Occupational Cancer Research Centre

INVESTIGATION OF NEUROLOGICAL OUTCOMES AND MCINTYRE POWDER EXPOSURE IN THE MINING MASTER FILE COHORT:

PROGRESS UPDATE

Submitted to:

The Workplace Safety Insurance Board of Ontario

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Towards a cancer-free workplace

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1. Background

For over five years, the Occupational Cancer Research Centre (OCRC) has been investigating the health of workers in the Ontario mining industry. This includes studies of the impact of exposure to radon and gamma radiation among uranium miners and broader efforts to establish a research platform using data from the Mining Master File and the Ontario Mining Exposure database, which was created by OCRC. Because of our experience with mining research the Workplace Safety and Insurance Board (WSIB) approached OCRC to undertake research on the relationship between exposure to McIntyre powder and neurological disease. In January of 2018, the WSIB awarded a contract to OCRC to start this research. This is our first formal progress report.

There are four major components to this work:

1. A review of materials held at the Archives of Ontario within the McIntyre Research Foundation fonds (F4170)
2. A comparison of the electronic Mining Master File (MMF) database with the paper records held at the WSIB (i.e., Mining Master File card index)
3. Linkage of the MMF with administrative health data held at the Institute for Clinical Evaluative Sciences (ICES)
4. Epidemiological analysis of the relationship between exposure to McIntyre Powder and neurological disease outcomes

This update reports on the progress made since the awarding of the contract and August 31, 2018. The progress to-date has been made in Parts 1 and 2, while Part 3 will commence in October 2018.

2. Archives Report

All available McIntyre Research Foundation records held by the Provincial Archives were accessed by OCRC. Records related to McIntyre powder exposure were scanned with digital copies then stored on a secured drive at OCRC. Documents were reviewed by OCRC researchers as part of the WSIB funded McIntyre Powder project with results summarized below.

The objectives of reviewing the McIntyre Research Foundation records held by the Provincial Archives was to understand whether the administration of aluminum powder and the amounts used per person changed over time, by reviewing historical records on the aluminum therapy from the Archives of Ontario.

2.1 Main Findings

McIntyre Research Limited (1939-1946) or the McIntyre Research Foundation (MRF 1946-1992) was a non-profit organization formed with the stated intent to conduct research and investigation concerning the prevention, mitigation, and eradication of industrial diseases [3]. The McIntyre Research Limited studied the aluminum therapy and patented it as a preventative measure in 1939 against silicosis, an occupational lung disease caused by inhaling crystalline silica dust [3].

The MRF contended that aluminum powder reduced the toxicity of siliceous materials by coating them with an insoluble and impermeable layer [4]. In animal experiments, the addition of fine metallic aluminum to silica dust via subcutaneous injection or inhalation showed the preventative effect on the development of lung fibrosis and silicosis [5]. Due to growing opposition and concerns over the link between aluminum exposure and Parkinson disease, the therapy was ceased by the Foundation in 1979 in Ontario [3] and at various points in time elsewhere.

2.1.1 McIntyre Powder Characteristics

The McIntyre Powder comprised of approximately 11% of metallic aluminum and the rest (~89%) aluminum oxide, as tested by the MRF around 1947, with X-ray diffraction at the Central Research Laboratory of Canadian Industries Limited. The patterns between the freshly made powder and those stored in cans for three years showed the same characteristics, and aluminum was the only metal found in X-ray diffraction [6]. In 1957, MRF presented the McIntyre Powder consisting of about 15% metallic aluminum with the rest 85% aluminum oxide [1]. When suspended by proper dispersal techniques, the particle size of McIntyre aluminum powder was extremely fine, with about 70% less than half a micron and 99.5% less than 5 microns, as reported by MRF in repeated observations under the microscope with dust collected on the filter using the filter paper sampler [6].

2.1.2 Historical Use of McIntyre Powder

The MRF controlled the production and type of aluminum powder used by granting patents. The first license was granted in December 1943, at the McIntyre Gold Mines Limited in Canada. Between 1943 and 1966, a total of 206 licenses were documented by MRF from 7 different countries: United States of America (108), Canada (90), Mexico (5), Chile (1), Australia (1), and Belgian Congo (1) [1], and one potential user of McIntyre powder from England found from

[1] Informal data sheets from McIntyre Research Foundation contains information on number of licenses granted and cancelled from 1943 to 1966, countries where licenses granted, and reasons of cancellations.

another source [7]. Over time, licensees canceled their licenses due to a variety of reasons including 'operation closed', 'hazard eliminated', 'never used', 'no medical support', or 'union opposition', and 'unknown'. In April 1979, only 20 active licensees were reported: 10 in Canada, 9 in the USA, and 1 in Mexico (See Appendix 1 for a list of Ontario users) [8].

2.1.3 Aluminum Therapy and Target levels

The treatment, in brief, required the workers to inhale air-suspended aluminum powders in a standing position before their work shifts at the specifically-constructed chamber, change room or tunnel (Refer to Appendix 3: Figure 4) [1]. The target amount for treatment was 1 milligram per cubic feet (mg/ft^3) or the equivalent of 35.6 milligrams per cubic meter (mg/m^3). The dispersal room was capable of maintaining the concentration of 20,000 to 34,000 particles per cubic centimeter (ppcc) under proper powder administration (See Appendix 2 for the administration procedures of aluminum prophylaxis) [9]. Employers were advised that workers should take a 10-minute treatment under dispersal concentration of 20,000-34,000 ppcc, or a 20-minute treatment under 10,000-20,000 ppcc [9]. Documents also stated that there would be no harm even if the exposure concentration was higher than 34,000 ppcc [9].

2.1.4 Limited MRF Dispersal Data

In order to test the dispersion of aluminum powder, the MRF had collected dispersal data from its licensee sites in Ontario and Quebec in 1964. A total of 29 test collections conducted at 27 Ontario and 2 Quebec mine sites were accessed by OCRC from the Archives of Ontario MRF fonds. Samples were taken with a standard filter paper sampler provided by the MRF.

The particle concentration is sampled by pulling air through the filter paper. The ratio of light passing through the filter before and after sampling, i.e. the MRF index $=I_O/I_F$, where I_O was the meter reading from light transmitted through the clean filter, and I_F through the dirty filter [10], had been calibrated to the thermal precipitator to obtain readings in particles per cubic centimeter. Below is an example of calibration chart used for the filter paper sampler around 1947 [6].

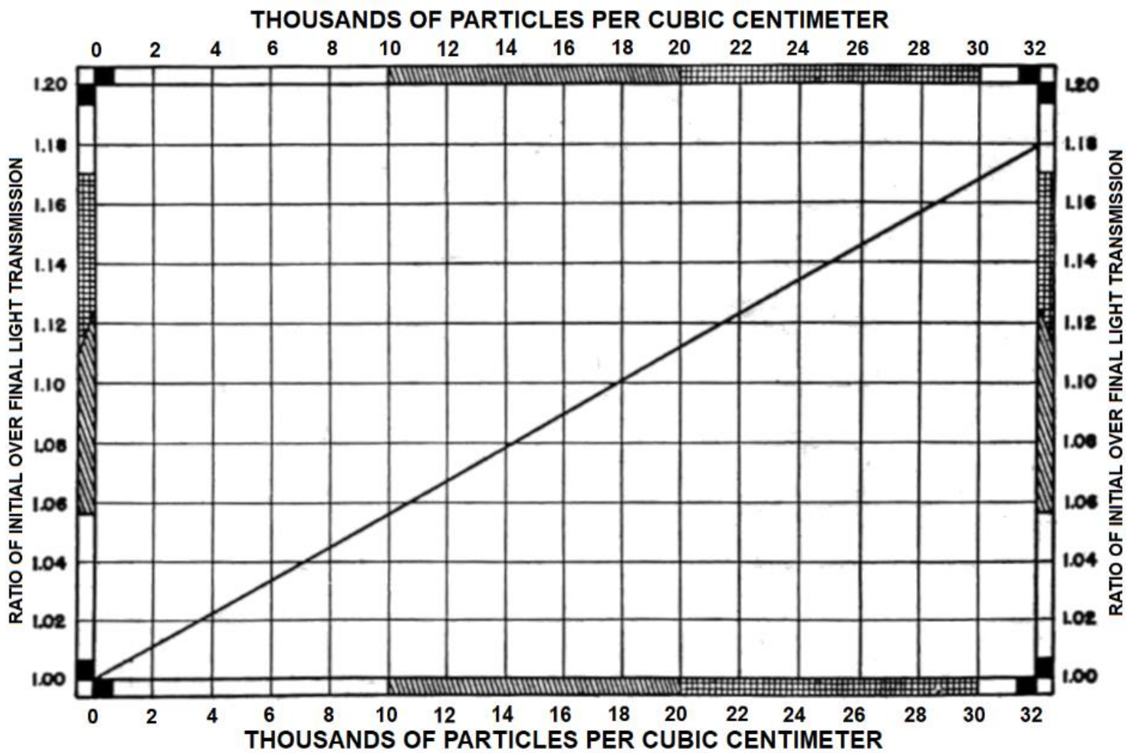


Figure 1. Calibration chart for the filter paper sampler [6].

Three to seven samples per mine were taken in the hour after dispersal every 10 to 20 minutes to check the initial concentration and attrition rates over time. Information was also recorded on temperature, humidity, ventilation, room capacity, powder usage per day/month/year, sampling type, workers' average length of exposure, as well as exposure concentrations at different check-in points, *etc*. The highest and lowest concentrations among multiple samples were identified to calculate the attrition rate, along with the median exposure length, sample number, and license number (See Appendix 3).

In detail, 27% of sampled sites achieved the highest dispersal concentration of between 10,000 and 20,000 ppcc, with workers receiving the treatment for an average of 7.8 minutes (range: 5.0-13.0) when it was advised to stay for 20 minutes. For the rest of sampled sites (63%) whose highest dispersal concentration reached above 20,000 ppcc (range: 20,000 to 80,000), if this concentration stabilized in the room, a 10-minute treatment was advised for worker groups, while the median length of actual exposure observed was 7.0 minutes (range: 0.5 to 19.0). During treatment, all samples had aluminum particles delivered mostly under 5 microns, meanwhile, some were larger sizes due to agglomerations.

The dispersal concentration was highly variable during treatment with the high attrition rate; 79% (21 out of 29) had the attrition rate above 45% within an hour, and over 50% of mine sites had attrition rate above 80%. The target dispersal practice, where it was key to maintain an air-locked dry environment, was not always achieved across mine sites [11]. For example, the MRF tester noted that over 50% of the mines after dispersal were found with 'window opened', 'lost control of the door', 'roof ventilation opened', or 'heater fan running', and other recorded examples included low discharged pressure or moist air provided for the compressed-air ejector, too small ejection holes cut for the aluminum can, *etc*.

2.2 Discussion

2.2.1 Variations of Aluminum Therapy Administration

The MRF dispersal data carried out by MRF is a source of data that can be used to better understand the actual administration of aluminum therapy conditions in 1964 at those 29 mine sites. This data indicated that aluminum therapy administration varied by mine sites. All sampled mines had reached the initial concentration between 11,000 and 80,000 ppcc, and within 45 to 60 minutes, 19 out of 27 mines (57%) did not maintain the concentration above 10,000 ppcc for the therapy period on the sampling day.

2.2.2 Possible Variations of Measurement Readings

The filter paper sampler may not be a reliable instrument to measure dust levels based on MRF internal re-calibration data. MRF re-calibrated its filter paper sampler to the thermal precipitator in 1968. A MRF internal report documented the unexpected large variation in dust estimates by one instrument and the large differences between three of the four instruments, and this variation could possibly be even larger under normal operation as compared to the controlled laboratory environment where the re-calibration took place [10].

While reviewing measurement notes, it was noted that the filter sampler also may not measure accurately under too high concentrations; for example, in sample no. 23, it was noted that the particles were too many to count on the filter, this sample was measured at 80,000 ppcc on the data sheet. The Foundation also aimed to take weight samples for gravimetric analysis to obtain the concentration in milligrams per liter, it was, however, later canceled due to very unstable performance [11].

2.2.3 Implications of Individual Level of Exposure

From the occupational epidemiology perspective, it would be challenging to assign actual exposure concentrations to each worker. Almost no information on the start and end time of treatment for each worker could be found in the data sheets, and most mines did not record their sampling time points. The dispersal concentration was highly variable during treatment over time, indicating that the amount received by the workers varied by individual and location, as well as time. For example, workers may receive minimal to no dose if they entered the room at the end of the treatment period. The worker group on average was not spending enough time as advised in the room with different treatment compliance patterns among workers; it was noted that younger workers tended to rush treatment [12].

2.3 Conclusion Regarding McIntyre Foundation Records

Based on limited dispersal data from the Archives of Ontario, the administration of aluminum powder was indicated to vary among mine sites, and the dose received by workers also likely varied between individuals. It is unclear whether the amounts used per person changed over time.

3. Assessment of MMF Electronic File and WSIB Paper Records

Prior to study commencement, concerns were raised that the Mining Master File (MMF) hard copy cards located at the WSIB may contain more workers than the MMF electronic data file. Conversely, it is not clear whether the WSIB holds a full set of hard copy MMF cards. Because of this, an exercise to cross-check the electronic file with the hard copy records was completed in order to provide reassurance that the electronic and paper files contain information on the same individuals. An assessment of completeness of the information contained within the electronic files was completed concurrently, with a particular focus on aluminum powder exposure information (i.e. was all information on exposure to McIntyre powder entered, accuracy of data, etc.)

This assessment was completed in four steps:

a) A review of the results of previous efforts to validate and evaluate the completeness of the MMF electronic database and Mining Master card index.

b) A random sample of 500 records from the electronic file was generated from the MMF nominal file transferred from the WSIB (n = 93,526) using the SAS Software System v9.4 [13]. This list was transferred to the WSIB where attempts were made to locate the corresponding hard copy paper records. Copies of these paper records were then furnished to OCRC under strict control at the WSIB building in order to enter the information into a database for comparison with the pre-existing electronic records. This was also an opportunity to determine whether hard copy records could easily be located by individual.

c) A second random sample of 500 hard copy MMF cards at the WSIB was generated using a proportional random pull of cards from WSIB cabinets (card were labelled and sorted in drawers by mine district and certification number issued). Cards were pulled from this list at random by WSIB staff and entered into the same database as the previous by OCRC staff at the WSIB building. These were also cross-referenced with the MMF electronic data file in order to ascertain if any of these were missing. This also allowed us to assess whether all relevant information was accurately entered into the electronic file.

d) A third list of 20 exam cards were pulled based on internal de-duplication results of the nominal file, which suggested 492 duplicates records. It was deemed prudent to investigate the circumstances of these duplicates with a subjective sample based on scenarios observed in the file (i.e., possibility of serial number typos, complete duplicate records and split work history records).

3.1 Main Findings

The sample of 1,000 miners while representing only 2% of the workers in the MMF, provides an estimate of the completeness of records contained within the file. Further, identifying the proportion of workers missed or the proportion of records with missing data will also provide an assessment of completeness of the file with each record (refer to Table 1).

Overall, one random electronic database record was not located among the hard copy exam cards (part b) and three exam cards were not located in the database (0.4%) (part c). Data entry of jobs beginning from first exam resulted in 18,525 case rows vs. 16,550 in the original MMF electronic work history and 95% agreement for job location across matched exam dates, with the exception of crusher work.

Table 1. MMF First exam district distribution of random samples of 500 each from the electronic database and hard-copy examination cards

Exam District of Miner Certification*	Exam Card Sample Frequency (%)	Database Sample Frequency (%)
Bancroft	8 (1.6)	9 (1.8)
Blind River	53 (10.6)	67 (13.4)
Cobalt	4 (0.8)	13 (2.6)
Harbour Street (W.C.B. Toronto)	7 (1.4)	4 (0.8)
Kirkland Lake	70 (13.9)	74 (14.8)
North Bay	4 (0.8)	1 (0.2)
Sudbury	185 (37.1)	178 (35.6)
Thunder Bay	88 (17.7)	57 (11.4)
Timmins	81 (16.1)	97 (19.4)
Total	500 (100)	500 (100)

***** Clinic where first physical and chest x-ray were performed for first entry into registry

It was evident that the exam card contents have varied over time, particularly since the inception of the original transfer to punch cards in 1951 and the further standardization of the card elements entered into the database beginning in 1955 (refer to Appendix 6) [2]. A substantial number of elements on cards post-1955 and included the electronic database were not present on the original exam cards issued in 1951 or prior. These elements include the following:

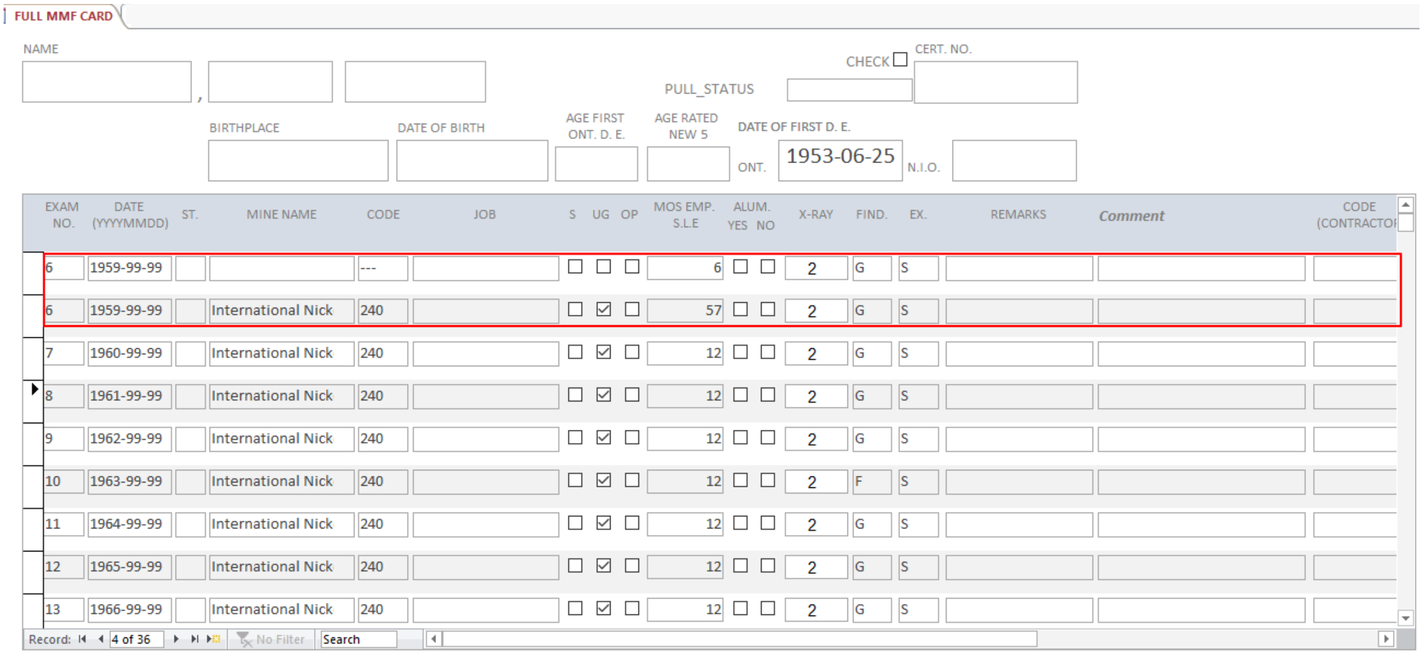
a. Mine code
b. Job location (Underground/Surface/Open Pit)
c. Clinical Exam District
d. First dust exposure year not separated between Ontario and elsewhere

Unfortunately, it was not possible to quantify the proportion of 1951 or prior cards used, though it appears substantial. This is particularly the case with long term miners who were hired prior to 1955 with the less comprehensive cards appearing to have been used over the life of their career (i.e., potentially 12 years previous mining outside Ontario and up to 23 years in Ontario per card; refer to Appendix 4 for examples of both card types). This does not hamper use of the database, however, as many of missing elements were coded retroactively during transfer to the electronic format, with much of the data entered into the miscellaneous remarks column, and further enhanced during the original studies using the MMF [14-16].

Another issue to consider is that approximately 5% of the job case records in the electronic work history file were blank or contained a zero work duration. We found that surface work (i.e., mill, plant and refinery but not surface mining) often lacked work duration on cards or, when present, was crossed off and marked as zero (7% of work lines in the sample). Though the manner of marking is inconsistent, this also did not appear to be an issue as the jobs involved were not underground or those with a likelihood to be exposed to aluminum powder (e.g., mill attendant, mine clerk, night watchman, etc.). Also related to this issue is that crusher operator or crusher labourer job titles were consistently coded as an underground work location in the database while clearly marked as surface, open pit or mill crushers on the exam cards. As these were noted as dusty jobs, they were also included in those exposed to aluminum powder.

Work history records were found to be largely aggregated in the database, starting anywhere from the second to the twelfth exam rather than the first (40.2%). This occurred when the mine camp, ore and work location remained the same (refer to Figure 2 for an example of aggregate record vs. complete information). This appeared to occur more often with previous mining outside Ontario, as records from other provinces and mixed ores were often aggregated into a single record using generic mine and ore code (i.e., 16% used 799 Outside Ontario and 99 Unknown ore rather than multiple case lines). This was observed by those who first used the database for epidemiological research, who addressed the issue through the creation the calendarized work history file which counted back work history segments to arrive at the actual first year of hire in Ontario (refer to Appendix 5 for basic structure of database tables). When compared to the first dust exposure in Ontario variable in the nominal file there is little difference (0.8%). It is quite apparent that the issues and differences observed thus far were a result of simplifying data entry and the limitations of the database technology, when the data were first transferred to the new format. Though these specific issues cannot be addressed for the remainder of the database, they present a negligible challenge to the proposed research.

Figure 2. MMF Database Example Entry with Information from Exams 1-6 Aggregated vs. Exam Card



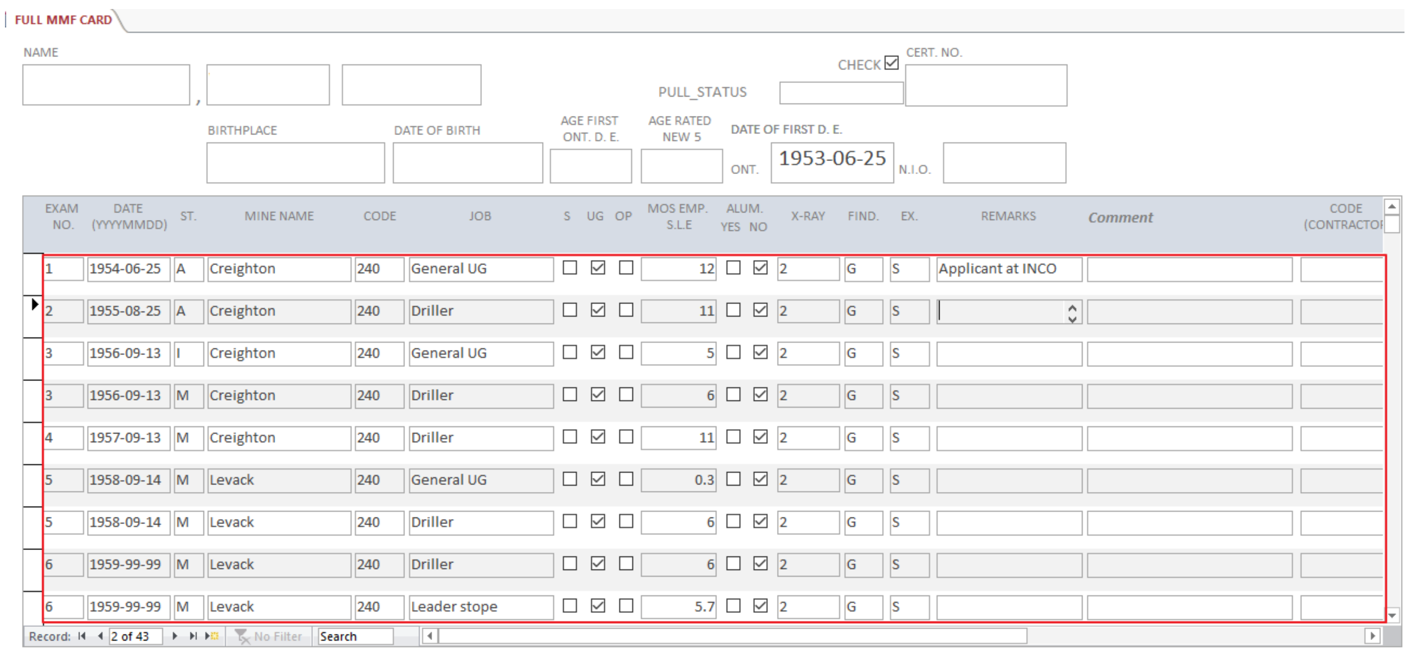
FULL MMF CARD

NAME | CHECK ☐ | CERT. NO. | PULL_STATUS

BIRTHPLACE | DATE OF BIRTH | AGE FIRST ONT. D. E. | AGE RATED NEW 5 | DATE OF FIRST D. E. ONT. 1953-06-25 | N.I.O.

EXAM NO.	DATE (YYYYMMDD)	ST.	MINE NAME	CODE	JOB	S	UG	OP	MOS EMP. S.L.E	ALUM. YES	ALUM. NO	X-RAY	FIND.	EX.	REMARKS	Comment	CODE (CONTRACTOR)
6	1959-99-99			---		☐	☐	☐	6	☐	☐	2	G	S			
6	1959-99-99		International Nick	240		☐	☑	☐	57	☐	☐	2	G	S			
7	1960-99-99		International Nick	240		☐	☑	☐	12	☐	☐	2	G	S			
8	1961-99-99		International Nick	240		☐	☑	☐	12	☐	☐	2	G	S			
9	1962-99-99		International Nick	240		☐	☑	☐	12	☐	☐	2	G	S			
10	1963-99-99		International Nick	240		☐	☑	☐	12	☐	☐	2	F	S			
11	1964-99-99		International Nick	240		☐	☑	☐	12	☐	☐	2	G	S			
12	1965-99-99		International Nick	240		☐	☑	☐	12	☐	☐	2	G	S			
13	1966-99-99		International Nick	240		☐	☑	☐	12	☐	☐	2	G	S			

Record: 4 of 36 No Filter Search



FULL MMF CARD

NAME | CHECK ☑ | CERT. NO. | PULL_STATUS

BIRTHPLACE | DATE OF BIRTH | AGE FIRST ONT. D. E. | AGE RATED NEW 5 | DATE OF FIRST D. E. ONT. 1953-06-25 | N.I.O.

EXAM NO.	DATE (YYYYMMDD)	ST.	MINE NAME	CODE	JOB	S	UG	OP	MOS EMP. S.L.E	ALUM. YES	ALUM. NO	X-RAY	FIND.	EX.	REMARKS	Comment	CODE (CONTRACTOR)
1	1954-06-25	A	Creighton	240	General UG	☐	☑	☐	12	☐	☑	2	G	S	Applicant at INCO		
2	1955-08-25	A	Creighton	240	Driller	☐	☑	☐	11	☐	☑	2	G	S			
3	1956-09-13	I	Creighton	240	General UG	☐	☑	☐	5	☐	☑	2	G	S			
3	1956-09-13	M	Creighton	240	Driller	☐	☑	☐	6	☐	☑	2	G	S			
4	1957-09-13	M	Creighton	240	Driller	☐	☑	☐	11	☐	☑	2	G	S			
5	1958-09-14	M	Levack	240	General UG	☐	☑	☐	0.3	☐	☑	2	G	S			
5	1958-09-14	M	Levack	240	Driller	☐	☑	☐	6	☐	☑	2	G	S			
6	1959-99-99	M	Levack	240	Driller	☐	☑	☐	6	☐	☑	2	G	S			
6	1959-99-99	M	Levack	240	Leader stope	☐	☑	☐	5.7	☐	☑	2	G	S			

Record: 2 of 43 No Filter Search

Notes: Red box represents corresponding work history segment in record
Exam No.: Miner's examination record sequence beginning with first examination (chest x-ray)
ST.: Miner certification status before examination (A = Applicant I = Initial holder M = Certified)
MOS EMP. S.L.E.: Months employed at listed mine and job since last exam
ALUM.: Aluminum (McIntyre) powder exposure since last exam (Y/N)
X-RAY: Chest x-ray rating for listed exam number
FIND: Clinical findings for examination and chest x-ray (e.g., G = Good and F = Fair)
EX.: MMF examination district where listed exam number (chest x-ray) took place (e.g., S = Sudbury)
FIRST D.E.: First dust exposure (i.e., first hire in mining) (ONT. = Ontario and N.I.O. = Not in Ontario)

3.2 Enhancement of McIntyre Powder Exposure Information

At the outset of the study the primary source of information on individual McIntyre Powder exposure was the MMF electronic database. The issue of most concern were any differences between the database and the exam cards with respect to the aluminum powder exposure variable. This variable was never transferred to the calendarized work history sheet and remained in the examination record sheet, separated from the context of mine or job category in the original work history file. These exposures were also backdated in the database to 1943 for known mines (39 gold and 9 uranium mines noted in the MMF codebook) that used McIntyre Powder.

Further, the database employed a system wherein once an affirmative or negative response was logged this would be carried forward into subsequent exam records until manually changed or stopped (refer to Appendix 7). The database, therefore, has affirmative responses to aluminum exposure into the 1980's that we believe to be in error. From the table it is apparent that the exam cards also list miners responding affirmatively to aluminum powder exposure beyond the date where this should have been possible. In addition, aluminum prophylaxis questions were not asked until July 1951, which seems accurate as 0% of cards had affirmative or negative responses prior to that date (refer to Table 2).

These issues have been addressed using a variety of data sources to create a more comprehensive list of aluminum powder using mines including periods of use. These sources included primarily the historic records from the Sudbury office of the Ministry of Labour held at the OCRC and McIntyre Research Foundation records held by the Provincial Archives of Ontario. This research has resulted in the 51 mine sites and one foundry listed in Table 3 compared to the original list of 48 sites and a foundry listed in the MMF codebook circa 1985. This was coded to create a new aluminum exposure variable so that this outcome would be constrained to mines known to have used McIntyre Powder during prescribed periods of use and would be more accurately assigned as exposed in work histories.

Table 2. First and Last Aluminum Exposure Report Years by Sample Source
(n = 996 miners found in database and exam cards)

Year of Aluminum (McIntyre) Exposure	Database Frequency of First exposures	Database Frequency of Last exposures	Exam Card Frequency of First exposures	Exam Card Frequency of Last exposures
<1944	3	1	0	0
≥1944	33	1	0	0
1945-1949†	57	32	0	0
1950-1954*	49	27	67	20
1955-1959	69	48	61	42
1960-1964	45	57	45	57
1965-1969	30	50	31	52
1970-1974	17	36	16	35
1975-1979	24	34	26	36
1980-1984	0	16	0	4
1984-1987	0	25	0	0
Total	327	327	246	246

*Exposure to aluminum powder was not noted on exam cards until July 1951

†Exposures prior to 1951 were coded according to list in Appendix F of the MMF code book

3.3 MMF Duplicate Pairs Investigation

Investigation of duplicate pair issues (part d) were revealed to have resulted from a variety of typographical errors as anticipated, but there were also other considerations. Eight of the twenty miner records were not found among the exam cards. The majority as presumed were due to entry errors of the miner certification number (mcert).

a) The exam cards had extra birth date and work history information such that one presumed duplicate pair were in fact the different miners (i.e., birth year & generic mine codes in database).
b) Additional microfiche checks for records with no cards turned up two different people with the same mcert identifiers as those found in the database to be duplicates. These were not the same names or birthdates associated in the database.
c) Further three exam cards had two separate mcert identifiers listed on the card with one crossed off and not appearing the in the database.
d) Two cards were found which explicitly stated that the assigned mcert had to be changed due to already being in use. These were never certified and do not appear among the calendarized work history file.

The majority of cards did indeed appear to be duplicate pairs or results of errors in identifier being used more than once and as they have been flagged should not pose an issue with record linkage or analysis.

3.4 Review of Previous MMF Record McMaster Validation Study

The validity of the data within the MMF has been previously investigated. Shannon and the Industrial Disease Standards Panel performed an inclusiveness test comparing MMF employment records with payroll records of three gold mining companies in separate Northern Ontario mining districts [17]. A list of 288 miners was obtained by random sampling then sorted by name and mining certificate number (mcert), of which, three were not found in the MMF database (inclusion of 99%).

Work histories at this point in the MMF included: mining company name, job type and duration of employment for each job held since last x-ray examination. A further random sample of 100 miners from the list of 285 matched miners was compared for agreement on the date of first hire at that mine and on the duration of employment. Early company records were missing for a further five miners who were then excluded [17].

Testing for agreement on start date of employment at a particular company was undertaken by comparing this date with information acquired from the Workers' Compensation Mining Master card index. There were no significant differences reported between company reports and the MMF for employment starting dates or duration of employment [17].

4. Overall Progress & Next Steps

With the current information available, it is not possible to quantify exposure to McIntyre Powder for each worker in the MMF using common measures of inhalation exposure. Instead, for the purposes of this study, exposure to McIntyre Power will be described using several metrics, all of which will be investigated in epidemiological analyses:

- Ever exposed to MP (yes/no)
- Duration of exposure to MP

We are still exploring one additional potential source of data. The biannual dust sampling reporting forms of the Mines Accident Prevention Association of Ontario (MAPAO) appear to have included data on the use of McIntyre powder from 1970 to 1979. However, we do not have access to a complete set of records and it is not clear whether use was consistently noted.

Figure 3. MAPAO Summary Air Conditions Survey with McIntyre Powder Subsection

FORM

SUMMARY OF SEMI-ANNUAL SURVEY OF AIR CONDITIONS

Surface

FIRM ______________ MINE OR PLANT ______________ PERIOD ENDING ______________ 19____

OPERATION	DUST - PPCC								SILICA ANALYSIS						EXHAUST VOLUME CFM	RESPIRATORS USED	
	NO. OF SAMPLES	AVERAGE	NO. OF SAMPLES				FILTERED AIR		% TOTAL			% FREE					
			0-300	300-500	500-800	800+	BEFORE SHAKING	AFTER SHAKING	LOW	HIGH	AVG.	LOW	HIGH	AVG.		VOL.	COMP.
1. OPEN PIT																	
2. PRIMARY CRUSHING																	
3. SECONDARY CRUSHING																	
4. SCREENING																	
5. CONVEYING AND TRANSFERS																	
6. WET MILLS AND CONCENTRATORS																	
7. DRY MILLS AND PROCESSES																	
8. ASSAY LABORATORIES																	
9. SMELTERS																	
10. REFINERIES																	
11. PELLETIZING PLANT																	
12. SHOPS																	
13.																	
14.																	
15.																	
16.																	
17.																	
18.																	
19. TOTALS (Weighted)																	

Aluminum Prophylaxis - Licence No. ________ Personnel Coverage (%) Miners ________ U.G. Staff ________ Crusher Ops. ________ Assay Staff __

No. cans used each time ________ Average Exposure Time ____________ (Mins.)

Design Concentration ________ PPCC (1000's) Measured Conc. After 15 min. ______ 20 min. _____ 45 mins. _____ 60 min. __

State Remedies being Planned or Applied to Reduce Undesirable Exposures.

NOTE: RETURN 2 COPIES OF FORMS 1 AND 2 TO MAPAO, 290 SECOND AVE. WEST, NORTH BAY, ONTARIO, PIB 3K9 BEFORE APRIL 15 FOR WINTER SURVEY AND OCTOBER 15 FOR SUMMER SURVEY.

Revised 1975

______________________ Surveyor

______________________ Manager

Note: **Red box** outlines section of form relevant to McIntyre Powder concentrations

As the electronic files seem relatively complete and the aluminum powder exposure variables have been addressed, the next steps are to transfer the relevant files to the Institute for Clinical and Evaluative Sciences (ICES) for record linkage with health outcomes data. Following the linkage, we will undertake the epidemiological analysis between the exposure metrics described above and the identified neurological outcomes.

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Appendix 1

Table 3. List of 52 confirmed Ontario McIntyre Research Foundation (MRF) Licensees (aluminum prophylaxis users)

MRF License No.	MMF Mine Code	McIntyre Powder Licensee (Minesite)	License Period	Use Period	Primary Ore
1	109	McIntyre Porcupine Mines Ltd (McIntyre) Pamour Porcupine Mines Ltd (Schumacher Division)	1943-1979	1943-1979	Gold
7	121	Lake Shore Mines Ltd (Lake Shore)	1943-1965	1944-1965	Gold
8	110	Pamour Porcupine Mines Ltd (Pamour)	1944-1979	1944-1979	Gold
9	107	Hallnor Mines Ltd (Hallnor)	1944-1973	1944-1971	Gold
10	101	Aunor Gold Mines Ltd (Aunor)	1944-1973	1945-1972	Gold
16	125	Toburn Gold Mines Ltd (Toburn)	1944-1952	1944-1953	Gold
17	120	Kirkland Lake Gold Mining Co. Ltd (Kirkland Lake Gold)	1944-1960	1944-1960	Gold
18	128	Kerr-Addison Gold Mines Ltd (Kerr-Addison)	1944-1979	1944-1979	Gold
19	122	Macassa Mines Ltd (Macassa) Willroy Mines Ltd (Macassa Division)	1944-1978	1944-1978	Gold
20	13907	Omega Gold Mines Ltd (Omega)	1944-1946	1944-1947	Gold
21	157	Macleod-Cockshutt Gold Mines Ltd (Macleod-Cockshutt)	*1944-1953*	1944-1953	Gold
22	139	Bidgood Kirkland Gold Mines Ltd (Bidgood)	1944-1948	1944-*1948*	Gold
23	103	Buffalo Ankerite Gold Mines Ltd (Buffalo Ankerite)	1944-1953	1944-1953	Gold
25	123	Sylvanite Gold Mines Ltd (Sylvanite)	1944-1961	1944-1961	Gold
26	131	Upper Canada Mines Ltd (Upper Canada)	1944-1972	*1944-1971*	Gold
28	105	Delnite Mines Ltd (Delnite)	1944-1964	1944-1964	Gold
29	106	Dome Mines Ltd (Dome)	1944-1979	1944-1979	Gold
30	104	Coniaurum Mines Ltd (Coniaurum)	1944-1961	1945-1961	Gold
31	151	Central Patricia Gold Mines Ltd (Central Patricia)	1944-1951	1944-1951	Gold
33	124	The Teck-Hughes Gold Mines Ltd (Teck Hughes)	1944-1967	1944-1968	Gold
34	156	Little Long Lac Gold Mines Ltd (Little Long Lac)	1944-1953	1944-*1954*	Gold
35	160	Mckenzie Red Lake Gold Mines Ltd (Mckenzie Red Lake)	1944-1952	1944-1953	Gold
37	152	Cochenour-Willans Gold Mines Ltd (Cochenour-Willans)	1944-1971	1944-1968	Gold
38	154	Hardrock Gold Mines Ltd (Hard Rock)	1944-1951	1944-1951	Gold
39	108	Hollinger Consolidated Gold Mines Ltd (Hollinger)	1944-1968	1944-1968	Gold
41	155	Leitch Gold Mines Ltd (Leitch)	1944-1964	1944-1965	Gold

MRF License No.	MMF Mine Code	McIntyre Powder Licensee (Minesite)	License Period	Use Period	Primary Ore
42	153	Hasaga Gold Mines Ltd (Hasaga)	1944-1952	1944-1952	Gold
43	111	Paymaster Consolidated Mines Ltd (Paymaster)	1944-1966	*1943*-1966	Gold
44	112	Preston East Dome Mines Ltd (Preston East Dome)	1944-1968	1944-1968	Gold
49	158	Madsen Red Lake Gold Mines Ltd (Madsen Red Lake)	1944-1976	1944-1976	Gold
		Bulora Corporation (Madsen Division)			
50	102	Broulan Porcupine Mines Ltd (Broulan Reef)	1944-1964	1952-1965	Gold
51	102	Bonetal Gold Mines Ltd (Bonetal)	1944-1952	1944-1952	Gold
53	126	Wright-Hargreaves Mines Ltd (Wright Hargreaves)	1944-1964	1944-1965	Gold
54	162	Pickle Crow Gold Mines Ltd (Pickle Crow)	1944-1966	1944-1966	Gold
57	127	Chesterville Mines Ltd (Chesterville)	1944-1953	1944-1952	Gold
86	113	Hollinger Consolidated Gold Mines Ltd (Ross)	1944-1976	1944-1979	Gold
		Pamour Porcupine Mines Ltd (Ross Division)			
	129	Matachewan Consolidated Mines Ltd (Matachewan Consolidated)	1945-*1957*	1945-*1957*	Gold
	132	Hollinger Consolidated Gold Mines Ltd (Young Davidson)	1944-1955	1944-*1956*	Gold
164	142	Renabie Mines Ltd (Renabie)	1948-*1969*	1948-*1970*	Gold
179	161	Dickenson Mines Ltd (New Dickenson)	1951-1978	1952-1976	Gold
181	150	Campbell Red Lake Mines Ltd (Campbell Red Lake)	1952-1979	1952-1979	Gold
137	8&4	Rio Algom Mines Ltd (Nordic)		1957-1979	Uranium
197	9&1	Rio Algom Mines Ltd (Quirke)		1956-1968	Uranium
197	9&0	Rio Algom Mines Ltd (New Quirke)		1968-1979	Uranium
200	8&3	Denison Mines Ltd (Denison)	1957-1979	1957-1979	Uranium
204	9&4	Rio Algom Mines Ltd (Panel)		*1957-1961*	Uranium
	8&0	Pronto Uranium Mines Ltd (Pronto)	1955-1960	1955-1960	Uranium
	8&6	Rio Algom Mines Ltd (Milliken)		1958-1964	Uranium
	9&5	Rio Algom Mines Ltd (Lacnor)		1957-1960	Uranium
206	5&1	Rio Algom Mines Ltd (Pronto Division - Pater)		1961-?	Copper
	38905	McIntyre Porcupine Mines Ltd (Castle-Trethewey)	1955-1966	1954-1966	Silver

NOTES: **Green shading** indicates a mine site with an ownership change during the aluminum use period under the same license #
Blue shading indicates separate mine sites where aluminum use or mine information were reported in combination

Appendix 2

Administration of Aluminum Prophylaxis [18]

There follows a description of the installation and operation of the facilities to administer aluminum powder for the prevention of silicosis.

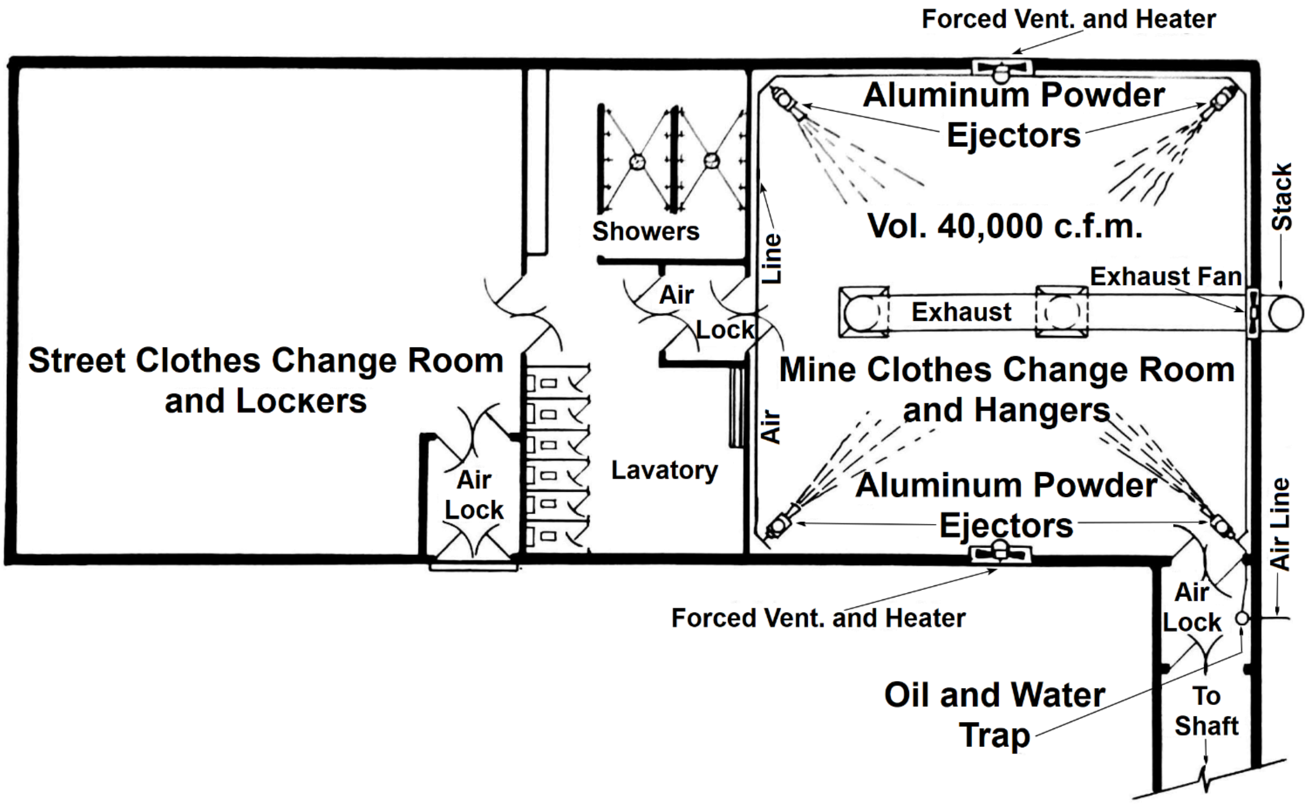
1. Where possible, aluminum prophylaxis should be provided each day to all employees exposed to siliceous dusts.
2. The treatment should be given in the change house while the men prepare to go on shift. It causes them no inconvenience whatever.
3. The room to be used should be reasonably airtight. During treatment, all fans should be stopped and the doors, windows and ventilators kept closed. Where strong natural drafts exist in doorways as the men pass into and out of the change room, an air-lock should be installed - that is, two sets of doors
4. The basis of dispersal is one gram of powder for each one thousand cubic feet of room content when the average period of exposure to aluminum is ten minutes; if it is twenty minutes, the amount to be used is halved.
5. Dispersal is accomplished by compressed air operated blowers that are suitably located and sufficient in number.
6. The compressed air to be used should be cleaned of moisture and oil by an efficient trap placed at the take-off from the main.
7. A 3/4-inch line suffices to serve the blowers with compressed air.
8. In most cases, the blowers are placed at a convenient height in the room corners and aligned so as to discharge horizontally towards the center of the change room, with a minimum of direct impingement on nearby objects.
9. The number of blowers needed depends on the size of the room and the amount of powder to be dispersed. Consistent with uniform suspension, more than one can of powder may be dispersed on the same occasion with one blower. The total number of units for a single room probably will not exceed six.
10. The blower itself is an inexpensive and simple device employing the Venturi principle. Its purpose is to evacuate the can and provide a uniform aerial- suspension of the powder, with a minimum of agglomerated particles.
11. There is a receptacle for the can in the upper part of the blower. As the lid is screwed into place by band, as tightly as possible, two perforated piercers - one ln the bottom of the receptacle, the other on the underside of the lid - puncture the can, top and bottom; these must be cleaned daily to prevent accumulation of powder. The threads of the lid may be lubricated periodically, care being taken to keep oil out of the chamber and off the piercers.
12. An air pressure of 35 to 40 pounds per square inch while blowing is recommended for good dispersal; this corresponds to about 100 pounds line pressure. The minimum discharge pressure to be used is 20 pounds.

13. The blowers are operated in rotation for one minute each, the last unit to be blown being the one which discharges towards the dead-end of the room.
14. Practically complete removal of the contents of the can is obtained by alternately covering and uncovering the small opening in the lid of the can holder while blowing.
15. The resultant aerial suspensions will provide initial concentrations of 30,000 to 35,000 particles per cubic centimeter, or more; this will decrease 40 to 45 per cent in an hour, due to dilution.
16. The men should be encouraged to spend at least 10 minutes in this atmosphere during which they should breathe through the mouth; nasal inhalation is advocated at other times.
17. When the last man has left the room, the air should be cleared of the suspensions by ventilation. This prevents settlement of powder, which is to be avoided in the case of street clothes.
18. Konimetry should not be employed to assess the particulate nature of suspensions of aluminum powder for silicosis prevention; it is incapable of dealing with the high concentrations and small, sizes involved. Thermal precipitator records examined at magnifications in excess of x500 admirably serve such determinations.
19. It is recommended that the booklet "Silicosis - What It Is and how It Can Be Prevented", be distributed freely amongst employees, prior to adoption of aluminum prophylaxis. Its use, supplemented by other educational measures, such as suitable posters, discussion, et cetera, will do much to facilitate general understanding of the value of the treatment.
20. Finally, it cannot be stressed too strongly that aluminum is not a "cure-all" for silicosis. It will not take the place of ventilation and dust control. A definite amount of aluminum is required to neutralize the toxic effects of a definite amount of quartz. It follows that, if the control of dust is neglected, additional aluminum powder would need to be administered. McIntyre Research deems such a procedure to be unwise. The reason is: Inhalation of any dust in excessive amounts overloads that mechanism of the lung whose duty it is to get rid of foreign substances.

THEREFORE, CONTROL DUST… USE ALUMINUM WISELY…
PREVENT SILICOSIS

Appendix 3

Figure 4. Aluminum Powder Dispersal in a Mine Dryhouse, adapted from Newkirk et al., 1957 [1]



Appendix 4

Table 4. Dust measurements within 40-60 minutes after the dispersal of McIntyre powder at 29 licensed mine drys in 1964 [12].

Sample #	License #	Median length of exposure among workers (min)	Highest Conc. (p.p.c.c.)	Lowest Conc. (p.p.c.c.)	Attrition rate (percentage)
1	1	6.5	50000	15500	69%
2	39	8.5	23000	3000	87%
3	29	17.0	27000	2000	93%
4	43	5.0	18000	6000	67%
5	44	8.0	13000	11000	16%
6	10	9.5	37000	2000	95%
7	50	6.5	18000	2000	89%
8	9	8.0	20000	2000	90%
9	8	6.0	39000	23000	41%
10	86	6.5	37000	23000	38%
11	206	10.1	22000	0	100%
12	200	6.5	27000	4000	85%
14	53	9.5	28000	13000	54%
15	26	4.5	37000	20000	46%
16	33	19.0	38000	23000	39%
17	18	5.5	40000	27000	33%
18	7	12.5	31000	11000	65%
19	19	7.0	24000	7000	71%
20	164	11.0	13000	3500	73%
21	41	11.5	11000	2000	82%
22	21	12.5	30000	9000	70%
23	179	0.5	80000	38000	53%
24	37	6.5	22000	4000	82%
25	181	8888$^+$	52000	7000	87%
26	49	7.5	16000	2000	88%
36	8888$^+$	13.0	16000	2000	88%
37	137	6.0	37000	26000	30%
27*	183	5.5	18000	5000	72%
28*	40	12.0	42000	3000	93%
Median (Range)		**8.0 (0.5-19.0)**	**27000 (11000, 80000)**	**6000 (0, 38000)**	**72% (15%, 100%)**

Note: #, number; Conc., concentration; *, Quebec mine sites; 8888$^+$, missing.

$$\text{Attrition rate}=\frac{highest\ Conc.-Lowest\ Conc.}{highest\ Conc.}\times 100\%.$$

Appendix 5

MMF Database Table Names and Descriptions

NOTE: The structure below refers to all possible Tables/sections of the complete MMF database (electronic file), while the available tables evaluated at the OCRC include (1, 5, 7, 8, 9, and 10):

1. **Identification Record** (RD-02421) occurs once per miner (contains all nominal information).
2. **Alternate Surname Record** (RD-02422) occurs once for each surname in excess of the one in the Identification Record.
3. **Alternate Given Name Record** (RD-02453) occurs once for each given name in excess of the two in the Identification Record.
4. **Claim Record** (RD-02423) occurs once for each known claim number. If one or more claims are known to exist but the claim number(s) are not available, the Claim Flag (DD-02850) in the Identification Record is turned on but Claim Record(s) are not created.
5. **Death Record** (RD-02424) occurs once if the decision has been made that the miner is possibly or probably dead. This section includes multiple sources of death records identified by source type.
6. **Death Link Record** (RD-02425) occurs once for each death certificate from Statistics Canada that indicates a strong possibility that the miner and the person represented by the death certificate are the same person. The presence of this record type should not be used as proof of the miner's death; any final decision is indicated by the Death Probability Code in the Death Record.
7. **Examination Record** (RD-02454) occurs once for each of the miner's annual physical and radiological examinations that have been coded and added to the file. (For certain non-uranium miners, examinations occurring prior to the miner accumulating 60 months or more total dust exposure have not been added to the file). Each miner should have at least one, and on average, ten of these records.
8. **S.L.E. Employment Record** (RD-02426) occurs once for each mine employment or period of unemployment since the last (previous) examination and, prior to the first examination, from the onset of mining. At least one, and up to 99 of these records are associated with each Examination Record.
9. **Individual Exposure Record** (RD-02427) occurs once for each employment and calendar year for which individual exposure data is available. This data is generally available for Ontario uranium employments in 1968 and later (prior to 1968 estimates are available based on area sampling).
10. **Calendarized Employment Record** (RD-02458) occurs once per employment (but not unemployment) per year. The data is essentially the S.L.E. Employment data reformatted into calendar year groupings and merged with the individual exposure data.

Appendix 6

Figure 5. Master Examination Record Card 1951 [2]

NAME ______________________ CERTIFICATE OR X-RAY NUMBER [ ]

BIRTHPLACE ______________ DATE OF BIRTH ______________ DATE OF FIRST DUST EXPOSURE ______________

PREVIOUS EXPOSURE NOT IN ONTARIO						PREVIOUS EXPOSURE IN ONTARIO					
YEAR	MINE OR OTHER EXPOSURE	COUNTRY	ORE	JOB	MOS	YEAR	MINE	CAMP	ORE	JOB	MOS.

EXAMINATIONS

NO.	DATE	STATUS	MINE	JOB	EXPOSURE S.L.E.	AL.	X-RAY	FINDINGS	CLAIM COMP.	REMARKS

WCB/MSU MC 1 MASTER EXAMINATION RECORD JANUARY 1951

Figure 6. Master Examination Record Card circa 1960-70 [1]

NAME			CLAIM NO.			CERT. NO.
S.I.N.	BIRTHPLACE	DATE OF BIRTH	AGE FIRST ONT. D. E.	AGE RATED NEW 5	DATE OF FIRST D. E. ONT.	N.I.O.

PREVIOUS EXPOSURE NOT IN ONTARIO						PREVIOUS EXPOSURE IN ONTARIO					
YEAR	MINE OR OTHER EXPOSURE	COUNTRY	ORE	JOB	MOS.	YEAR	MINE OR OTHER EXPOSURE	CAMP	ORE	JOB	MOS.

EXAMINATIONS

EXAM. NO.	DATE	ST.	MINE NAME	MINE CODE	JOB	S	UG	OP	MOS EMP. S.L.E.	ALUM. YES	ALUM. NO.	X-RAY	FIND.	CLAIM COMP.	EX.	REMARKS

MASTER EXAMINATION RECORD FORM 230 REV. 1.74

Appendix 7

Mining Master File Aluminum Coding Instruction Excerpts

Aluminum Exposure Code (Alum. S.L.E.)

0. No aluminum powder has been administered in Ontario since last examination and for unemployment at the first examination.
1. Aluminum powder has been administered in Ontario since last examination.
2. Totally employed in mining outside Ontario.

The dates for commencement of aluminum powder at Ontario mines and groups of workmen receiving this powder are listed in Appendix F. If only the starting date is given, the powder is still being administered.

For the majority of examinations since July 1, 1951, a "Yes" or "No" answer re aluminum powder will be recorded on the Master Record Card. This must be checked with the list in Appendix F for discrepancies before coding.

Further Instructions:

Alum. S.L.E. (Since Last Exam): Must be coded if Update Action code is "C" and Examination No. is 01.

This is a 1-digit numeric code which indicates whether a person is receiving aluminum powder in Ontario.

This field must be coded if examination number is 01. For subsequent examinations only a change from the previous examination has to be coded.

If there is no change from the previous examination the computer program will automatically carry the data forward into the new examination record.

Code - if the Aluminum S.L.E. is unknown.