.m.	68	21.0		24.2		3.08	---	--	
Aisle between Pots 73-84	6-8-48	9:10-9:40 a.m.	81	25.2		20.2		2.60	---	--	Anode effect #75
In front of Pot 84	6-8-48	9:10-9:40 a.m.	75	25.2		5.5		0.72	---	--	Anode effect #75
Front Deck of Pot 84	6-8-48	9:45-10:10 a.m.	80	21.0		18.8		2.49	0.007	--	Changing carbons in area
Rear Deck of Pot 84	6-8-48	9:45-10:10 a.m.	83	21.0		16.2		2.14	0.0015	--	Changing carbons in area
Front Deck of Pot 57	6-9-48	1:55-2:20 p.m.	90	21.0	13.1(p) 16.7(a)	29.8	1.77(p) 2.25(a)	4.02	0.005	1.90	Breaking in #99,#58,#56
In front of Pot 57	6-9-48	2:25-2:50 p.m.	86	21.0	8.4(p) 11.4(a)	19.8	1.11(p) 1.51(a)	2.62	---	0.81	Anode effect #100
Aisle between Pots 57-100	6-9-48	2:55-3:23 p.m.	88	23.5	5.95(p) 11.6(a)	17.55	0.80(p) 1.54(a)	2.34	---	0.60	Anode effect #57
In front of Pot 100	6-9-48	3:33-3:58 p.m.	88	21.0	5.47(p) 6.56(a)	12.03	0.73(p) 0.87(a)	1.60	---	0.56	Oreing up; breaking in #101; anode effect #58
Front Deck of Pot 100	6-9-48	4:00-4:05 p.m.	93	4.2	31.6(p) 32.8(a)	64.4	4.25(p) 4.40(a)	8.65	---	2.24	Precipitator burned out after 5 min.

Table 2 continued

Sample and Location	Date	Time	Temp. °F.	Sample Ft.^{3}	Mg. F/10 M^3	F in p.p.m.	CO %	SO_2 p.p.m.	Remarks
Rear Deck of Pot 100	6-9-48	4:25-4:53 p.m.	95	21.0	8.3	1.10	0.001	--	
Misc. Samples									
Rest Area between 40 Pot and Center Section Line #1 (pouring area)	6-7-48	12:10-12:40 p.m.	83	25.2	29.5	3.94	---	--	
Rest Area between Chippawa and Center Section Line #1 (pouring area)	6-9-48	10:08-10:36 a.m.	75	23.5	22.0	2.9	---	--	No pouring
Crane: Line #2	6-10-48	8:15-8:36 a.m.	95	17.6	83.5	11.4	0.005	--	Changing carbons
Crane: North end, Line #2	6-10-48	9:00-9:07 a.m.	100	5.8	58.3	8.0	---	--	Tapping
Crane: Line #2	6-10-48	9:15-9:30 a.m.	100	12.6	47.4	6.4	0.005	--	Moving carbons
Crane: South end, Line #3 (Center Section)	6-10-48	10:45-11:00 a.m.	110	12.6	77.0	10.6	0.005	--	Tapping
Carbon Rodding	6-10-48	1:30-1:55 p.m.	79	21.0	11.8	1.55	0.001	--	Intermittent operation

Table 2 continued

Sample and Location	Date	Time	Temp. °F.	Sample Ft.^{3}	Mg. F/10 M^3	F in p.p.m.	CO %	SO_2 p.p.m.	Remarks
Cleaning Syphons	6-10-48	2:30-2:35 p.m.	82	4.2	20.6	2.7	---	--	First floor; clean two per day
Rest Area Chippawa Section South End of Line #3	6-10-48	3:25-3:50 p.m.	89	21.0	30.5	4.2	---	--	
Butt Breaking Line #4 between Chippawa and 40 Pot Section	6-10-48	3:30-3:50 p.m.	80	16.8	13.6	1.8	---	--	In front of wall opening; ventilation good
Rest Area Line #3 between Center and Chippawa Section	6-10-48	3:55-4:25 p.m.	92	25.2	26.4	3.5	---	--	Near pouring area; no pouring
Grill over Casting Furnace	6-8-48		--	--	--	--	0.001	--	

(p) -- Precipitator Sample
(a) -- Absorber Sample

Table 3

Average Concentrations of Fluorine, in Parts Per Million in the Atmosphere at Various Locations in the Pot Room

Location	Hall Pots			Niagara Pots			Overall Mean
	Line 1	Line 2	Avg. for Section	Line 3	Line 4	Avg. for Section	
Between pots	3.32	1.70	2.51				
In front of pots	5.14	3.73	4.44	1.35	2.57	1.99	
Center of aisle between pots	5.35	3.47	4.41	2.44	3.15	2.79	
On back decks of pots				4.76	4.37	4.50	
On front decks of pots				3.30	5.43	4.36	
Rest areas	3.30		3.30	3.26	1.78	2.89	
Avg. for area including rest areas	4.35	2.87	3.48	2.83	3.93	3.42	3.79*
Avg. for area excluding rest areas	4.46		3.68	2.79	3.99	3.40	3.82#
Cranes (tapping and changing carbons)	23.4	9.7	14.1	10.6	5.25	7.92	11.73
Cranes (moving carbons)		6.4	6.4		3.68	3.68	5.04
Butt breaking							1.78
Screening							0.27
Carbon rodding							1.55
Syphon cleaning							2.70

*Mean value of first series of samples (May 17-21) 3.52; of second series (June 7-10) 4.05
#Mean value of first series of samples (May 17-21) 3.55; of second series (June 7-10) 4.09

Table 4

Occupational Duties and Time Spent Thereon

Title	Duty	Per Cent of Time on Duty
Pot Tender	Adds ore, stirs pots, adjusts electrodes, maintains voltage	50
	Rest Area	50
Tapper, Carbon Changer	Taps pots and pours ingots	35
	Changes carbons	15
	Breaks carbon butts	3
	General pot room plus rest areas	47
Crane Operator	Taps pots, pours ingots, and changes carbons	35
	Moves carbons	15
	Rest areas	50
Line Shift Foreman	Supervises general pot room	100
Pot Changer	Disconnects and connects Hall pots into line (or connects baking jumpers on all pots), connects switch plates, etc.	Not possible to estimate
Technical Control	Takes samples, measures depth of baths	30
	Controls voltages, etc.	30
	Office	40

Table 4 continued

Title	Duty	Per Cent of Time on Duty
Bath Screening	Screens bath material	Intermittent; varies greatly
	Rest area	40
Pot Digger	Works on disconnected pots, near general pot room	Intermittent; estimated 1 pot per 10 days
Carbon Rodding	Cleans rods, casts and sets rods in carbons, etc.	100
Cleaner	Cleans towers	Intermittent; once every 3 months, 4 hours for 4 men
	Cleans pans under gratings	Intermittent; no estimate

Table 5

Average Concentrations of Fluorine to Which Workers in Various Occupations at the Niagara Plant of the Aluminum Company of America Appear to Have Been Exposed Over the Period of the Working Day

(Weighted Averages of Composite Exposures of the Day)

Occupation	Line	Concentration of Fluorine in p.p.m.	Group Averages in p.p.m.
Pot Tender	1	4.35	3.03
	2	2.87	
	3	2.57	
	4	2.33	
Tapper, Carbon Changer	1	4.35	3.22
	2	2.87	
	3	2.84	
	4	2.81	
Crane Operator	1	10.80	6.43
	2	5.80	
	3	5.89	
	4	3.22	
Line Shift Foremen	1	4.35	3.48
	2	2.87	
	3	2.83	

Table 6

Proportion (Per Cent) of Total Fluorine Present in the Atmosphere as Gaseous Fluorine

Location	Hall Pots			Niagara Pots		
	Line 1	Line 2	Section	Line 3	Line 4	Section
Between pots	49.4	50.7	50.8			
In front of pots	54.8	39.2	49.9	61.2	52.0	56.0
On front decks				49.2	51.2	50.5
On back decks				57.9	52.6	54.7
In center of aisles between pots	70.7	29.6	51.0	46.2	59.3	52.9

Mean = 50.7 ± 1.4%

Table 7

The Fluorine Content of Settled Dust Removed from the Cranes

Crane	Date	Per Cent Fluorine
North Crane of Line 1	5-20-48	6.15
North Crane of Line 2	6-10-48	7.52
South Crane of Line 3	6-10-48	5.03
North Crane of Line 4	5-20-48	7.76
Average		6.62

Table 8

Average Concentrations (Per Cent) of Carbon Monoxide Found in the Atmosphere at Various Points in the Pot Room

Location	Hall Pot Section	Niagara Pot Section
Between pots	0.0014	
In front of pots	0.0005	
On front decks		0.0036
On back decks		0.0035
In aisles between pots	0.0010	0.0010

Mean = 0.0026 ± 0.0002

Special Samples

North end of line 3, over furnace	0.0015
Cranes	0.0046
Carbon rodding	0.001

Table 9

Average Concentrations (p.p.m.) of Sulfur Dioxide Found at Various Locations in the Pot Room

Location	Hall Pot Section	Niagara Pot Section
Between pots	0.67	
In front of pots	0.72	0.33
On front decks		0.85
On back decks		0.85
In aisle between pots	0.74	0.34

Mean = 0.63 ± 0.06

Table 10

Comparative Results (Fluorine as p.p.m.) Obtained Independently by the Aluminum Company and the Kettering Laboratory

Location	Aluminum Company	Kettering Laboratory
Line 1		
Between pots 23 and 24	4.60	4.37
In front of pot 23	4.70	3.94
Aisle between pots 23-80	4.90	4.15
In front of pot 80	3.40	3.04
Between pots 79 and 80	0.91	1.64
Between pots 61 and 62	4.42	4.47
Aisle between pots 41 and 62	7.87	7.15
Between pots 41 and 42	1.51	1.78
In front of pot 61	4.30	4.70
Line 3		
Front deck of pot 48	2.95	3.18
In front of pot 48	1.43	1.06
Line 4		
Rear deck of pot 100	2.96	2.68
Front deck of pot 100	9.95	7.15
Aisle between pots 100 and 57	4.80	4.70
In front of pot 100	2.90	4.46
In front of pot 57	2.51	2.48
Front deck of pot 57	3.93	3.26
Rear deck of pot 57	Lost	6.75
Front deck of pot 93	4.25	7.65
In front of pot 93	2.42	5.44
Aisle between pots 64 and 93	3.89	4.15
In front of pot 64	3.44	3.84
Average	3.91	4.05

Table 11

Temperatures and Barometric Pressures
Prevailing During Periods of Sampling at Niagara Falls

	Barometric Pressure (inches of Hg)	Temperature °F.
May 17	29.45	60
May 18	29.40	56
May 19	29.85	54
May 20	29.45	56
May 21	29.25	60
June 7	29.35	68
June 8	29.20	63
June 9	29.50	69
June 10	29.60	68

APPENDIX B

SUMMARY SHEET

Name
Home Address

Occupation

Race Sex Age S M W D
City
Family M.D.
Employed by Aluminum Co. of America
Niagara Falls Works

HISTORY

PHYSICAL FINDINGS T P R BP Ht. Wt. Vit. Cap. cc

LABORATORY STUDIES

Blood: RBC. 10^6/mm^3, WBC. 10^3/mm^3, Hb gm. %, PCV % cells
Diff: Poly. %, Lymph. %, Mon. %, E. %, B. %, Other %
Serology (Lab.), Sed. rate mm/hr.
Urine Color S.G. pH Alb. Red. Benz.
Centrif. sed.

OTHER OBSERVATIONS

DIAGNOSES

....., Examiner

Date:

OCCUPATIONAL HISTORY—(List all previous occupations and duration of each in chronological order).

Number years employed, Niagara Works. Types of tasks and duration of each in order:

Hours of work /wk. Time off work last 5 years from any cause. Enumerate:

PAST HISTORY

Birthplace
Childhood illnesses
Rubeola
Rheumatic fever
Enuresis 8-12 years

Residence most of life
Whooping cough
Mumps
Scarlet fever
Chicken pox
Behavior problems

Schooling

Metabolic and infecious diseases. Malaria TBC Rheumatic fever Polio
Typhoid Diabetes Allergies Other
Previous general examinations: Army
Insurance Plant
Hospitalizations and reason for each

Operations other than above.
Nervous breakdown
Injuries and Accidents

FAMILY HISTORY

Father Age Health
Mother Age Health
Siblings Health
Familial diseases: Vascular Malignant
Metabolic Allergic Congenital

FAMILY BACKGROUND

MARITAL HISTORY

Duration
Spouse Health
Children Health

SOCIAL ENVIRONMENT

Physical

Familial

Amusements

Organizations, politics, church

FINANCIAL STATUS

Intake/outgo
Resources, security

HABITS

Tobacco
Coffee, tea

Alcohol
Drugs

SYSTEMIC HISTORY

GENERAL. Predominate feeling
Usual weight — Recent change
Sleep, dreams
Energy pattern:

SKIN

VASOMOTOR: Cold and wet hands — Itching
Faintness — Paraesthesias
Tolerance of heat and cold

CONSCIOUSNESS: Headache
Syncope, convulsions

VISION

HEARING

NASAL PASSAGES

MOUTH AND TONGUE — Gums: bleeding
Teeth — Dentist

PHARYNX AND NECK

LYMPH GLANDS

CARDIORESPIRATORY: Cough
Difficulty breathing
Palpitation
Pain

GASTRO-INTESTINAL and HEPATIC SYSTEM
Appetite
Upset stomach — Jaundice
Pain
Bowels
Effect of food
Food Habits

URINARY
Frequency — Urgency — Nocturia — Dysuria

MENSTRUAL

Pregnancies

SEXUAL: Venereal disease
Libido

JOINTS and BACK

NEUROLOGICAL: Dysaesthesia, paresis, trembling
Balance, gait

INTELLECTUAL DISTURBANCES
Memory, concentration, inefficiency, confusion

AFFECTIVE REACTIONS
Happiness — Making friends
Nervousness — Worriness
Touchy, feeling watched
Anxiety, unusual fears
Discouragement, depression
Dominant ideation

INSIGHT
Visceral response to fear
Relation between environment and symptoms

OTHER CONFINING ILLNESSES not described above with dates

Name Date

Ideal weight for height

Weight .100/ideal weight

PHYSICAL EXAMINATION

Height Weight Temperature (M) Pulse

Respirations Blood pressure (position)

GENERAL APPEARANCE

MENTAL STATUS:

SKIN

HEAD—Masses or tenderness

EYES—Pupils Equality Size Contour

Position Reaction to light Accom.

Sclerae Conjunctivae Lids

Extrinsic ocular movements Nystagmus

Grounds—Vascular Hippus

Discs

Retina

Vision without glasses With glasses

EARS— **Fork** **Schwabach** **Weber** **Drums**

R AC BC

L AC BC

NOSE—Mucous membrane Obstruction

MOUTH—Lips Mucous membrane Tongue

Gums Teeth

THROAT—Tonsils Pharynx

LYMPH GLANDS

NECK and THYROID

CHEST—shape Movements

BREASTS

LUNGS

HEART—Rhythm PMI Sounds

Bruits

Gallops Thrills Rubs

BLOOD VESSELS

ABDOMEN—Masses or tenderness

Liver Spleen Kidneys

Herniae Scars

GENITALIA, PELVIC

RECTAL

EXTREMITIES and BACK

NEUROLOGICAL—

Muscle power and tone

Sensations

Tremor Ataxia

REFLEXES— Abd.

BJ TJ WJ RP Hoff. U. L. Crem. KJ AJ Plantar Other

Right—

Left —

SPECIAL EXAMINATIONS

Signature of Examiner:.....

Appendix C

DISABILITY FROM FLUOROSIS OF BONE

On October 5, 1948 a conference was held at the Kettering Laboratory of Applied Physiology in Cincinnati, Ohio attended by the authors of this report and by Dr. Dudley Irwin, Medical Director of the Aluminum Company of America, Mr. Lester Cralley (ALCOA) and Dr. W. R. Scott of Niagara Falls, N.Y., roentgenologist. The data of the health survey were critically reviewed. Certain additional facts came to light, and certain points were checked and verified or corrected, so as properly to be incorporated in the report. In addition Dr. Irwin requested that an attempt be made to evaluate the degree of disability found in the 120 cases reported as having fluorosis of bone.

This is a difficult task. Disability from any disorder derives from a number of factors, including the degree and extent of structural change, the extent and degree of functional change, the nature of a man's job and the extent of his satisfaction or pride in it, his will to work, the attitudes of his co-workers, and many others. For example: A man of 58 years with severe Dupuytren's contractures of the hands may have no symptoms, he will not be able to perform many fine movements, but he may feel well, be anxious to work, and may handle a job as elevator operator, guard, inspector, or other, quite as well as anyone else. What degree of disability has he? Based upon a classification of function of his hands in relation to what normal hands are supposed to be able to do, he has perhaps 75% total permanent disability. However, if

having been so classified, he receives compensation for such disability and is thereby prevented from accepting appropriate employment which will provide for his needs far better than does his compensation, he has been dealt with unwisely and actually unfairly.

It therefore appears to us that final decisions concerning the disability of any man in this plant must be made individually in terms of the factors involved at the time the question arises, and that they cannot be made equitably or finally on any other basis.

The following statements therefore are based upon the situation as observed in the Niagara Works at the time of the examinations (May and June 1948) on the assumption that these men would continue their employment at their present tasks where possible and at lighter tasks when indicated and where feasible, if they reject voluntary retirement under the provisions of the then operating company policy. Furthermore, the statements apply only to that portion of any man's disability which can be fairly attributed to fluorosis of bone. (A man with far advanced arteriosclerotic heart disease with congestive failure who has severe fluorosis of bone but no symptoms therefrom and who shows no limitation of normal motion in his bones and joints may be classified as "without disability" - an obvious fallacy.)

A critical review of the 59 cases of questionable and slight fluorosis of bone found on this survey leads us to believe that in no instance was there evidence of disability in any degree therefrom. Furthermore, if exposure to fluorides is stopped, the bony changes may be expected to revert to normal

without the development of any degree of disability. Finally, there is no evidence to indicate that the finding of slight or questionable fluorosis of bone will in any way alter normal expectancy as regards employability or longevity.

The following are the names and clock numbers of men with moderate fluorosis of bone who are given the same disability rating as was given above for all those with slight or questionable fluorosis.

Name	Clock No.
[redacted]	[redacted]

The other men with moderate or severe fluorosis of bone have been carefully studied. It is my considered opinion that from the scientific point of view none of these men has disability in excess of 25% due solely to fluorosis of bone. However, I am aware that in a court of law, under circumstances which may exist after the Niagara Falls Works is closed, the combination of fluorosis of bone plus osteo-arthritis of the spine plus pre-existing conditions which may or may not have been exaggerated by one or the other of these disorders which are related to employment, much greater disabilities may be claimed and allowed. For that reason I have tried to estimate the upper limit of disability which might be claimed from the evidence available.

Estimates of degrees of disability were based on a review of the entire record in each individual case. Persons with moderate or severe fluorosis without any symptoms or signs

and with little or no hypertrophic change about joints or ligaments and who were 50 years of age or older, were arbitrarily considered to have 10% disability. It is assumed that even with the cessation of exposure to fluorides they will not become entirely free from evidence of fluorosis within their expected life span.

Men who have a considerable degree of fluorosis with hypertrophic changes in the areas of increased bone density and who have no physical signs of limitation of motion and no symptoms are arbitrarily defined as having less than 25% disability.

Men with lesions similar to those described above plus some vague symptoms referable to the areas involved but without physical signs of impaired function, are arbitrarily defined as having from 25-50% disability.

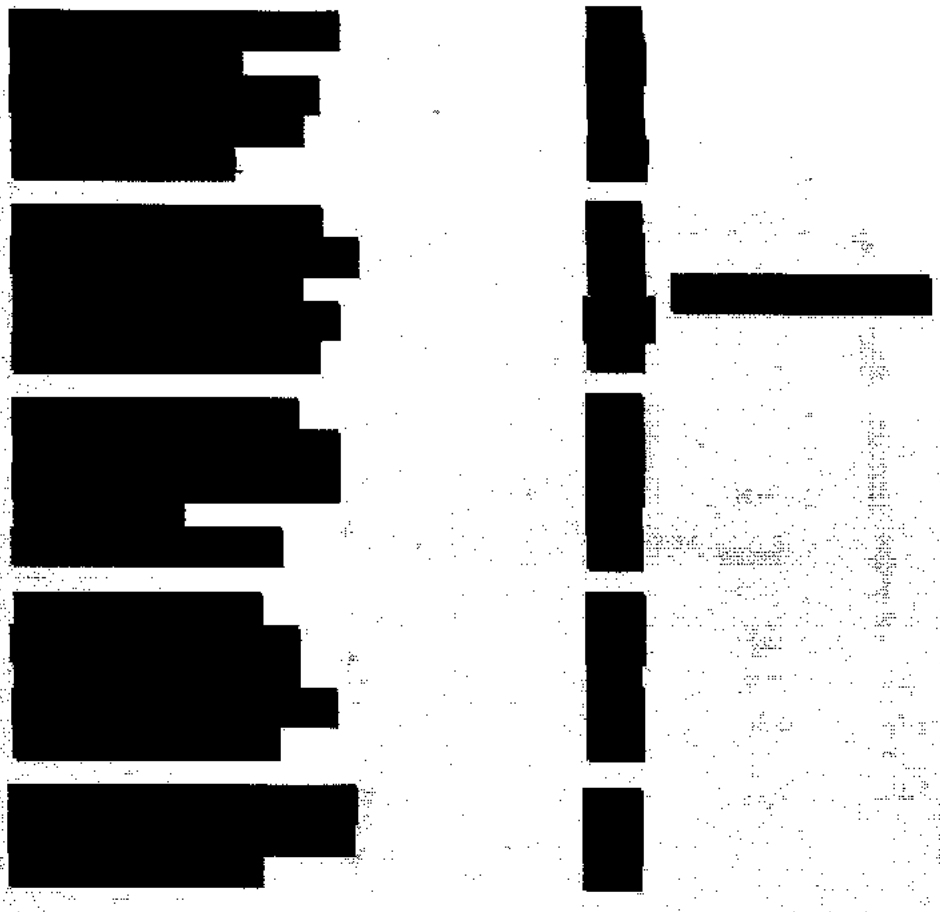
Men of the immediately foregoing type who also give evidence of limited motion of joints or back with or without symptoms and who because of their present age cannot be expected to recover within their expected life span, are arbitrarily considered to be from 50-75% disabled if their limited function is slight or moderate and 100% disabled if it is marked (even though they are still employed).

The names and clock numbers of each group are as follows:

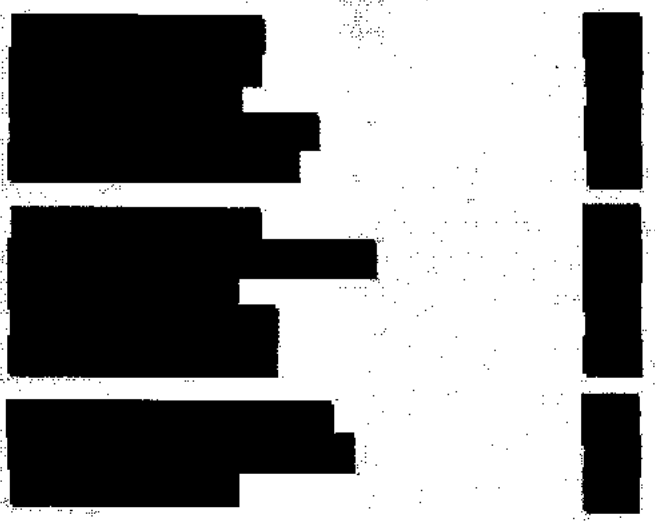
10% Disability

[redacted]

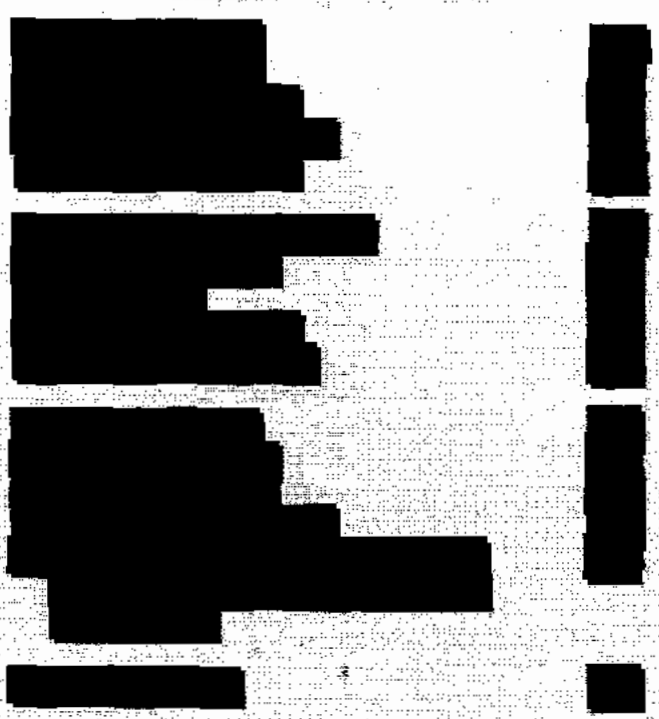
Less than 25% Disability



25-50% Disability



50-75% Disability



100% Disability

Many of these men have disabilities from other causes in excess of the amounts estimated in relation to fluorosis. Most if not all of the estimates of disability except those recorded as 100% are believed to err on the side of being too high. However, any man with severe fluorosis of bone may claim and be allowed 100% disability if in the course of seeking new employment, he is refused employment because of the changes which may be seen on his chest X-ray. All of the estimates of disability were made by the undersigned and do not necessarily reflect the opinion of the other examiners or of Dr. Scott, roentgenologist.

Wm. F. Ashe, M.D.