DUSTY, DIRTY, AND DEADLY

A Retrospective Profile of the Neelon Casting Foundry

Sudbury, Ontario 1972-2007

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We acknowledge the contributions of former Neelon workers or family members including:
Tony Johnson, Al Horner, Peter Panek, Daren Smith, George Cameron, Doris Vallencourt, Susan Cindric, Maurice Meilleur, Tim Bourguignon, Philip Dougan, Todd Lepage, Doug Chamberland, Junior Ilnitski, Mike Cote, Bill Cameron, Emerson Crane, Willy Stockhaus, Marcell Bart Bedard, Tina Vincent-Gagnon, Renee Lefebvre, Barbara Ballance, Stacy Thurlow, Luc Larochelle, John Henry, Stephanie Cresswell Young, Josie Wedlock Gauthier, and the many other ex-Neelon workers whose knowledge became part of our discussions.

We acknowledge, with great appreciation, the careful edit and critical review of the manuscript by Dr. Christine Oliver. Her questions and challenges have made this a better report. However, the authors assume full responsibility for any errors or omissions.

We acknowledge, with appreciation, OHCOW employees Lisa Wilder and Cait Wittke for their report design and final edit prior to publication.

Finally, we acknowledge Dave Wilken, Interim Chief Executive Officer (CEO) at OHCOW, for encouraging these investigations into Occupational Disease Clusters in Ontario.

*Former Neelon worker's description of the plant via correspondence.

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Preface

Before we met, officially, for the first time as the Neelon Workers' Advisory Committee (NWAC) to document chemical exposures associated with work processes at Neelon Casting, Sudbury, members of the group had their own history. Jessica Montgomery, former United Steelworkers (USW) union representative and a number of former Neelon workers, together with Andrew Zarnke of the Occupational Health Clinics for Ontario Workers (OHCOW) worked for more than a year to identify former Neelon workers who died since the plant closed its doors in 2007. The purpose of this committee was to document chemical exposures at Neelon and secure justice for those who died as a result of working there, often years before reaching retirement. We asked Jessica to begin this report with the story of how we came together.

> **Jessica's Story:** *In January of 2020, I received a call from WSIB requesting my assistance for a past Neelon Casting employee. The worker was palliative and had been diagnosed with Chronic Obstructive Pulmonary Disease and needed assistance navigating his claim. I agreed to assist; however, Neelon Casting was far before my time. Neelon Casting/Dana Brake Parts/ Affinia Canada Corp. was in operation from 1974-2007. Unfortunately, in 2008, the Steelworkers Hall in Sudbury burnt down and we lost all records pertaining to Neelon Casting. Our local president at the time had worked as a summer student at Neelon Casting at one point in time, so he was able to attest to some of the working conditions. I was facing many obstacles at this point. We had no documentation, no contacts, and I had to provide supporting documentation to the Workplace Safety and Insurance Board. I needed a job description, health and safety documents, and anything I could find to help support his claim. My first thought was to Google. During this search, I found the "Past Neelon Casting Employees" on Facebook. So, I requested to join the group. I got a message from Daryl Park asking me who I was and if I ever worked at Neelon. I explained what my intentions were, and I was welcomed to the group. I made a post explaining that I worked as a WSIB worker representative for USW Local 2020 and I was assisting a past employee with his claim for COPD. I explained that I have this past member who worked in the melt department for 27 years, and I needed to know what his job duties were and what he may have been exposed to. I received an overwhelming number of replies from former employees offering their knowledge and experience. I then received a call from Mike Quenneville, who introduced himself as a past Joint Health and Safety Committee member and that he wanted to meet with me as he had a large duffle bag of documentation for me. He stated: "I have been holding onto documentation for over twenty years just for this moment." I then met with Mike, who provided a significant amount of information. Shortly afterward, I was contacted by another former Joint Health and Safety Committee member who also had a large storage bin filled with documentation. I reviewed and organized all the materials and provided the relevant information to the board.*
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> *I also submitted two Freedom of Information requests to the Ministry of Labour seeking records of complaints made to the Ministry, any orders that had been issued, and documentation of site visits. Once all this documentation was received, I forwarded it to the WSIB for review. After examining the documents and my submissions the WSIB ultimately allowed the claim. When I received the decision letter, I returned to the group to share the outcome and thank them all for their efforts and support.*
>
> *I noticed on the top of the Facebook page a pinned post titled "Memorial Page for Our Brothers Who Passed Away." When I went through the post, I noticed that there were well over 50 names posted. I then decided to go through the obituaries. I printed them all out. I went through each obituary, and at the bottom where it says where the family would like donations forwarded to, I highlighted them. I noticed a trend of Northern Cancer Foundation and Heart and Stroke Foundation. I then decided to pose another question to the group. My post stated: "Who else is sick?" To my surprise, many of the members of the Facebook group stated that they had various health concerns, and I then noticed many workers had been diagnosed with the very illness that my first worker had been diagnosed with.*

I did not believe that this was a coincidence. I brought forward to our local union executive that I believed I had identified a cluster of occupational illnesses. I had identified cases of COPD, lung cancer, silicosis, HAVS, and various other respiratory illnesses. I explained that these workers were sick and that someone had to act. Our local agreed that this fight was our responsibility to take on.

I then reached out to Sylvia Boyce, the District 6 Health and Safety Coordinator, who arranged a meeting with Dave Wilken from OHCOW, where we presented the project. Fortunately, OHCOW agreed to support the work. I was then introduced to Andrew, who quickly became my primary contact. Together with Andrew, we developed a plan that outlined how OHCOW would receive the documentation, how claims would be registered with OHCOW, and how we would provide the board with the documentation I had accumulated.

From there, our joint efforts continued to grow. Following our media release, we were contacted by Judith D'Sousa from the Workplace Safety and Insurance Board to discuss how we would proceed with registering all the claimants. Judith and I established a process for registering the claims, and the board created a dedicated team to handle the Neelon Casting claims specifically.

OHCOW, Andrew, and the broader team have played and continue to play a vital role in this project. I am very honoured to be part of such an important initiative alongside the union, OHCOW, and, most importantly, the former workers of The Neelon Casting foundry.

As we move forward, we are working through decision letters, developing a retrospective exposure profile of the plant, and completing work history surveys, while OHCOW has begun the individual file work. We will continue to assist USW with registering claims within the cohort, and following up with workers and their families.

Introduction

This retrospective exposure study of the Neelon Casting foundry located in Sudbury, Ontario (ON) follows two similar studies of the General Electric (2017) and Ventra Plastics (2020) plants in Peterborough, ON. These studies apply qualitative, investigative, and analytical methods to assess historical toxic exposures at plants where cancer clusters have been identified. The present study was carried out in the context of large numbers of presumed occupationally acquired diseases and illnesses identified among former Neelon employees—and likelihood that such diseases are related to exposures to highly toxic and carcinogenic chemicals used, or produced, in foundry production processes. That so many Neelon workers died young, well before retirement age, should be kept in mind while reading this report.

Between November 2021 and June 2022, we met regularly with the NWAC, USW union representatives, and OHCOW staff carrying out a series of focus group and personal interviews on the nature of work conditions at the plant. In addition, we received written testimony and evidence from other workers or family members wishing to participate in this fact-finding initiative. This study was commissioned by OHCOW, in cooperation with USW Local 2020.

Methodology (See Appendix A for expanded discussion/references)

Mixed Method Research: Our objective in this study was to characterize the extent and nature of exposures at the Neelon foundry, retrospectively. To achieve this objective, we had to overcome a number of research challenges. For example: there was limited, reliable, hard exposure data from hygiene monitoring; the plant had been shuttered for close to 15 years; production methods changed over the years; it was difficult to assess exposures from work records because many workers floated in and out of multiple departments; and limited, but growing data, on the state of former workers' physical health.

Risk Based Approach: To overcome these challenges, we employed a risk-based approach relying on a methodological mix of both qualitative and quantitative data and information. This risk-based approach involved the application of basic concepts and tenets of industrial hygiene to identify exposure risk factors in the production processes, and the conditions under which workers performed their tasks. The risk factor framework included the following:

1. The physical state(s) of the chemical;
2. The quantity of the materials used;
3. Direct handling of the chemical(s);
4. Duration of the exposures;
5. State of the ventilation system;
6. Provision of proper PPE;
7. Work practices;
8. Work information about the hazards including MSDSs;
9. Health and safety culture.

From these we were able to determine workers' likelihood of exposure to toxic chemicals and processes and estimate qualitatively the extent and nature of these exposures.

Participatory Research Methods: To gather necessary information on the way production was carried out, the tasks that were performed, and materials used in production, we relied upon participatory action research employing extensive focus group and individual interviews.

Regular focus group attendees included 5 former Neelon workers recruited by the local union and the OHCOW. We met for approximately 3 hours every other week from November, 2021 to June, 2022. These workers represented most departments at Neelon and were able to provide important documentation including: Joint Committee minutes; MOL inspection reports; MSDS's; blueprints of the plant layout; written worker concerns/complaints about unsafe conditions; a company production procedure manual; local news clippings; and photographs of processes. The widow of a deceased worker provided additional MSDSs and other documentation. We also conducted individual interviews with workers identified by the Neelon Worker Advisory Committee (NWAC) as having special knowledge of a particular process or department. Other information was gathered from workers through the Neelon Facebook page. The information provided by worker members of NWAC was recorded anonymously, governed by a broad confidentiality agreement between OHCOW and Local 2020 of the USW union.

Documentation: We relied on multiple sources of documentation including: an intensive review of Ministry of Labour inspection and hygiene reports; material safety data sheets on chemicals used; and Joint Health and Safety Committee minutes (JHSC) covering the period 1976 to 2007. In addition to primary interview data, we undertook a review of the industrial hygiene and toxicological literature on foundry production. We consulted with two OHCOW industrial hygienists who had undertaken industrial hygiene monitoring of foundry works in the past. And finally we conducted a survey of relevant epidemiological studies on occupational disease in the foundry industry. Together, these multiple sources enhanced the reliability of our interview and other data by acting as a cross checking of information from varied sources as to both accuracy and representativeness.

Hazard Mapping: We employed exercises in Hazard Mapping, based on worker drawn block diagrams of the plant floor plan with identification of machinery and production processes. Using these we were able to visualize production flows, while conducting our task analyses and hazard assessments.

Risk Exposure Analysis: Combined, these various sources of information enabled us to assess workers' risk of exposure(s) and then characterize the extent and nature of such exposures. Before proceeding with the contents of this report, we discuss, briefly, the occupational disease context of metal founding in general—and Neelon Casting, in particular. It is important to note this industry is conditioned by two significant, and established, characteristics and risk factors: 1. Foundry workers are constantly exposed to a multiplicity of toxic chemicals; 2. The founding industry itself is deemed carcinogenic to humans.

Multiple Chemical Exposures: According to the International Agency for Research on Cancer (IARC), foundry work involves diverse processes with the risk of exposures to highly toxic chemicals including: silica, carbon monoxide, airborne polycyclic aromatic hydrocarbons or PAHs (result of thermal decomposition of carbonaceous ingredients added to foundry sand), airborne chromium, lead, antimony and nickel, in addition to bindery chemicals including formaldehyde, isocyanates and amines (IARC, 2012). In this study we pay special attention to the impact of multiple exposures to these diverse chemicals, as both a causative agent and potent risk factor for occupationally induced cancer, and other diseases of work.

Foundry Work as Carcinogenic: In reference to published industrial hygiene and epidemiology literature, we begin with a citation on foundry work from the most recent monograph on the subject published by the International Agency for Research on Cancer (IARC) in 2012. After extensive research, IARC's Working Group on the Founding Industry concluded that metal founding is a group 1 (human) carcinogen, in stating the following:

"There is sufficient evidence in humans for the carcinogenicity of occupational exposures during iron and steel founding. Occupational exposures during iron and steel founding cause cancer of the lung. No data on the carcinogenicity to experimental animals of mixtures present in iron and steel founding were available to the Working Group. Occupational exposures during iron and steel founding are carcinogenic to humans" (Group 1) (IARC, Monograph Vol. 100F, 2012 Occupational Exposures during Iron and Steel Founding).

Using This Report

This report was prepared as a resource for: Neelon Casting workers and families dealing with occupational illness; the workers' union (USW, Local 2020); OHCOW; Office of the Worker Advisor (OWA) and other worker advocates; physicians, nurses, hygienists; and other professionals who care for and/or advocate for occupationally ill workers. Importantly, it is a resource for the Ontario Ministry of Labour and the Workplace Safety and Insurance Board (WSIB) to be used as evidence in support of Neelon workers' health claims, and to further prevention efforts by the Ontario government.

The body of the report is divided into two main sections: 1. A broad narrative of the plant's functioning and history followed by departmental risk-based assessments of worker exposures to toxic chemicals, based on NWAC discussion and backed by government (MOL) and union documentation; 2. Review of the medical/occupational disease literatures relevant to the foundry industry, and their discussion in the context of this report's findings. This document includes a number of Appendices (from A to J) to provide supplemental information and evidence in the filing and support of worker claims. These include: expanded discussion of the research methods; foundry processes and chemical hazards by department (NIOSH); chemical health effects table (NIOSH); Ministry of Labour reports and orders; review of (Neelon) biological and air sampling monitoring; Union worker concerns/Joint Health and Safety Committee minutes; review of available Neelon MSDS's; Neelon procedure manual by Job classification; departmental hazard mapping of the plant, and; annotated bibliography of research on foundry illnesses, including cancer.

Brief History of Neelon Casting' Production Systems

Plant Operations and Processes: Neelon Casting, located in Sudbury, ON was established in 1976 as a small-sized foundry operation. The foundry initially produced a variety of cast products but later specialized in automotive parts, with a focus on brake parts. Over the years the foundry was in business, production processes remained fundamentally the same – the use of green sand moulding methods and processes involving resin binders and release agents. At opening, the company employed 45 workers and operated with one shift, producing approximately 20 tons of castings per day. By closing, in 2007, more than 300 workers produced 180 tons of brake products per day (over three shifts) and Neelon had grown to a mid-sized operation.

From the beginning, the plant was highly mechanized, utilizing state of the art sand casting and molten metal processes and methods. During its first decade (prior to expansion) the Melt Department operated with one arc (melt) furnace, having a 3-ton capacity, and two channel (storage) furnaces (referred to as an Ajax), each with a 30-ton capacity. Ajax furnaces stored metal in a molten state ready to supply the auto pour furnace (5.5-ton capacity), which in turn carried the molten metal to the Mould Department, where it was poured into the single Disamatic (workers called it the Disa) moulding machine that produced the metal castings.

Other production processes included the making of cores in the Core Department, and removal of newly formed metal casts from the sand moulds that were then cleaned and grinded to specification in the Finishing Department in preparation for shipping. Just prior to casting of metal parts, cores that formed the inner voids were inserted into the sand mould and hot metal was immediately poured. Once castings were poured and solidified, the sand moulds went through cooling, shakeout, and retrieval of the metal parts followed by rough cleaning, grinding, and final finishing of the brake castings.

During the final shakeout/finishing stage, part of the sand was recovered as "reclaimed" sand and sent to the sand silo where it was mixed with clean sand, sea coal, and bentonite clay destined to be reused (in the disa process) to form new moulds. Depending on the percentage of reclaimed sand, this reprocessed mould sand would contain residues of phenol formaldehyde resins, metal, and release agents. Also, in the sand were residues from the core sand and metals and polycyclic aromatic hydrocarbons (PAHs) produced during the mould pouring process under extreme temperatures.

Expansion Period: In the mid-1980s, the plant significantly expanded production by adding two additional arc furnaces, two induction furnaces, and two more Ajax furnaces. This expansion was accompanied by the installation of two additional auto pour furnaces, with the number of Disa mould machines/ lines increasing from one to three. Following this expansion, the foundry employed over 200 employees and included: three electric arc furnaces for melting metals, three Ajax (melt storage) furnaces, and two coreless electric induction (melting) furnaces. The Moulding Department now included: three Disa mould machines part of three conveyor lines to move castings to a much-expanded shakeout and Finishing Department. To complete this expansion, the Core Department expanded from two to three lines to feed newly formed cores to Disa operators on the three mould conveyor lines. Workers noted that with expansion, Neelon Casting was recognized as one of the best rotor producers in Canada and the United States: ***"We cornered a lot of the market at that time. There is no doubt we were good at what we did"*** (NWAC member).

Increased Toxic Exposures: These expansion activities had a dramatic impact on production as well as health and safety conditions in the plant. The volume of product output was said to have increased by over 30% and the volume of raw materials and chemicals handled increased ten-fold, a dramatic increase. The volume of casting sand (which contained quartz silica, clay, sea coal [a graphite product] and water) prepared and then mixed with resins and other chemicals increased correspondingly—which led to a parallel increase in the volume of sand shakeout, recovery, cleaning, and mixing. For the Melt Department, the amount of raw and scrap metals increased substantially, as did the volume of molten, fuming, metals containing lead, cadmium, chromium, sulphur, antimony, zinc, nickel and other alloys. Sand (silica) in its many forms was ubiquitous in the foundry. It was especially present in the form of very fine airborne silica dust throughout the plant that, with expansion, greatly increased in volume. The sand was coated with binding and release agents, as well as metals, forming a complex mixture of inhalable toxic chemicals.

Airborne concentrations of lead, silica, triethylamine (TEA), and carbon monoxide (CO) increased in various departments as illustrated in hygiene monitoring reports, including reports of levels of CO hundreds of times higher than the regulatory limit, in addition to high levels of other toxic chemicals such as TEA. High body burdens of lead and antimony, indicative of high air concentrations, were identified in several workers. Silica and lead levels, measured annually in the plant, consistently exceeded OEL levels as measured in hygiene assessments conducted by the Ministry of Labour (MOL), the Occupational Clinics for Ontario Workers (OHCOW) and private consulting companies (Appendix E, pp 182-195).

Impact of Expansion: Plant expansions had a profound impact on exposure to noise (and consequent noise-induced hearing loss) and also led to an increase in musculoskeletal injuries due to increased pace of production/workloads (without corresponding measures to address serious ergonomic problems), in addition to the increase in toxic exposures for workers. Plant expansion, and added intensity of work regimes (greater physical effort required), was met with exacerbated environmental changes including extreme heat in all departments, at times reaching 150 degrees F, and noise levels exceeding the provincial occupational exposure limit by 10-fold, with levels as high as 105+ dBA being common (Appendix D, MOL Report #s: 13779KEDA; 18458M; 86F059A0B; 94332GAAR; 13779KEDA; 1071392; 53054). In addition, work shifts were increased in number from one to three—with frequent shift changes (i.e., two 12-hour shifts followed by an 8-hour shift).

Economic Factors and the Health and Safety of Workers: The history of Neelon Casting can be characterized as an economic roller coaster. The company was officially established in 1976 by Peter Kenny, after purchasing and modernizing the previous Neelon Steel Company in 1974. By 1994, Kenny sold the company to the Echlin Corporation, a U.S. company located in Illinois. Echlin was sold to the (U.S.) Dana Corporation in 1998, and then to the (U.S.) Affinia group in 2004. It was Affinia that closed the doors of Neelon Casting for the last time on June 22, 2007, after making the decision to produce offshore in lower-wage Mexico or China.

Economic pressure on the workforce intensified in the mid 1980's and 1990's, when economic conditions and international competition forced many companies, caught in an economic squeeze, to extract concessions from workers in the form of more flexible work conditions and wage concessions. Neelon was no exception to this trend in labour relations and collective bargaining. In 1985, the local union entered into a five-year, no-wage increase, agreement in return for a profit-sharing arrangement, and modicum of job security.

Wage increases were tied to profitability and meeting of production targets and quotas, as part of an economic incentive system. As workers recalled during our interviews, ***"We were working longer and harder to maintain our standard of living."*** This production speed up adversely affected the health and safety conditions in the plant. According to workers, injuries and illnesses increased in number during this period of austerity. Worker complaints, concerns, and work refusals increased, as did the number and frequency of MOL inspector visits and issuance of orders.

During this time, there was excessive use of overtime hours of work, further increasing worker exposures to toxic work conditions and chemicals. Already working 12-hour shifts, workers increasingly worked overtime as well, to supplement low wages and differential pay rates. It was common practice to put in 48 to 60 hours of work per week. Since the lowest pay rates were often in job classifications with some of the worst exposures to chemical and physical agents, these workers were placed at disproportionate risk of harm due to increased exposure time and reduced recovery time. Adding to workers' level of risk, was the practice among many employees of working through entitled holidays, vacations, and other time-off.

Ventilation and Exposure Controls

General Ventilation: Despite lacking adequate ventilation from the day the plant opened, there was no significant improvement in the ventilation system with expansions in production. It did not follow expansionary trends in production, and there was not any significant improvement in the foundry's ventilation system. According to a union health & safety representative: ***"Most of the measures taken never resulted in improvements in air quality—and measures taken to improve local exhaust systems were never truly effective and, over time, there was a resort to personal***

protective equipment that, in many instances, was not appropriate for the type of exposure and proved very uncomfortable to wear, given the extremely hot environment." As example, there is documented evidence of recurrent over-exposures to CO, carbon dioxide, silica, sulfur, antimony, TEA, formaldehyde, methylene bisphenol diisocyanate (MDI) and lead. (Appendix D, MOL Report #s: A-4035; 12282DA0B; 89G164AOBR; 23718; 37736; F. Holmes 10/1378; 16978FEOB; 16978FEOB; 01/051981(core dept.); 09080DEOB-M; 05081LAOB; 32084FAOB; 1101569; 104884; 05081LAOB; 52290; 37084KAOB 12/11/84-MOL (plant wide) Reports on exposures to MDI, formaldehyde and TEA; A-2507; 05081LAOB (Si excessive); 89L415EOBR; 91H406EOBA).

There were frequent complaints about the major ventilation system being tampered with in order to cool the hot environment, especially during summer months. Written statements and complaints from worker Health & Safety representatives stated that local exhaust ventilation was subverted by the use of large oscillating fans and wall exhausts—with doors to the outside purposely left open. (Appendix F, WORKERS' CONCERNS AND COMPLAINTS by date: 06/15/2006; 01/02/2007; 01/30/2007)

Developing effective plant wide ventilation, including local contaminant extraction systems, remained a major challenge due to the physical structure of the plant, and nature of the production processes. Most important is the fact that the building was mostly open concept, with few work processes able to be both isolated and separately exhausted.

In fact, the MOL noted in its reports that with expansion, the employer failed to provide a revised plan or set of drawings to ensure that the ventilation system would be able to effectively meet the ventilation challenges of their planned large expansion in production. The company did not carry out a pre-expansion assessment, nor did they follow through when the ministry required an assessment after the plant was already in operation (Appendix D, MOL Report #s dated 1990-91 (Plant Wide): 89L415EOBR; 08071991). Company documents provided to the MOL, contained only cubic feet per minute (CFM) ratings of exhaust fans—with no indication of locations of capture hoods or canopies for maximum efficiency required for full worker protection.

Local Exhaust Ventilation (LEV): The few LEV systems in the plant (Melt and Core Departments) were not effective. LEV was incorrect for the physical structure of the plant and production processes carried out. This is evidenced by poor containment and capture, very much dependent on the type of hood and canopies and their strategic location in the production process. In choosing the required LEV, the company did not properly assess the energy of the work processes and size of the containment cloud likely to be associated with the increased scale of production. While various attempts were made to address these problems with LEV, there was no overall comprehensive ventilation plan. The patchwork measures undertaken did not bring relief and, at times, exacerbated conditions for workers. Another fundamental problem in the operation of the LEV system was poor maintenance, including, failure to carry out routine, in-house, work on a regular basis. In addition, the employer neglected to make timely repairs to damaged LEV, even when routinely noted by the union health & safety representative (Appendix D, MOL Report #s: 89L415EOBR; 89G164AOAR; 87G250EAOP; 91H406EOBA; 77HO23CO00; JUNE 1978; 291-00014-0001; 16978FEOB; Appendix F, (Worker Concerns and Joint Health and Safety Committee Minutes: Log: 200 April, May, June; 7-1999, 10-1999).

LEV was not practicable to address certain processes. For example, control of CO levels in moulding, cooling, and shakeout was better addressed by providing enhanced and effective, general ventilation to dilute levels of CO.

Maintenance of the Ventilation system(s): Foundries, in general, are harsh environments for LEV systems; if regular maintenance and repairs are not carried out, performance is adversely affected, as it was at Neelon—in some cases leading to additional/higher worker exposures. In general, air quality in the plant was abysmal. Worker complaints were frequent. Workers identified specific sources of exceptional contaminations. These included large amounts of soot, dust, and other contaminants in the air when both arc furnaces were functioning simultaneously—and during pour stage, when excessive fumes and smoke were produced. Air contamination was particularly severe when pig iron was used with subsequent pouring of "half-lines" that created dense smouldering. The problem of ventilation was apparent in the early years when natural ventilation was relied upon including use of louvers, open doors, and large oscillating fans. The company tried to incorporate a Heating Ventilation and Air Conditioning (HVAC) system that worked relatively efficiently when the building was sealed, but areas including melt and core could never be adequately cooled for workers. According to NWAC members, the continued use of louvers and doors in conjunction with the HVAC system only subverted the LEV systems.

Personal Protective Equipment (PPE): In addition to the importance of effective ventilation, the range of control measures must include provision of effective PPE, along with training, their proper fit, and maintenance—supplemented by appropriate administrative controls including scheduling and hydration measures to control heat stress. There is evidence, none of these controls were ever fully implemented and enforced. It was apparent from descriptions of worker behaviours in relation to the use/non-use of PPE, that a full-scale program including proper PPE to address: the type of hazard; maintenance of equipment; and training of workers, was not in place. For example, gloves used during moulding, core, and shakeout operations did not provide sufficient protection against binder and release chemicals—regularly deteriorating throughout a shift. Gloves and respirators were often removed and left on work benches when not in use. Improper use of PPE pointed to a lack of training and supervision. Not all workers wore the available PPE, and some wore it incorrectly. Protective furnace suits were shared, rather than provided to individual melt workers. There were frequent complaints by the Union Health & Safety representatives calling attention to workers not wearing the PPE required—both by regulation and company policy. It is irresponsible for a company to provide protective equipment but then neglect to enforce that PPE be properly fitted, consistently worn, and well maintained.

Long-term employees indicated that safety conditions during the early years of operation were extremely poor; other than 3M dust masks and hearing protection, no proper, or mandatory, PPE was worn. Conditions in the plant were described as extremely dirty, dusty and smoky. No protective equipment was provided or mandated even for extreme exposures. For example, one NWAC member noted: ***"Melt deck workers were not provided with heat resistant aluminum-coated suits for close contact with molten metals; you had to buy your own if you wanted some protection."*** Or, as a former Neelon worker stated bluntly: ***"Conditions, especially at the beginning, suffered from the three D's—Dirty, Dusty, and Deadly."***

Workers complained of regularly having to share the few protective aluminized suits available when working close to ladles and furnace openings containing metal heated to 2500 F. According to NWAC members, these suits (in continual use throughout a shift) were always damp from the perspiration of a previous worker, as all shared the same suit in carrying out their daily tasks.

Administrative Controls: With respect to administrative controls (particularly mitigation measures for heat stress) the employer was regularly cited for deliberately ignoring the heat stress protocol and control measures ordered by the MOL (and agreed to with the union). ***"Many times, we would put up a thermometer at the arc furnace, and it would register 150 degrees F+, but the employer kept taking it down so we could not have a reading to implement the heat stress control measures"*** (NWAC member).

Occupational Health researchers have noted that when moulding and core making are mechanized and largely contained, exposures are not significantly different from similar manual processes if proper maintenance of such machines is not performed (National Occupational Health and Safety Commission, 1989). Examples of this occurred at Neelon in core making and shot blasting, where the processes were automated and enclosed, yet there was significant exposure to respirable dust from sand and mould release agents including "core wash" (triethylamine or TEA), and CO leaking from core machines—as well as exposures to silica sand leaking from "perpetually" warped Wheelabrator (shot blast machine) doors.

Some processes were exceedingly dangerous and unhealthy. Early on, the company made castings from "ductile," a metal alloy requiring a granite-like additive composed of black granules that produced caustic and choking clouds of smoke, with a heavy pungent odour. When "bubbling" this molten material, a melt operator was required to introduce oxygen gas through an opening in the bottom of a large 5'x30" ladle. This would cause the melt to react violently and bubble over. There was no local exhaust ventilation or proper respiratory equipment provided. As described by an NWAC member: ***"It was so dusty that sun beams coming through windows were thick with floating dusts particles that we could clearly see and breathed in. And I have to ask, what was all that stuff doing to me?"***

Based on both worker interviews and MOL reports (Appendix D, MOL Reports #s: 77HO23CO00; 25481HAAB; 87G250EOAP; 37084KAOB; 27283BEAA; 94332GAAR; 91H406EOBA), exposure controls were seriously deficient in preventing and mitigating worker exposures—adding to workers' already high levels of psychosocial stress, especially for those handling molten metal where there was no room for error. For example, one former worker stated:

"This was a stressful environment because you knew how dangerous this work was. Mistakes were unforgiving— you knew you wouldn't come out alive if you made one wrong move. You were constantly on the alert for something critical to go wrong."

Another NWAC member poignantly shared: ***"I never got over the death of (names worker) a young (age 20) new employee, who was burned to death when a ladle poured molten metal on him. Re-living our work experiences these last couple of months put me into a depression. I couldn't speak to anyone for weeks and needed to get some professional help. That tragedy changed my life forever."***

Identifying Exposure Risk Points

In the Occupational Disease literature, the following are identified as production activities in Foundries where a risk of exposure is likely:

1. Handling raw materials, in this case: scrap metals, sand, binders and release agents;
2. Preparing and mixing the sand for mould and core production;
3. Direct exposure to the mould and core making processes;
4. Reclaiming sand and other materials used in core and mould production for re-use;
5. Melting steel, iron, and other metal alloys from scrap;
6. Pouring, transferring, and slagging molten metal;
7. Shaking out moulds and cores to retrieve castings;
8. Cleaning castings by chipping, grinding, and cutting extraneous materials;
9. Maintaining and repairing equipment used in melting, pouring, and slagging—as well as core and mould making;
10. Cleaning of all foundry areas (particularly the "dead zone" at Neelon).

In addition, factors affecting exposure risks during these foundry processes include:

1. The type of metal to be cast;
2. The type of mould material used;
3. The volume of materials handled;
4. The toxicity of materials including chemical by-products and decomposition products;
5. Physical state(s) of chemicals/agents;
6. Effective routes of entry into the body;
7. Particle size/nano particles;
8. The size of castings being poured;
9. The plant layout and production flow(s);
10. The rate of production;
11. The age of the plant, and suitability for the work performed;
12. State of engineering exposure controls;

13. The state of housekeeping work practices;
14. Extensive mental and physical stress associated with: exposures to high levels of heat and chemical products; physically demanding work; and continual monitoring of unpredictable, potentially life-threatening risks associated with working with molten metal, and its many points of danger;
15. The state of access to training and information about the hazards and how to work safely.

(These risk factors have been broadly recognized in the occupational health literature on foundry work. References of note in this regard include the following: Scott, 1976; NIOSH, 1985; National Occupational Health and Safety Commission, 1989; Dodson, 2001; NORA-NIOSH, 2004; Ribeiro, 2006; International Finance Corporation, 2007; Wojtynek, 2011; Safe Work Australia, 2013; IARC, updated 2014; Hye et al, 2015; Mgonja, 2017; Cooke et al, 2017; LaMerrill, 2020).

Of note, as an example of management's deficiency on point #15, workers' fundamental right to "access information" on the hazards and risks they faced, we quote the following statement from a former Neelon worker: ***"Workers didn't know what chemicals were used in the Core Room. The co-chair of the Joint Health and Safety Committee gave the company a list of chemicals to test, which they resisted at every level."*** In fact, for years, Neelon workers received little information about the chemicals they handled daily, or how to safely work with them. But it isn't only the company that was resistive. According to former workers, the state of government enforcement was problematic too. As one NWAC member complained: ***"To get the MOL to do something, you had to do a work refusal and stop production."***

Risk Factors Common to All Neelon Employees

One NWAC member reflected on the many risks workers faced: ***"Workers at Neelon pushed their bodies to the maximum. They were required to give their all. Conditions at the plant were extremely hot, dusty, dirty, and dangerous due to both physical and chemical hazards. The work effort required was physically demanding to the extreme. Every production process generated its unique set of toxic exposures without adequate control measures to mitigate them. Thus injuries, illnesses—and even death from work at this foundry were quite common."*** To put this quote in context, the broad scope of occupational health and hygiene literature we referenced in producing this report is replete with dire accounts and warnings associated with the high death and disease toll among foundry workers, worldwide.

While there are specific factors unique to certain industrial processes, there are also unique factors that can contribute to generalized patterns or clusters of illness at a particular workplace. Some are linked to building and ventilation design and/or the production system's condition. Others have to do with production processes, housekeeping, and maintenance issues. We identify a number of circumstances that can be viewed as having created common risk factors for workers at the Neelon Casting plant including:

Open concept building where contaminants moved freely throughout the plant;

- Non-functioning/inadequate general ventilation system;
- Close proximity to, and direct handling of, production process chemicals by workers within an open concept building;
- Rotating and flexible workforce;
- Inadequate local exhaust ventilation at the point of production;
- No (or inadequate) PPE provided or used, and general lack of training in its use;
- Extremely high volumes of toxic chemicals used and contaminants produced;
- Intensely hot work environment combined with physically demanding work;

- Widespread use of free-standing industrial fans to address intense heat;
- Intensification of work/expansion of production causing stress on workers;
- Economic factors including low pay rates, 24/7 production schedules, and excessive overtime leading to greater frequency and/or longer duration of exposures and shorter worker recovery time;
- End of shift, 15-minute daily clean-up in addition to end-of-week, intense, 4-hour simultaneous clean-up of all machines that included: scraping, chipping, sanding, spraying with solvents; refractory rebuilding; and dry sweeping and blowing work surfaces with compressed air (Utility workers were usually assigned these tasks);
- Major fume and smoke contamination of lunchrooms as a result of their location(s);
- Economic factors contributing to limited expenditures on health and safety and other improvements for workers, as well as reduced pay and financial insecurity.

Exposure Risks at Neelon by Department and Work Process

Introduction: Categorizations made by former Neelon workers provide evidence of unique exposure risks associated with different departments at the plant, as one worker shared, ***"We referred to core room (workers) as gas heads, grinding room (workers) as rust heads, and mould and melt (workers) as sleepy heads."***

This example of playful, but also serious "naming" to categorize co-workers in different departments has a basis in reality as major exposures for workers included: TEA gas for core workers; exposure to metal and silica dust for grinders; and CO (carbon monoxide) exposures for the mould and melt department workers. In fact, CO was an "accidental discovery" that explained why so many melt and mould workers were falling asleep at their workstations. These workers were chronically exposed to high levels of CO coming off the mould line and during shakeout. It was reported that one worker was killed in a car crash on his way home, the result of "falling asleep at the wheel." Over the years, numerous workers were disciplined by the company for falling asleep on the job.

But worker-exposures to individual chemicals tell only one part of the story. For workers at Neelon Casting (as is the case with foundry work in general), toxic exposures also involved multiple chemicals and complex chemical mixtures, further complicated by extremes of temperature and doing physically demanding work. Using data gathered from the NWAC and other sources detailing the production activities carried out at Neelon, we outline the work processes and toxic chemical exposures, and their level of risk, for each department in summary fashion.

NOTE: Primary sources of documentation pertaining to each department includes Ministry of Labour Reports, Joint Health & Safety Committee reports, and Material Safety Data Sheets (MSDSs) for chemicals used in each department, with full references found in the report's Appendices.

THE MELT/REFRACTORY DEPARTMENT

General Description

The Melt/Refractory Department measured about 130' x 50' x 35' high and was organized around two elevated melt decks (#1 and #2). The melt decks contained three large arc melt furnaces, two large Ajax holding furnaces, and two small coreless furnaces. The three arcs were 10 feet in diameter, the Ajax furnaces were 12 feet in diameter, and the smaller coreless furnaces were 3 feet in diameter. The melt decks were staffed by 9 workers per shift with an added foreman/lead hand on the day shift. Included were: three furnace operators, two crane operators, two refractory workers, and two laborers. Deck #1 housed two arc furnaces and was staffed by: one lead hand, a crane operator, and a laborer. Melt Deck #2 housed a third Ajax and two coreless furnaces and was staffed by: one coreless operator, a crane operator, and a laborer. The Melt Department included a small refractory department consisting of 1-2 refractory specialists per shift who performed emergency repairs as well as weekly rebuilds/maintenance repairs for the many furnaces and ladles. (Workers rotated between one 8 and two 10-hour shifts). In addition to the two melt decks, Melt Department workers were also responsible for three smaller auto pour furnaces that supplied melt to the (automatic) pour boxes that fed Disa machines, where the brake parts were cast. (For a short time, the company supplied small orders of other casted metal products including sports equipment and in-house equipment such as spoons and small ladles).

Production Processes

1. Preheating arc furnaces;
2. Charging (loading) arc furnaces with scrap metal;
3. Testing and inoculation of melt;
4. Transferring melt to storage furnaces;
5. Slagging furnaces;
6. Cleaning Tasks.

Preheating Arc Furnaces: Melt deck operators employed a natural gas torch to heat the furnace prior to charging. The temperature to be obtained ranged between 2500-2800F.

Charging Arc Furnaces: Crane operators, using remote controlled overhead cranes, moved, loaded, and dumped pig iron, steel, and various scrap metals (contaminated with sand, dirt and metal dust) into the heated furnace. At maximum production, an arc furnace produced approximately 40 melts per shift for a total of approximately 1,920,000 lbs of molten metal per shift. As scrap was dropped into the furnace, flare-ups often occurred due to contaminants or oil on the scrap metal.

Testing and Inoculation: The "melt decks" surrounding the furnace vessels were elevated, providing staff with direct access to furnace side doors in order to test and inoculate the molten metal. Workers collected two samples of the molten metal, the first to identify its physical qualities (strength, elasticity, brittleness) by cooling, then subjecting the sample to numerous physical tests. The second melt sample was used to identify its chemical composition, by breaking it down into particulate, then using a spectrometer to determine its chemical formula. Initially this work was done by Metal Lab Techs but in later years was shifted to Melt Deck personnel. Inoculation involved the addition of chemicals and metals (often in large amounts) to achieve correct physical and chemical qualities as well as the temperature required for the product being cast. In the production of brake castings, additives to the melt would include: 500 lbs of silicon, 5-10 lbs. of sulfur, up to 500 lbs. of carbon and several pounds of antimony, in addition to smaller amounts of manganese, chromium, copper and tin (NWAC). To mix these additives, melt deck workers injected nitrogen gas into the 2800F molten metal using an 8′ x 3″ carbon lance contained within a steel pipe. This process was referred to as "bubbling" in the additives. Once the liquid metal achieved the required temperature (2500-2800F) and metallurgy, the melt was transferred to one of two holding Ajax furnaces.

Transferring The Molten Metal: The melt produced was continually being transferred and poured using various sized ladles—completing in one shift approximately 360 pours (120 transfers x 2 pours per transfer) from arc furnace to bull ladle and bull ladle to Ajax furnace. At the height of production, metal transfer activity in the department was described as comparable to the traffic encountered on a "super highway" during heavy traffic.

Slagging: Slagging melt involved the removal of impurities. Workers were positioned one to two feet from the melt during slagging, while manually raking the surface of the melt in the furnace (or ladle) by drawing the slag towards themselves, then dumping it into an open pit or slag box located below the deck. It was a very physical task, made more difficult by a combination of the normally hot environment and being located 1-2 feet away from molten metal. Melt deck workers executed slagging procedures approximately 70 to 80 times per shift. There was no local exhaust ventilation nor was additional supply-air directed at workers performing these often laborious and heavy, tasks.

Cleaning Tasks: Daily sweeping and blowing off floors and machines and shoveling (often smouldering) slag from slag boxes.

Chemical Exposures

Toxic exposures began with the initial charging process when an overhead crane magnetically picked up thousands of pounds of iron, steel, and scrap metals from bins then dropped the (dirty and dusty) load into an arc furnace—creating in the process, massive plumes of dust and smoke containing silica, gases (e.g., CO, sulphur oxide, nitrogen oxide) and various metal and carbon particulates.

At maximum production, the three arc furnaces produced nearly 5 to 6 million pounds of melt daily over three shifts. Melt produced was repeatedly transferred and poured using various sized ladles—from arc furnace to bull ladle and bull ladle to Ajax furnace. In addition, numerous smaller pours occurred between coreless and Ajax furnaces, and between metal transfer ladles and auto pours (including final pours initially into a mould line's pour box which then automatically filled the moulds). This continual movement of solid and molten metal resulted in the release of significant concentrations of metals and chemicals, in the form of fumes, gases, and dusts. These included phosphorous, cadmium, chrome, magnesium, zinc, nickel, antimony, arsenic, manganese, sulphur, beryllium, barium, and tin, as well as contaminants produced through pyrolysis of residues found on scrap metal (e.g., silica, carbon, lead, anti-corrosion agents, grease and oils). These decomposition contaminants included: cristobalite, CO, and CO_2, as well as numerous polycyclic aromatic hydrocarbons (PAHs) in addition to benzene, benzo-pyrene, toluene (BTEX) etc. (NIOSH, 1985; HSE, 2017; Bauer et al, 2018; Dungan et al, 2007; Freire et al, 2020; Hye et al, 2015; IARC, 2009; Kmita et al, 2019; Mgonja, 2017; Michaud, 1993; National Occupational Health and Safety Commission-Australia, 1989; Riaz, et al, 2017; Ribeiro et al, 2006; Safe Work Australia, 2013; Scott, 1976; Sen et al, 2019; Zarei et al, 2017; Zhang et al, 2020).

Additional sources of contaminants included lead coming from scrap metals—especially gaskets and bearings. The presence of lead is confirmed by the fact that some workers were found to have substantial body burdens of lead and/or antimony in their blood and urine. (Appendix E, Hygiene Report #: 23718 (10/26/94, p.183; OHCOW/Gauvin p.186; Appendix D, MOL Report: June 20, 1984).

To summarize, under high heat many contaminants were released into the plant environment as fumes, dusts, vapours, and gases composed of the original contaminants as well as decomposition by-products containing PHAs, CO, sulphur dioxide, carbon dioxide, in addition to a variety of heavy metal fumes (NIOSH, 1985; HSE 2017; HEALTH AND SAFETY AUSTRALIA 2007; and Appendix D, MOL Reports #s: 25481HAAB; 37681CAOB; 28083BEEA; 89G164AOBR; 23718; 37736; 1092181; 77HO23CO00; 16978FEOB; 16978FEOB; A2499; OHB09080DEO-B+M; 25481HAAB; A-8786/A8785; 27283BEEA; 32084FAOB; 85C109-0; EAR 891060/89H160MAAV; 38679; 16978FEOB; 05081LAOB; A-2507; 25481HAAB; 05081LAOB; 27283BEAA;32084FAOB; 86FO59AOB; 86F059AOB; 89L415EOBR; 91H406EOBA).

The formation of PAHs was due to oils and grease on scrap metals. As a former Neelon worker stated, "…we would run the stampings and borings, that were full of machine oil and anti-corrosion agents, through the coreless furnaces and it would light up the whole plant with flames and smoke. We would have to shut the system down. It would burn your lungs and eyes." Another NWAC member shared: "Once in a while, we had to throw sulphur in the Ajax, and pretty much had to evacuate the plant. That would blow dust off the building (ceiling beams) , and it would look like the power went out. All the soot on the beams went air-borne right down to the floor, with fans blowing it everywhere" (Appendix D, MOL Report#: 89G164AOBR).

The toxicity, carcinogenicity, and health effects of these various melt additives are well known and documented in the literature (NIOSH, 1985; Appendix B Foundry Processes and Hazards Table; and Appendix C Health Effects Table). Biologic monitoring of workers exposed to these additives provides evidence of foundry workers' exposures. These "body burden" measures are discussed later in the Discussion section of the report.

MOL inspection and hygiene assessments confirm the extent of exposures to toxic smoke, fumes, and gases generated in the melt department (Appendix D, MOL Report #s: 39681CAOB; 25481HAAB; 47481GNOB; 37681CAOB; 32282OEDA; 3221282BEDA; 12282AOB). In the above reports, certain workers, areas, and work activities were listed as of particular concern, including: Refractory workers, labourers, during ladle pouring, and on the catwalk.

Additional toxic exposures would occur during slagging (removal of impurities) and if water was used to cool the slag, hydrogen sulphide (H2S) gas would form, further adding to the exposures for these already stressed workers.

Understanding the magnitude of these complex chemical processes and exposures requires taking into account the large surface areas of the numerous, relatively open, crucibles and ladles used for pouring and transferring tremendous amounts of melt (calculated to be about two million pounds per day) creating large surface areas for the release of significant amounts of fumes, gases, and fugitive emissions into the work environment.

Complaints about the smoke and dust levels generated during pouring and slagging operations were frequent (not only at the melt decks, but also from workers in nearby core and mould departments) (Appendix D, MOL Report #: 88120EAAV).

MOL inspection and hygiene assessments confirm the extent of exposures to toxic smoke, fumes, and gases generated in the melt department (Appendix D, MOL Reports #s: 39681CAOB; 25481HAAB; 47481GNOB; 37681CAOB; 32282OEDA; 3221282BEDA; 12282AOB).

Job Related Exposure Risks

Melt personnel with different job classifications, worked closely, did interchangeable jobs, and shared a highly contaminated environment. Melt workers were exposed to dense fumes and smoke, composed of iron oxides, manganese oxides, antimony, copper, tin, lead, and volatile organic compounds and also included PAHs from scrap charges. The scrap charges were contaminated with oils, greases, anti-corrosion coatings and decomposition by-products.

These exposures occurred during charging, tapping, and pouring of the melt – and while transferring ladles of melt to the three Ajax holding furnaces. Transferring the molten metal from arcs to Ajax furnaces involved 44 transfers and 88 pours; and, from Ajax furnaces to the auto pours in the mould department, required another 80 pours and transfers. Each of these transfers and pours entailed exposure risks to both operators and bystanders. Transfers from the coreless furnaces (approximately 48 per shift) resulted in considerable additional risk of exposures. During cleanup, workers were exposed to dusts, fumes, vapours and particulate while sweeping/blowing off floors and machines and shoveling slag built up in slag boxes.

Specific Worker Exposure Points Are Listed below:

1. Preheating of the charge and furnaces with torches or preheaters which produced large amounts of carbon monoxide;
2. Picking up and dropping the charges which generated substantial amounts of metal and silica dust, and;
3. Dropping the charges into the molten metal which produced explosive plumes of smoke and flames, as well as metal containing dusts, vapours and gases from the burning of carbonaceous materials;
4. Pouring the melt Increased surface level exposure/air contact with further release of gases, fumes, and vapour;
5. Frequent inoculation of melt with sulphur, copper, and silicon carbide, resulted in additional exposures, and;
6. Slagging operations generated hot, dense, long-smouldering fumes.

In addition to these hazardous exposures from routine procedures, significant exposures occurred in non-routine circumstances. For example, wet charge (liquid in the melt) explosions resulted in “blow ups” releasing enormous amounts of gases, vapours, and dust. Non-routine exposures also occurred during burnouts when melt burned holes in the ladles; and, during spills or flare-ups.

Additional tasks carried out by crane and melt operators involved refractory duties including chipping and "ramming" the inside of a furnace with pneumatic chippers/rammers. As a result of these activities and materials processed, melt deck personnel were exposed to: extreme temperatures >120 F, noise levels between 87 and 90+ dBA as well as continuous impact noise, in addition to airborne dust, fumes, and gases (the later included, PAHs, antimony, iron oxides, CO, CO_2, cristobalite, tridymite, carbon dust, silicon and lead). There is a report of bystander exposures to antimony associated with elevated antimony/blood concentrations in an employee that were 10 times the normal concentration (Appendix D, MOL Reports #s: 23718; 32168; 3736; 23718).

Worker exposures to lead at the plant were discovered in mid 1980s, mainly the result of biological and air monitoring requirements under newly enacted, lead regulations. Sampling from both decks indicated high lead concentrations requiring removal of workers from the melt area and implementation of a lead control program under the Designated Substances Regulation for lead. The source of lead contamination was found to be scrap metals containing lead coatings, gaskets, and bearings. It can be assumed that workers were exposed to elevated concentrations of lead for as long as 10 years before it was finally identified and corrected (Appendix D, MOL Report #s: 85CO75MOH; 86FO59HOB; 89G164AOBR).

Ventilation and PPE Issues

Ventilation in the Melt Department was a major issue, as well as adequacy and availability of Personal Protection Equipment (PPE). There was no exhaust ventilation for the Ajax furnaces or during the pouring and transferring of melt throughout a shift. The frequency of transfers and pouring of melt is significant to exposure risks.

While arc furnaces were exhaust-ventilated during melts, there was no (or incomplete) exhaust-venting of fumes and smoke during: 1. charging; 2. tapping and pouring; and 3. slagging processes. Slagging operations lacked a source of fresh air to cool the operator and a system of ventilating the smouldering slag left on floors or in slag boxes. There was no horizontal side stream exhaust ventilation to extract the smoke and fumes from workers' breathing zone. Consequently, these operations were frequent sources of high heat and hot metal splashes, in addition to exposures to metal fume, dust, and IR radiation (Appendix D, MOL Report #: 27283BEAA).

Local exhaust ventilation in arc furnaces was particularly ineffective because of the poor fit and seal between the canopy and lid of the furnaces due to continual warping. Inspectors recommended the (totally ineffective) use of loose sand to seal the gaps where the fumes and smoke were leaking. Slowly rising fumes and smoke from this area regularly travelled in dense plumes across to the core, mould, and shakeout areas, resulting in workers regularly engaging in work refusals under Section 43 of the Occupational Health and Safety Act. The many toxic contaminants did not rise quickly enough to be successfully vented through the roof level LEV.

With respect to the provision and use of PPE, workers and their designated health and safety representatives frequently complained about the inadequacy of respiratory protection and employers not enforcing mandated wearing of PPE (workers labeled the PPE as uncomfortable, too hot to wear, or not effective). Former Health and Safety reps said they frequently complained to management about equipment not being worn or not being worn correctly. Workers also noted that heat resistant aluminum suits were not provided by the employer forcing them to share suits with other workers, or buy their own (NWAC member).

Summary of Melt Department Chemical Exposure Risks

1. **Inhalation and other stessors:** Workers inhaled a complex mix of silica and condensed heavy metal dust (FeO, CuO, Cd, Pb, Ni, S, Si, (cristobalite, tridymite), antimony, Zn, Be, Cr, Mg, Mn. They also Inhaled CO, CO_2 at high concentrations; refractory fibres (aluminized RCFs); combustion by-products; PAHs, and NxO; dense smoke with BTEX; UV, IR, and EMFs. In addition, workers were exposed to high noised levels between 85 and 105 db, and severe heat stress (90 F to 150 F)
2. **Workers' symptoms and complaints:** headaches, skin rashes and irritation, irritated eyes, nose and throat,

coughing, lung congestion, fatigue, dizziness, hearing loss (See MOL reports, worker complaints/JHSC, Body burden data in Appendices D, E, and F).

REFRACTORY DEPARTMENT

General Description

The Refractory Department was an integral part of the Melt Department. Refractory workers were responsible for maintenance and repair of all furnaces, ladles, and other melt storage equipment. This included responsibility for trouble shooting malfunctions in melt operations and repairing and proactively rebuilding ladles and furnace refractories as preventive measures. Their daily work was divided between the emergency repairs of burn holes in ladles and furnaces, and maintenance of the brick lining of furnaces and other melt vessels.

The importance and dangers of this work are highlighted in the following statement by an NWAC member: ***"Everyone around the furnace was a trouble shooter. We watched them all the time—the arcs, the auto pours, the ladles. It started as a little glow inside the framework. Guys would jump in there with an air hose to stop melt from running out. I watched a worker plug a ladle 10 feet in the air with a spoon and some RAM—with guys trying to make sure it didn't burn anything while moving the ladle to the auto pour and dumping it as fast as they could. If guys jumped in (to perform) what we called crazy acts—if they hadn't, there would have been a disaster and there would have been many fatalities. We never looked for praise, but never got a thank you. A lot of guys risked their lives."***

Production Processes

Refractory workers were responsible for maintaining, monitoring, and repairing all furnaces, ladles, and auto pours for the Melt and Mould Departments. These responsibilities included: re-lining, repairing and rebuilding the inside of all furnaces, ladles and auto pour refractories. Workers carried out daily/weekly maintenance that was often conducted during live pouring operations. Major repairs and rebuilds were carried out more intensely during periodic shutdowns. Tasks associated with re-lining and rebuilding the inside of furnaces involved the application of refractory material in the form of pastes, washes, and in dry form (pounding it on using pneumatic rammers and hammers). Repairs and rebuilds entailed the extremely dusty and dirty, often difficult, removal of hardened refractory materials using pneumatic chippers, jack hammers, rock drills, electric vibrators, and grinders as well as hand scrapers. These activities resulted in the production of large amounts of fine dust and fibres, some of which were carcinogenic.

Refractory material ingredients included: silica, quartz, cristobalite, oxides of aluminum, clay, refractory fibres (RCFs), consisting mainly of aluminous spun fibre mimicking asbestos, called Cer wool.

The lancing of auto pours was among the worst refractory jobs. This involved use of a metal rod equipped with a supply of natural gas/oxygen that created a 'torch' that would heat and eventually dislodge solidified slag and metal. High levels of smoke, fumes, and crystallized RAM (dry product) were produced in the process. This task resulted in high numbers of worker complaints with affected workers often sent to lunch rooms when exercising their right to refuse under the Occupational Health and Safety Act (Appendix D, MOL Report #s: 37736; 7274; 881205EAAV; 2808313EAA; 32282BEDA; 27283BEAA; 25481HAAB; 1046255; 1092181). Refractory workers who performed the lancing task were equipped with gloves, goggles and cartridge respirators.

Another hazardous exposure for refractory workers involved the application of a material called "Dry-Vibe." This was a powdery refractory product containing, as its principal constituents, aluminum oxide, and both silica and titanium dioxides. Dry-Vibe was applied dry, in loose powdery form, using vibrating tools that (in conjunction with the remaining heat in the furnace), caused the material to harden and form a protective layer on walls and floor of a furnace. Dust levels created in the process were so high that respiratory filters worn by workers clogged within minutes, requiring frequent change. This material was handled directly and poured from as many as 26 bags per task, with each bag weighing 50 lbs. Workers became completely covered in this dusty material while working in the confined furnace spaces, leading one Neelon worker to identify that: ***"You could not see the refractory worker who was working inside the furnace, you could only see the top of his head"*** (NWAC member).

Refractory Materials: Various refractory materials were used as pastes and washes to repair holes and cracks in ladles and furnace walls. These materials included the following: Silica quartz, clay, sand, and refractory ceramic fibres (RCF), which are aluminous spun fibres mimicking asbestos and contained in RCF products like Cer wool. Another material was BLU-RAM 90 that contained quartz, cristobalite, oxides of aluminum, and phosphoric acid. BLU-RAM 90 was rated by IARC as a Group 2B (possibly carcinogenic to humans) carcinogen (Appendix G: MSDS List). These products were handled and installed manually. Other RAM materials included Black Ram-Gunning; Monogun 70 and Monogun 80; Supercast 32 (used in castable refractories); and Dry Vibe used for coreless relining. During a rebuild, these materials were removed in their hardened state. To accomplish this task, workers used pneumatic chippers, rammers, jackhammers, rock drills, electric vibrators/grinders and scrapers, resulting in the production of large amounts of fine dusts and fibres, some of which were suspected carcinogens. These activities additionally produced toxic vapours and lead fumes from residue on furnace and ladle surfaces (Appendix G: see MSDS ingredient lists for known refractory chemicals).

Workers used refractory products in large quantities. For example, 40 to 60 lbs. of RAM 90 were required to repair the top cap of a coreless furnace; 40 to 50 lbs. were needed to repair a ladle. To repair a large Ajax furnace required approximately 2500 and 3800 lbs of material. In addition, ten to 15 lbs. of RAM 90 were used in washes, applied manually, with (and often without) gloves. Workers stated that ***"when RAM was applied to hot ladles, it would give off lots of smoke and was very stinky"*** (NWAC Members).

Another refractory product was Monagun 70, or 90, sprayed on the walls of both arc and Ajax furnaces to build them up when they became "too thin." The spray application of Monagun, along with the manual application of clay-like RAM 70 and 90, produced mists and vapours, during application. Monagun products were regularly mixed with liquid, in a pot large enough to hold eleven 50 lb bags of the material, then "blown" onto the walls of ladles that had worn thin. In addition, workers used a RCF product called Fibrefax paper as a liner (mainly in ladles) when applying refractory materials. When removing this lining, pneumatic tools were required to break the paper from the surface, thus releasing into the air, fine airborne dust containing the product's asbestos-like fibres. Fibrefax gaskets, used to tighten down lids on auto pours, were known to give off green coloured smoke when applied to hot surfaces. Cer wool, a much thicker, asbestos-like product than Fibrefax paper, was described as a much "easier" product for workers to handle.

In describing a particularly dangerous refractory repair task, one NWAC member shared: "***We'd tap an arc at 2800 degrees F and refractory maintenance was expected to go in there and patch it when it was still 'beet' red.***" Another member followed, by stating: "***You had a blasting machine and a hopper connected to pressurized air that you filled with water and material [e..g., Monogun 70] and then shot it onto the wall of the furnace.***"

Due to the extreme heat in furnaces and other vessels undergoing refractory repair, the products used would undergo chemical transformation. Significant work was done while inside the inner core of a furnace, often after an emergency spill and while partially filled with hot molten metal. As described by a NWAC member: ***"It still was hot enough to burn the soles of your work boots. To prevent that we would lay a bed of Cer wool on the furnace floor to insulate us from the intense heat."*** Cer wool, an (asbestos-like) RCF product is rated a Group 2B carcinogen by the International Agency on Research on Cancer (IARC, 2012).

Note on Asbestos and Cer Wool: The discovery of asbestos at Neelon in 1999, occurred 10 years after the company opened. It was first identified on the melt deck walls in the form of asbestos fibre sheets and tiles. Asbestos was subsequently found in fire blankets, gloves, and gaskets which were replaced by similar heat resistant products made of an asbestos-like product, called Cer wool. Cer wool was also contained in solid boards workers used to insulate many other departmental processes; when these boards were cut using saws, fibers were seen in the surrounding air. This aluminous-silica fibre product was also used to insulate, or seal, lids on the auto pours. It was employed by refractory workers, as well as metal transfer and auto pour operators, and was widely used in rebuilding furnaces. At meetings, worker members expressed concern that Cer wool, having a similar fibre structure to asbestos, might one day prove to be just as dangerous. In fact, Cer wool has recently been linked to similar lung effects as asbestos, with researchers concluding it may prove to be just as hazardous (Utel and Maxim, 2018; Bruckner et al, 2021).

Summary of Refractory Department Chemical Exposure Risks

1. High risk for inhalation, absorption and ingestion of refractory dust and fibres containing: Si, AIO, cristobalite, tridymite, heavy metals (Pb, Antimony, molybendum, tin, AIO, Ni, Zn, Mn, Mg, Cu, Fe, Cd), PAHs, BTEX, CO, CO_2, NXO, welding fumes and gases, UV, IR, EMFs, high noised levels
2. Workers' symptoms and complaints: upper respiratory tract inflammation including: coughing, eye, nose, throat, skin irritation and rashes, dizziness, headaches, hearing loss, loss of consciousness.

THE SCRAP YARD

General Description and Risks

Workers employed in the outside scrap yard were employees of the Falcon Steel Company, a subsidiary of Neelon Casting. They operated, diesel-fueled, heavy equipment to move bulk materials around the yard, including sand and metals. Much of their metal supplied Neelon, including ingots of steel and iron, and scrap metals they delivered to bins inside the Melt Department. Outside scrap yard workers' exposures regularly included silica dust and diesel exhaust emissions from the heavy equipment used. Another task performed by yard workers was torch cutting of railroad tracks and other large metal items. This involved the use of oxy-acetylene cutting torches, exposing workers to toxic emissions including welding gases, metal fumes, and combustion by-products.

Outside workers were also subject to toxic releases from the Melt Department through exit doors and exhaust stacks located adjacent to the scrap yard. In addition, used transformers and barrels containing polychlorinated biphenyl (PCB) oil were stored in the yard and it was yard workers' responsibility to physically move them into storage. These containers, when full of PCBs, were known to leak toxins when transported or moved; such leakages were linked to corrosion and/or physical damage. By law, PCBs are required to be stored in containment pools, not in metal barrels.

Summary of Scrap Yard Chemical Exposure Risks

1. Inhalation of silica and heavy metals, diesel exhaust, welding fumes, PCBs.
2. Worker complaints (no specific information)

METAL AND SAND LABORATORIES

General Description And Risks

Laboratory technicians worked in every department of the plant, testing, measuring, and sampling both the melted material (metal lab) and sand mixes (sand lab). Lab technicians measured tensile strength of metal prior to casting and inoculated both melt and sand with additives according to specification. Three technicians worked each shift: one in the sand lab, one in the metal lab and one as utility technician. According to an NWAC member, although three were officially available to work each shift, only two technicians were actually scheduled about a third of the time. When new lab equipment was added/ testing methods improved to the point that additional technical help was needed and the third position of "utility" technician was filled. All three positions were considered interchangeable with technicians working in three-week rotations at each job (Technicians could also be interchangeable within the same shift).

Metal Laboratory: The metal laboratory analyzed all metal samples from both melt and DISA production lines. For most of the first ten years, metal lab techs collected their own samples from furnaces in both the Melt and (Disa lines in the) Mould Departments; this practice continued until 1992, when sampling shifted to workers within both departments. Up till then, technicians were directly exposed to releases from furnaces and ladles while taking melt samples. Until the plant closed, technicians were exposed to dusts associated with grinding and cutting done in the preparation of metal samples for analysis. This work was done outside their office adjacent to a melt deck.

Metal lab technicians employed a LECO Carbon and Sulphur analyzer and two direct-reading emission spectrometers during the use and application of various chemicals while analyzing samples. The work of the utility technician involved: the pouring of test bars for tensile testing, keeping inoculant feeders full, and completing microanalysis on samples of finished castings.

Microanalysis involved cutting a small section of a casting, then grinding and polishing it to a mirror finish before examining the structure of the cast iron under a high magnification microscope. The polishing compound label warned that the product caused birth defects in laboratory animals. For years, lab personnel (who were predominantly female), complained about this potential, and were finally supplied with gloves for protection. A number of lab technicians, who became pregnant, expressed concern about working with the product and filed for worker compensation benefits for loss of income during a leave of absence to prevent harm to the fetus. Their claims were based on the Material Safety Data Sheet (MSDS) that contained a warning of danger to the fetus; the WSIB refused these claims. Eventually, the workers were successful after a claim was made through the company's insurance plan, following an appeal to the Ontario Insurance Commission.

Bystander exposures were a significant source of toxic exposures for technicians, leading to frequent health complaints by metal lab workers. For example, one technician observed: "***Where we would grind our samples was right outside on the melt deck where you would be exposed to dust and fumes from the melt. There were a lot of dry noses and heat rashes.***" Bystander exposures to dust and fumes also incurred during retrieval and preparation of samples for analysis.

Sand Laboratory: Sand laboratory technicians prepped and supplied mould sand to Core and Mould Departments, 14 to 16 times per shift. The sand for the Mould Department was made with reclaimed sand from shakeout in the Finishing Department and included both core and mould sands. The distribution and mixing of ingredients were carried out in large high-speed mixers controlled by Sand Lab Technicians using a control panel in their lab. Technicians collected hourly samples from the production line, testing for moisture, strength, and content. The sand lab mechanically controlled the cooling of the sand and castings.

Mould sand was mixed with sea coal (fine coal dust), clay or bentonite (referred to as "western" or "southern" clay), and water. Sea coal is a ground bituminous coal. Bituminous coal is a soft, natural coal containing 30-40% volatile matter (as molten metal flows into a mould, the sea coal is ignited, consuming oxygen in the mould cavity, providing an oxygen-reducing atmosphere). The "sooting" action of this ignition prevents the "cutting" action of the flowing metal against mould sand, thus inhibiting metal fusion with silica sand grains. The gas content from the sea coal forms a cushion at the metal interface, allowing the metal to lie more evenly and smoothly within the mould.

The different gases formed during casting consisted of CO, CO_2, and PAHs; these were a major source of contamination in the Mould Department, during pouring operations, and later during shakeout. As a result, lab employees in the Mould Department, as well as workers during shakeout in the Finishing Department, were exposed to significant concentrations of CO, CO_2, PAHs and BTEX (refers to the combination of the compounds benzene, toluene, ethylbenzene and xylene). These reducing gases, formed under thermal conditions, are the "useful portion" of sea coal that affects the extent of peel during shakeout (i.e., ease of mould sand break-up with reduced shot consumption and blasting time required to remove sand adhering to castings in the Wheelabrator machines).

Clay ("bentonite") is an organic mineral found in natural deposits. Bentonite is a montmorillonite plastic clay mineral used as a binder in foundry sand to give it strength. According to the supplier's (Halliburton) Safety Data Sheet (2019) bentonite contains crystalline quartz silica which transforms to tridymite, or cristobalite, under extreme heat. The mould sand properties are directly related to the amount of adjusted clay. The performance of bentonite is related to particle size distribution. Different forms of bentonite depend on the preponderance of calcium or sodium ions, and each will have a different structural quality.

Halliburton Energy Services, states in the SDS (2019) for their product "National Bentonite" that: Bentonite is composed of crystalline silica rated as a **Group 1 carcinogen**. Its decomposition by-product is amorphous silica that can transform into tridymite and cristobalite at 870 C and 1470 C, respectively. Both Cristobalite and tridymite are rated as human carcinogens (See Appendix G: MSDS list, for National Bentonite in Section 7: 7.1. under Precautions for Safe Handling).

An important aspect of mould sand is the oolitic characteristic when processed. Oolitic sand consists of mould sand particles that have become coated with metals. This occurs as a result of the interface between sand and metal (at a temperature of 2600F) during the pouring and cooling phase. It is well established that exposure to foundry "dust" involves dust particulate that has coatings of metals as a result of this interface. This metallic coat adds an additional dimension to silica exposure in foundry work, with its unique biological interaction and implications for health outcomes for workers.

Of additional concern is growing evidence that the health impact of exposure to silica during shake out and finishing may depend upon the percentage of "reclaimed" sand in the mould sand mix. Studies by Holzer et al, demonstrate that increased use of reclaimed sand is linked to a significant increase in volume of emitted gases (up to three-fold) by introducing additional amounts of inactive binders (Holtzer et al, 2016 and 2020).

An NWAC member summed up the work of Sand Lab Technicians in the following way: "***Lab techs used grinders and sanders. They mixed and added chemicals such as sea coal, urethanes, and clay to the mixes of sand for the core and mould departments. They measured and tested the quality of the sand for the production of cores and moulds.***"

Sand Lab Technicians retrieved their sand samples directly until 2004. According to several former Lab technicians, this task exposed them to chemical releases prevalent in the Core, Mould, and Finishing Departments, in addition to chemicals used for sand analyses and measurements. Chemicals most commonly used in the sand lab included: bentonite; sea coal; fine silica sand; nitric acid; methanol; hydrochloric acid; sulfuric acid; methylene blue; sodium; and pyrophosphate. The locations of the Metal and Sand Laboratories exposed technicians in both, to toxins from the Mould and Core Departments – and, to some extent, the Melt Department.

There were several polishing compounds lab workers used to finely polish samples for micro-analysis, known as diamond paste, and diamond suspension. Both were used for years without skin or respiratory protection—then discontinued when it was discovered that the labels indicated it was an animal fetal-toxin. (According to several lab technicians interviewed, the label stated the product "causes birth defects in laboratory animals." We could not confirm as MSDSs for these products were not available).

Secondhand Smoke: For years, secondhand tobacco smoke was an issue for the lab technicians. The metal lab was fully enclosed and had "recycled air-conditioned" air. One Advisory Committee member identified that ***"When I started there, smoking was everywhere and if your co-worker was a smoker you were stuck in the room with them."*** In addition, secondhand smoke from the lunchroom was sucked into the lab both because of negative pressure created by oven exhaust fans in the lab, and because the lab opened directly to a lunchroom.

Clean-up: Use of compressed air to clean off floors and work tables. Solvents were often used to clean tools and test equipment.

Summary of Metal and Sand Lab Chemical Exposure Risks

1. **Metal Lab:** inhalation of heavy metal dust and fumes; silica; CO; PAHs; BTEX; acid fumes; polishing compounds; cleaning compounds and solvents; HCL; Methylene blue; pyrophosphate; nitric acid; and rust inhibitors.
2. **Sand Lab:** inhalation of bentonite dust; innoculants; PAHs; acid fumes; graphite isocyanates; CO; CO_2; BTEX; Sea Coal; silica; clay dust; and second-hand smoke.
3. **Symptoms for Both Lab Groups:** irritated eyes/nose/throat; headaches; skin irritation and rashes; and possible exposure to fetal toxins in polishing compounds for Metal Lab.

CORE MAKING DEPARTMENT

General Description

The Core Department was located on two levels occupying an area measuring 200′ x 200′ x 30′. The department consisted of 45 workers over three shifts including: 6 core operators, 6 core handlers ("chasers") and 3 core storage workers per shift assigned to the three production lines. The making of cores involved a sand moulding process using metal patterns to form what would become inner voids of whatever brake product was being made. The machines employed to form the cores were called Redfords and Shalcos, with Redfords being the most commonly used. Total production was estimated at 1000 to 3000 cores per shift. Workers in Core experienced and reported severe upper respiratory symptoms and nosebleeds, with work refusals or complaints occurring on a regular basis.

Production Processes

The production method used at Neelon was called the isocure "cold cure" process. The stages of production included the following:

1. Preparation of sand mix on the upper (mezzanine) level carried out by Lab Technicians;
2. Release of newly-mixed sand onto three open, rotating, bladed tables for distribution into the core making machines on the level below;
3. Distribution of sand mix into the core box(es) of moulding machine(s) where TEA gas was "blown in" as curing agent as cores were formed;
4 Hand retrieval of newly formed cores by "chasers" who quickly hand delivered a pair of cores to nearby operator for dipping in a protective graphite wash;
5. Placement of newly dipped cores onto a conveyor oven for baking at 500 degrees for five minutes;
6. Retrieval of baked cores by "packer" for stacking in multiple layers on plywood sheets prior to storage;
7. Cleaning tasks associated with production.

Preparation of sand mix: Sand Lab Technicians were responsible for preparing the specific sand-resin mix required for the product being produced using the formula provided by manufacturer. Mixing was done electronically in the sand lab office by apportioning the exact amounts of beach sand, various resins, solvents, release/curing agents as required. While the sand was being mixed in large, enclosed, high-speed mixers, the Lab Tech continued to sample and analyze the mix, to ensure it met product specifications.

Release of sand mix onto rotating tables: Once mixed, the sand automatically poured out of the mixer onto one of three open, rotating, bladed turntables, where a utility worker kept the mix moving and bladed tables free from sand-resin build up. This was a physically difficult job due to the amount of sand being handled and the stickiness of the resin coated sand. Workers doing this task were exposed to isocyanates in the form of gasses and dust formed during the mixing process.

Distribution of sand into core boxes and formation of cores: As sand mix entered the core box of a core-making machine, it was subjected to an infusion of triethylamine (TEA) gas—the result of heating TEA in a 45-gallon drum (which NWAC members described as a ***"sludge-like slurry"***). As the heated TEA gas was blown into the core machine, it immediately catalyzed the sand mix, hardening the newly formed core.

Retrieval and "Dipping" of newly formed cores: Once formed, cores were hand retrieved by a core "chaser" who quickly carried them to a core operator seated before a vat of core wash (graphite-based Sea Coal) who then dipped two cores at a time into the wash to protect them from breakage during the baking process.

Baking of cores in ovens: After dipping and wiping the cores by hand, an operator placed them on a conveyor belt (two at a time) that moved the cores through an oven (one, of two available) heated to 500 degrees for five minutes to complete the core-making process.

Retrieval and stacking of cores: Following completion of the bake cycle, cores moved along the line's conveyor belt to a "packer" who quickly inspected each one before "packing" them onto a 4 x 4 sheet of plywood set up on rollers (behind the worker). As many as four different types of cores could be coming through oven feeder lines at once, each having to be placed in a pre-determined number and location on the plywood sheet. Following the placement of spacers on the now fully "packed" sheet, another sheet was placed on top until a pre-determined number of plywood layers was completed. The stacked skid was moved down a roller line and the work of packing and stacking was repeated. Newly formed cores continued to off-gas while being handled and stacked by workers, as full product cure required approximately 8 hours of drying time. The most difficult aspects of "packing and stacking" of the cores were the repetitive nature of the work, the awkward movements required, continual deterioration of gloves, and the need to keep up with the moving line. According to a NWAC member, ***"many people were eliminated, or quit, on their first day at this job."***

Cleaning tasks associated with production: There were daily cleaning tasks associated with maintaining production that included twice (or more) cleaning of machines and equipment (turntables, hoppers, machines and metal patterns) that were prone to build-up of sand mix and/or core materials. An additional daily task was the sweeping/blowing of floors and surfaces at the end of the day. Once a week, a more thorough and detailed cleaning of all machines and floors was undertaken (see following section on chemical exposure risks for more details).

Chemical Exposure Risks

In the Core Department, the handling of and/or exposure to chemical additives began on the mezzanine level where preparation, mixing, and testing of the core sand mix was done by a Sand Lab Technician. The sand (stored in bins on the level above the core making machines) and binder components (in a liquid form) were mixed thoroughly. Typically, the two-part binder contained phenolic resin and isocyanates (MDI). The catalyst was triethylamine—which was blown into the core making machine. Exposures occurred mostly during the pouring stage as mixing was enclosed. However, major exposures would occur when mixed sand was poured onto the open turntables. The majority of work processes were automated, but sampling and testing exposed technicians to small amounts of sand and binders. NWAC members described the mixed sand as having a ***"flour-like, and sooty"*** consistency that was easily airborne, thus inhalation was a primary route of exposure.

More toxic exposures began with the sand resin mix being openly poured onto one of three rotating turntables prior to core making (releasing fumes, vapours and dust into the air), and continued through core formation (associated mainly with leakage of TEA gas fumes through doors and gaskets) becoming most widespread during the long off-gassing as core workers prepared newly formed cores for final bake and packing for storage. The mixture of potentially toxic chemicals included: phenol formaldehyde resins; catalytic agents used to harden the core; release agents; and core wash used prior to baking including the following specific chemicals identified in both MOL inspection reports and MSDSs: CB-A-900; CB-B-920M; Isocote CGW015 and CG2022; Isocure 1-49-48 and 11-612; release agents Ploy-dimethyl siloxane; synthetic hydrocarbon/carbolic acid type ester; Technikura coreactant Part 2; Third Part Additive; 9016-87-9 (polymeric diphenylmethane diisocyanates MDI); Velva Dri GS graphite core wash; and Vainseal silicone

(See Appendix G for MSDSs, and Appendix D, MOL Report #ISB-04/26/76).

Exposure to Isocyanate Coated Sand: Core workers were first exposed to large amounts of chemicals when newly mixed sand was released onto the three large turntables for distribution to the (eight) core making machines on the level below. Being open operations, the three upper-level turntables contained large amounts of disturbed sand mix in the form of dust, dirt, and fumes. Utility workers at the turntables (in addition to workers entering and exiting nearby lunchrooms) were exposed to potentially high levels of inhaled dusts and resin chemical releases (Appendix D, MOL Reports #'s: 85C109AOB and 85C109-O). One NWAC member developed severe skin dermatitis from resin binders while working as a "utility" worker assigned to the turntables. It was determined that he became sensitized to the isocyanate-containing binders and could no longer work in the Core Department. Workers assigned to the rotating turntables experienced severe upper respiratory symptoms, with work refusals occurring regularly.

Exposures to Amines: Immediately, as sand mix entered the core box of a core-making machine, it was infused with Triethylamine gas to catalyze the sand, and harden the newly created core. Due both to frequent overloading of the core boxes, and wear and tear on cold box gaskets, TEA leakage from the core machines was a constant problem. Peak TEA levels could occur if the process did not stop in time, causing the gaskets to rupture. While MOL inspectors estimated TEA exposures to be "low" because some readings were well below the OEL, other readings were at the "high" end, but still below or at the OEL. Workers felt differently about these readings and viewed TEA exposures as a significant concern, summed up by a former core worker's observation: ***"One of the effects was that even with three days off from work, my wife and friends could still smell TEA gas coming out of my body. Many workers complained about this problem."*** Workers regularly exhibited symptoms associated with TEA over- exposures, including seeing blue (or purple) "halos" around lights, having frequent nosebleeds, and often complaining of irritated eyes/nose/throats. Workers reported "glue-like nauseating odors" in the department, especially coming from the 500-degree ovens (Appendix D, MOL Report #s: 0208DMAA; A-3499; OHB090DEOB; and Report dated 01/05/81). Frequently, MOL monitoring was at odds with adverse health effects workers' experienced. It is worth nothing that the OEL for TEA was originally set to prevent acute eye inflammation and irritation and not more serious chronic and systemic effects under consideration (Appendix D, Mol Report #s: EAR891060 and 89H160MAAV). While the company was in operation, the official TEA OEL of 10ppm was 20 times higher than the current OEL standard of 0.5 ppm (ACIGH). Hygiene monitoring conducted by OHCOW in 1999 re-calculated the previous levels recorded, identifying them as up to 51 times higher than the current OEL (OHCOW, 1999). It is important to note that reduction of the OEL to its current level was adopted specifically to reflect updated scientific findings on acute and chronic health effects (Appendix D, MOL Report #: 89L415EOBR). This shows that OELs and TLVs are not health-based limits, as attested to by evidence of adverse effects at levels far below adopted TLVs/OELs (Castlemen and Ziem, 1988). While IARC is yet to classify TEA's carcinogenicity, several studies indicate that TEA has serious, systemic and synergistic health effects when exposures occur in conjunction with silica dust (Zarei et al, 2017).

Exposures to Core Wash: Core wash (BPCI Sudbury Product Name Core Wash) was a major contaminant in the core department being used as a "wash" on newly formed cores prior to baking—to provide additional strength and resistance to heat during casting. The core wash was contained in large vats, where core operators dipped cores, two at a time, shaking off excess wash twice, and then wiping the circumference with a cloth while simultaneously placing cores on an oven conveyor belt. This was a messy job, and dried core wash made up a significant percent of the sand and other particulate that was swept up/blown around by fans in the department. Workers complained that the product ate through their protective gloves, whether cloth or rubber. Packers were regularly exposed to newly ***"baked on"*** core wash when handling the completed cores during inspection and packing for storage. The ingredient list included: magnesium carbonate; kaolin; graphite; fuller's earth; mica; talc; and quartz. Identified as "non-hazardous," under normal conditions of use, the MSDS further identifies it as: an irritant of nose, throat, lungs if airborne; a skin and eye irritant with prolonged or repeated use; causing fibrosis and aggravating other respiratory conditions (mica); causing benign pneumoconiosis with chronic inhalation (Kaoline and Fuller's Earth); causing cancer, silicosis and pneumoconiosis in generating silica dust (quartz); causing lung damage (talc). The MSDS further states that: general and local ventilation be provided if airborne contaminants are generated, to keep exposures below acceptable levels. If these can't be met, respirators should be used.

Exposures to Multiple Fugitive Emissions: There were multiple fugitive emissions coming from core machines and ovens during the 8-hour cure time which generated a complex mix of nitrogen, amines, formaldehyde, CO, CO_2, ammonia, fine quartz silica, isocyanates, and furan, in addition to phenolic resins which can also emit formaldehyde, phenol, acrolein, aldehydes, ketones, sulfur dioxide, hydrogen sulfide, and a variety of Polycyclic Aromatic Hydrocarbons (PAHs) (Appendix D, MOL Report #s: 110159; 1061972; 104884; NIOSH, 1985). A vivid, visually poetic, description provided by a former core worker describing the frequent assaults on air quality at the plant is informative: ***"… from the gray dust everywhere from core wash, to the purple haze around the light fixtures as TEA gas leaked from core machines, to the green and yellow nasty clouds that would come at you when a nearby auto pour would burn out, to the black sand from the mould department that covered everyone with a layer of fine black particles – it was so bad in places like the dead zone that the only thing you would see was a worker's white teeth."***

Exposures Associated with Cleaning Operations: Workers handled large amounts of a strong, multi-solvent, metal cleaner used to clean the core machines and patterns (2 times or more per shift). The cleaner was used in spray form and described as *"extremely irritating."* The product was delivered to the plant in large drums, with workers filling and refilling spray bottles as needed (Appendix G, Metal Cleaner 27 ingredients listed glycol ester DPM, butyrolactone, diacetone alcohol, dibasic ester). Operators were required to clean the core boxes of Redford and Shalco machines twice a shift using the cleaner, steel wool, and a wire brush, in addition to an air hose. According to a former Neelon worker, ***"The metal cleaner was really bad; it came in a spray bottle. There was mist throughout the core department [as a result]."*** Aggravating such exposures was the frequent use of compressed air to remove the cleaner and whatever resins and sand were present on patterns and machines, thereby creating chemical vapours and silica dusts containing graphite (Appendix D, MOL Report #s: 38679; 64649; 1061971).

Other cleaning tasks associated with significant chemical exposures occurred during weekly plant-wide cleaning of all departmental machines and floors. This cleaning was scheduled at the end of the Friday work shift over an allotted 4-hour period. Machines cleaned included: sand hoppers; mixers; turntables; Redford and Shalco core boxes; core wash dipping tanks; and two ovens. According to company documents specific weekly cleaning activities included the following: draining core wash tanks and removing build-up; cleaning the two ovens; draining the conveyor belt cleaner trays; removing sand mag blow plates and chipping out sand; scraping and chipping out the sand mixers; scraping and chipping out turntable plows (in most cases the work required the use of pneumatic chippers, one-inch scrapers, and pressurized air hoses—and in some instances the use of metal cleaner, steel wool or a special definer tool used to remove excess sand). Utility workers were assigned weekly clean-up of large amounts of accumulated core, core wash, and dust build-up under the storage racks where literally thousands of cores would accumulate in a broken state. After doing this task, a NWAC member described himself as being "completely grey from the core wash —from head to toe."

Additional Chemical Exposures: Every Core operator and "utility" worker carried a tiny bottle of super glue called "396 Locktite" used to glue metal to metal. The MSDS identifies the ingredients as ethyl2-cyanocrylate and methyl methacrylate polymer and states that: exposure to vapours above established limits results in respiratory irritation which may lead to difficulty in breathing and tightness in the chest. A former worker described its use as follows: *"We would glue product dates (stamped on aluminum tape) into the core boxes when it was time to change products or if the date fell out. It was very strong glue."* Date codes were also applied to metal patterns using the super glue followed by the spray application of a curing accelerator.

Job Related Exposure Risks

Lab Worker: Technicians' direct exposure to chemicals in the Core Department was limited to the sampling and testing of the sand mix to ensure correct proportions of sand and chemicals; this was done by hand and involved direct exposure to small amounts of sand and resin ingredients.

Utility Worker on Mezzanine Sand Turntables: The utility worker assigned to monitor, and keep clean, the three large rotating turntables was exposed to high levels of silica dust and fumes associated with the resin additives. Sand tables frequently became clogged with cured hard resin, requiring removal. This was a much-disliked job that involved chipping hardened resins stuck to the rotating tables, then blowing the loosened flakes and dust with compressed air. During this cleaning process, significant amounts of resin coated sand and dust were generated in the work environment, subjecting workers and bystanders (including other workers going /coming from the lunch rooms), to significant inhalation and skin absorption risk to silica sand coated with resins including isocyanates. Utility workers provided backup to operators for water and rest breaks as well as other jobs, when needed, including packing cores and conducting tests.

Core Operator/Core Chaser/Core Packer: Due to the large amount of coated sand and dust generated within the department, all core workers were at risk of multiple chemical exposures via inhalation, but also dermally in the handling, dipping and packing of newly formed, still curing, cores. In addition to specific tasks, core workers engaged in major cleaning and other tasks potentially exposing them to: TEA gas; isocyanates; resin fumes/residue; and sand particulate coated with multiple chemicals (e.g., solvents, release agents, binders and combustion by-products, alone, and in combination) present in the work environment. By stander exposures to metal fumes and metal coated sand coming from the Melt Department, in addition to metallic/binder coated sand from the Mould Department, added to the complex mix of exposures for core and near-by workers.

Dermal Exposures: While inhalation exposures were considerable, skin absorption must be taken into account given the manual handling of chemically treated cores during transfers and retrieval. Core operators were dermally exposed to core wash during hand dipping of cores and shaking off the wash twice while wiping the outer circumference and placing them on the oven conveyor. Core packers were exposed dermally to the same core wash chemicals through direct handling of cores and removal of excess wash prior to packing. Core chasers were dermally exposed to hot, freshly curing isocyanates and other binder products, while hand-transporting cores to an operator, prior to baking. Work became more stressful when there were "problems" on a line. For example, one NWAC member stated that as a core operator: "***When you were dipping cores and your partner (chaser) had to fix a machine, you had to chase as well as dip them, sometimes retrieving cores from multiple lines with your gloves dripping all over the floor.***"

In addition, machine operators, handlers, and utility personnel were exposed to metal cleaners and residues applied manually to clean the core making equipment. These chemicals are not only a carcinogenic risk, but can produce severe damage to the liver, kidneys and lungs – in addition to directly damaging the eyes, nose and throat. Note that heat and perspiration is known to enhance absorption through the skin (Appendix D, MOL Report #s: 38679; 64649; 86002; 1061972; 1101569; 104884. Also see JHSC reports: 09/28/99 to 03/2000).

Cleaning Task Exposures: In addition to their main work tasks, operators and chasers performed cleaning and other daily tasks, each with its own exposure risk: core box cleaning (2 x per shift); sand hopper and mixer manual cleaning (1 x per week); Zip slip application of release agent (when product required); changes of Redford/Shalco core boxes (as required); hardness and breakage testing and "First-Off" inspection (i.e., first production run of each shift). Additional daily task for packers included manual inspection of the different types of freshly made cores (single, two cores back-to-back, assembly cores (two poured at once). Inhalation and absorption of metal cleaner glycol ether DPM, butyrolactone, diacetone, dibasic ester, and glue containing ethyl 2 cyanocrylate, methyl methacrylate.

Weekly cleaning of all equipment (simultaneously throughout the plant) added additional risk exposures—in addition to those generated within the department, including those related to: sand run out of machines onto the floor prior to cleaning; chipping, scraping and sanding of various machines, hoppers, and mixers; draining of core wash tanks; and dry sweeping/blowing off floors and all work surfaces. The weekly release of sand and gasses from the core making machines prior to cleaning sometimes resulted in gaskets blowing out, shooting sand and gas outward for a radius of up to ten feet (Appendix D, MOL report #: 09080DEOB). Tasks also included refilling the 3-part binder tanks by hand following different chemical ratios of various binder ingredients which put workers at risk of exposure to isocyanates (Appendix D, MOL Report #s: A-8785 and A-8786; 03682JAAB; 32084FAOB; 37084KAOB).

Ventiliation and PPE Related Issues

The single source of local exhaust ventilation (LEV) was installed to vent the two ovens. Otherwise, general ventilation was relied upon. In addition, fans were liberally used throughout the department for cooling. Workers were provided with masks but their use was discretionary (other than possibly near TEA). According to company documents, the only explicitly identified PPE used in the department included goggles and rubber or cotton gloves (which were often deemed inadequate for the job). Even during major cleaning tasks that included the use of pneumatic chippers, scrapers and sanders the only PPE required were goggles and rubber gloves. These jobs were dirty, lengthy, difficult and often involved working inside various machines that no one liked doing. The widow of a long-deceased former employee (who died in his mid-30s) shared: ***"My husband hated getting inside and scraping the large machines. It was a very dirty job; he did it all the time and It bothered me a lot."***

MOL reports of complaints, symptoms, and work refusals indicate numerous instances of nose bleeds and workers falling asleep at work stations, or when driving home from work. Given the levels of silica dust coated with resins and other chemicals, as well as exposures to carbon monoxide, toxic exposures in this department were significant and ventilation was inadequate (Appendix D, MOL Report #s: 0208DMAA; 77H023000; A2499; 85C109AOB; EAR891060/89160MAAV; 38679).

It was common practice to regularly blow the floor area off with high-pressure air hoses creating an environment where, as a former worker described: ***"the dust was just crazy…a cloud of dust would float all the way over to auto pour #3 in a thick, greyish cloud."***

The ovens were natural gas-fed burners that produced CO and CO_2 as well as other by-products of the incomplete burning processes. For a small number of cast products requiring a much deeper cavity, a chemical known as Zip Slip was used to spray 2 or 3 "shots" into the mould's deep cavity for ease of release (Appendix D, MOL Report #: 77H23COO).

Summary of Core Department Chemical Exposure Risks

1. Inhalation and absorption of: solvents; isocyanates (MDI); polymeric resins and release agents; decomposition by-products (amines, toluene, SO2, formaldehyde, phenols, acrolein, CO, trichloroethane, bentonite, TEA, silica graphite, ammonia); metal cleaner 27 (glycol ether, DPM, butyrolactone, diacetone, dibasic ester, morphine, glycol ether); and glues (containing methyl 2-cyanoacrylate, polymethyl methacrylate, hydroquinone). Other exposures included high noise levels, heat stress, and overwhelming odors from TEA and core processes.
2. Worker symptoms and complaints: frequent complaints of eye/nose/throat irritation and distorted vision, nose bleeds, skin rash/irritation, lung congestion, nausea, hives, headaches, dizziness, loss of consciousness, hearing loss, and facial swelling (See Appendices D, E, and F).

PATTERN MAKING SHOP

General Description

The Pattern Shop (which measured 80′ x 50′) was responsible for the maintenance, cleaning, repair, and changing of patterns as required. Patterns are metal inserts placed into the mould sand to create the shape and size of a product being cast. Pattern workers also built wooden patterns, specifically for small gates, runners and risers because metal patterns would shrink when cooled, leaving an inaccurate impression in the sand mould. In addition to constructing wood patterns, workers manufactured wooden frames for rebuilding furnaces. The shop employed 4 to 5 workers per shift to ensure that patterns and tooling were clean and in good condition. The workers provided necessary tooling for the Redford, Shalco, and Disa machines in both Core and Mold Departments in addition to removing and installing patterns from these systems when damaged, or requiring a product change. Pattern workers' activities were divided between working in their own shop and other departments, based on keeping the three production lines running smoothly. Pattern workers also served as maintenance helpers (as needed) in other areas of the plant. Generally, workers spent 25% of their week in other departments (2 to 3 hours per task) thus were exposed to hazardous chemicals and toxins in those departments as well. "Repair" was the major job category for Pattern workers according to the 2006 Neelon Production Manual but other job categories included: CCM Operator (responsible for testing of patterns to match original specifications); tooling Coordinator (no job description); and Moulding Utility/Core Room Floater (worker assigned to either Mould or Core Department to facilitate pattern changes). These job titles seemed to be the company's response to cost/efficiency evaluation, shortly before the plant closed. NWAC members were unaware of these job classifications, with workers in the Pattern Department described as able to do all job tasks with no specific job title.

Production Processes

Work was primarily integrated into the production processes of both Core and Mould Departments with workers having set jobs related to start and finish of the day's production, emergency repairs, and preparation of patterns for the next day or shift. These tasks can be viewed as:

1. Pattern maintenance including cleaning and repairing of metal and wooden patterns;
2. Wooden Pattern building and refractory repair;
3. Changing and inserting patterns into Redford, Shalco, and Disa machines as required which may include cleaning and minor repairs to machines;
4. Emergency response/repairs due to malfunctions;
5. Assisting other departments; and
6. Cleaning tasks.

Pattern Maintenance: To ensure that metal patterns and tooling (provided by customer) functioned properly, pattern workers continually took measurements of pattern size and shape and inspected for defects or damage. Workers would clean the patterns, usually with a compressed air gun to remove sand and other contaminants left from the previous moulding, and if needed, used metal solvent and steel wool/wire brushes to remove debris. Patterns were then sprayed with metal release agents to ensure that sand did not stick to the pattern during its next use.

Wooden Pattern building and Repair: The pattern shop included a large carpentry section where patterns were fashioned from cherry wood, specifically for small or fine parts—in particular, gates, runner, and risers. Wood was used because metal patterns would shrink when cooled, leaving an inaccurate impression in the sand mold. Workers used band saws, planes, chisels, joiners, grinders and sanders in this work. In addition to constructing wooden patterns for core and moulding, pattern workers also built wood frames used in refractory rebuilds of furnaces. Wood patterns were cleaned with a product called LPS. Repairs of wooden patterns frequently involved the use of a two-part epoxy to re-attach loose gate patterns. We have no additional information for these two products.

Pattern Changing and Insertion: Pattern workers were often required to work inside large core and moulding machines while inserting and changing patterns or when cleaning and doing repairs. This involved work inside confined, often tight spaces while using metal cleaners and tools. Workers were also required to clean core boxes in Redford, Shalco, and Disa machines using the same strong metal cleaner. In the Mould Department, workers sprayed down patterns with a release agent before every production cycle.

Emergency Response: Pattern workers were on call for any emergency that would occur involving pattern functioning. This might include a simple cleaning or a more difficult repair operation. For example, a worker could spend as little time as a few minutes or many hours on an emergency call.

Additional Tasks: Pattern workers were recruited as maintenance helpers for other departments. This exposed them to work environments throughout the plant and their observations and experiences authenticate those of workers assigned to the different departments. Additionally, they assisted the Finishing Department by regularly checking the dimensions on gates and risers. They also engaged in daily and weekly clean-up of the pattern shop which involved sweeping and blowing off tables and equipment exposing them to a mixture of contaminated sand and metal as well as wood dust/particulate.

Chemical Exposure Risks

Both metal cleaner and metal release chemicals (which created a fine airborne mist) were used in large amounts in the Pattern Department in cleaning and preparation of metal patterns for their next use (specific product name is Metal Cleaner 27 listed in Appendix G). The most toxic pattern shop chemical mentioned by NWAC members was Metal Cleaner 27: ***"The worst chemical in the pattern shop was the metal cleaner that was used, and then blown-off, with a high-pressure air hose. The procedures would create great clouds of dust, containing silica and metal cleaner, that was inhaled by the pattern worker as well as other workers in the vicinity. The metal cleaner and an air hose were also used to clean core boxes in the Core and Mould Departments. PPE was used. Pattern workers would clean about 2 to 3 core boxes a day." In describing the metal cleaner, another pattern worker stated: "It was a high carcinogen. Made my fingers swell to twice their size when cracks happened with the rubber gloves…no one knows how long it stays in the air after blowing-off?" A long-time worker in the Pattern Shop said this about the metal cleaner: "I fought to have (safety) levels of the metal cleaner tested and the results were not good. Levels were so high when they tested it, that it was off their charts. So, we had to use self-contained breathing tanks with a suit until they got a new type of metal cleaner, which they said was 'safe to drink'. So, I told him to go ahead and have the first drink. We also used toluene to remove contact glue until they got rid of it because it was bad for you. The core room used air hoses to clean off core boxes, so they worked all shift with silica sand floating in the air, as we did also in the Pattern Shop."***

To repair metal patterns, lead was cut from bars of lead solder by workers and pounded into pattern cavities, then the solder was smoothed using a soldering iron. NWAC members noted that metal patterns were often heated, producing strong, pungent odours.

Since Pattern Shop workers also did carpentry, the atmosphere was described as heavily laden with suspended wood dust (no air concentration data available). Inhalation of wood dust is shown to slow down clearance of dust in the lungs and upper respiratory tract and alter the structure of mucus membrane in the nose and sinus cavities with the risk of nasal and sinus cancer (Mgonja CT, 2017). A cleaner called LPS was used to clean wood patterns leaving a thin film of grease on the wood pattern. The cleaner was first sprayed on and further applied using sponges, rags, and bare hands. Although workers said they generally used PPE in the course of their work, often on small "quick" jobs they did not bother. A long time Pattern Shop supervisor shared: ***"In most cases, white paper masks were used and fumes would go right through them. I have COPD. I didn't realize until after a year that it could be work-related."*** During repair of wooden patterns, a two-part epoxy called "bondo" filler was used to re-attach loose gate patterns. Workers would also glue wood gates and risers to (metal) patterns as well as affix metal date codes for each batch of cores (the filler product contains respiratory irritants, ethyl2-cyanoacrylate and methyl methacrylate polymer).

During cleaning and repairing of metal patterns, considerable quantities of "used" sand from both Core and Mould Departments were generated in the form of dust and particulate, adding to the toxic mix of solvents, glues, metal particulate, and wood dust known to be present in the environment.

Job Related Exposure Risk

There was generally only one job category associated with the Pattern Shop that of maintaining, cleaning and servicing the various patterns used in both core and mould production. Because workers spent their time divided between the Pattern Shop and working in other departments their work histories must take this into consideration. Generally, workers' major toxic exposure risks included handling and breathing in strong metal cleaners, release agents, glues, coated silica, and wood dusts generated in the Pattern Shop itself, in addition to the exposure risks associated with Core and Mould Departments where they spent approximately 25% of their time.

Ventilation And PPE Issues

Ventilation was generally poor, as was provision and use of appropriate/adequate PPE. Workers relied only on the general ventilation system to dilute airborne contaminants to which they were exposed on a regular basis. The shop had fans but lacked adequate LEV until approximately 2000 when, as one worker explained: ***"CO testing went off the charts"*** and they installed additional LEV systems in the department. According to ex-pattern workers, respiratory protection provided was either ***"inappropriate for the exposure or not enforced"*** until much later in the company's history.

Summary Of Pattern Shop Chemical Exposure Risks

1. Inhalation/absorption (wood dust); solvents (metal cleaner 27 containing glycol ether, DPM, Butyrolantone diacetone alcohol, dibasic ester, morpholine); PAHs; silica dust; welding fumes (maintenance); refractory dust and heavy metals when fitting frames into furnaces; CO; Stoddard solvent (alkyhline petroleum distillates); "360 Locktite" adhesive Super Bond (methyl 2-cyanocralate, poly methyl methacrylate), and a two-part epoxy "bondo" filler. Workers were also exposed to high noise levels and heat stress.
2. Worker symptoms and complaints: upper respiratory inflammation, eye/nose/throat irritation, skin rash, lung congestion, headaches, dizziness, Central Nervous System (CNS) effects, heat stress, and hearing loss.

THE MOULD DEPARTMENT

General Description

The Mould Department was where the actual casting of metal brake parts occurred. The department employed 15 workers per shift, with 5 workers per line (3 lines) including: 1 core tray operator; 1 Disa operator; 1 auto pour operator; 1 metal transfer operator; and 1 moulding utilities worker.

The company began (1976-1986) with a single mould line; by 1991 it had three mould lines, with the building expanded by 34,000 sq. ft. to accommodate the major increase in production.

With expansion, there were three mould lines, each having an auto pour and Disamatic moulding machine. The pour capacity for line #1 line was approximately 200 pours per hour; line #2 was 250 pours per hour; and line #3 was 300 pours per hour for a total of approximately 750 pours per hour (Appendix D, MOL Report #: ISB-02/26/76). By the time the plant closed it, was estimated that Neelon produced up to 1000 metal castings per hour).

Production Processes

1. Preparation of sand carried out by the Sand Lab Technicians on mezzanine;
2. Insertion of core and closing of two half moulds to form a completed mould for casting;
3. Auto Pouring of molten metal into semi-automatic Disa mould machines; and
4. Clean up.

Sand Preparation: The sand preparation process involved the mixing of sand with bentonite clay, sea coal (a bituminous, or "soft" coal to prevent burn on), and water. In addition, various release agents were added to ensure moulds did not adhere to the patterns. The actual sand was a combination of clean sand and recycled sand from the core making process (containing resins and other contaminants). The bentonite, sand, reclaimed core sand, and sea coal were stored in separate silos outside the plant and pneumatically transferred into the mixing process, using blowers and pinch valves. This mould sand re-mixing process, carried out by Sand Lab personnel was monitored and tested regularly. The various mix ingredients were added to mould sand via the Muller, or mixing, machine. After mixing, the sand was fed into a Disa machine where casting took place. The sea coal burned off quickly during casting, allowing numerous gasses to escape. This burn-off enabled the sand to 'peel away,' creating a smooth finish on the brake part.

Core Insertion and Mould Formation: The semi-automated Disa mould production process began with compression of sand against the metal patterns to create the two halves of the mould. An automated machine then inserted the core into a "core setter" space and the two halves of a mould closed, forming the completed mould with a shaped cavity created to receive molten metal.

Auto Pour of Hot Molten Metal: Auto pour furnaces were the delivery and storage system for the molten metal that fed into the three Disa machines. Prior to each pour, a set of "chamber sprayers" released lubricant, coating the inner surfaces of the newly formed mould to aid the flow of melt inside the mould, and assist in smooth movement of completed moulds along the pour rail of the Roberts conveyor system. During mould production various inoculants were added to both moulds and molten metal.

Complexity of Chemical Exposures

There was minimal chemical exposure for Lab technicians during the largely automated sand mix operation except when conducting sampling and testing. There were numerous instances involving significant exposures to bentonite associated with outside silos. On occasion, Sand Lab Techs were confronted with problems in the transfer system between silos, and maintenance personnel were called in. If a transfer was inadvertently initiated while a maintenance mechanic was checking the equipment, the mix spewed out covering the worker in sand mix, with the small workroom becoming contaminated with bentonite and sea coal. Labourers responsible for cleaning these spills were exposed to dust from these materials.

During insertion of the cores, chemical exposures to bystanders (e.g., core tray operator, disa operator, and mould utility workers) were associated with chemicals and toxins in the ambient air. The auto-pour operation that followed, generated emissions of metal fumes, chemical vapours, and gases. As the extremely hot molten metal (approximately 2600F) made contact with the sand mix, there was a significant release of smoke, fumes, and gases as a result of the sea coal igniting. Workers described the environment as ***"very smoky and hazy."*** CO was emitted as a result of incineration of sea coal and other carbonaceous materials; the levels identified at Neelon were 100s of times in excess of the OELs with measurements as high as 1700 ppm (Appendix D, MOL Report #s: 91H406EOBA; 52290; 1101569; 104884). Such high measurements were evidenced by workers losing consciousness, or falling asleep, while operating mould machines and auto pour furnaces. Over the years many workers were written up by the company for "sleeping at their workstations" until it was discovered they were actually suffering from carbon monoxide poisoning, due to extremely high CO levels in both Mould and Core Departments (Appendix E, JHSC data on CO monitoring: 11/26/99;12/17/99;03/200112/13/14/2002;12/14/2002;04/03/2002;13/14/2003;01/09/2003;08/25/2003; 01/02/2007; 01/30/2007; 05/13/2007). All CO-effected mould workers were in close proximity to the sand mould production processes (Exposed workers included: laborers raking off excess melt from above the lines; core tray operators; Disa Operators; auto pour operators; and metal transfer operators).

The complexity of emissions released as a result of pyrolysis (created by hot metal hitting the sand mix) requires detailed analysis. The emissions contained decomposition by-products from coated sand, burning sea coal, phenolic resins, and release-agents that resulted in exposures to: metal fumes (lead, antimony, magnesium, cadmium et al); sulfur; formaldehyde; silica; isocyanates; amines; phenols; nitrogen; CO; CO_2; PAHs; benzene; benzo-pyrene; toluene; and xylene. Silica in the sand mix was likely released in the form of cristobalite or tridymite as a result of exposure to high heat (Appendix D, MOL Report #s: 25481HAAB; 05081LAOB; 37084KAOB; 85C19AOB; 87G250EOAP; 52290; NIOSH 1985).

During mould production various inoculants were added to both the mould and molten metal. One such inoculant was a dusty, grainy, silver material added as they filled with molten metal. This inoculant was designed to aid in the proper microstructure formation. The metal/utility tech controlling the flow kept the screw feeder full by scooping pails of the material from barrels and working it through a screen into the screw feeder hopper. One NWAC member recalled: "This material reacted with the sweat on your skin and made you itchy." We were unable to identify the name of this chemical as there was no MSDS, nor was it mentioned in the company's Operations Manual, or known by workers interviewed.

The term "mould line smoulder" was used to describe burn-off and smoke as a result of pyrolysis. Fumes were so intense that there were complaints from those working directly in moulding, as well as by-standers working in lunch-rooms, labs, the mould/core area, and even as far as areas in shakeout and finishing. These bystanders were exposed to significant levels of grinding dust consisting of silica, metals, and grit from the grinding department located adjacent to Disa operators, auto pour operators, and metal transfer operators (Appendix D, MOL Report #s: 16978FEOB; 05081LAOB). They were also exposed to: metal fumes and dusts containing lead, antimony, cadmium, amines, ammonia, PAHs, benzene, toluene, xylene, chlorine, MDI, formaldehyde and other aldehydes, furfuryl alcohol, triethyl-amine, sulfur oxides and hydrogen sulphide – as well as hexamethylenetramine, if production changed to a hot box moulding process. These emissions are endemic to the foundry industry and well recognized in the industrial hygiene literature (NIOSH, HSE, Australian Government Public Service, ILO, WHO).

Job Related Exposure Risks

Core Tray Operator: Responsible for unloading core skids onto trays to be sent to Disa operator via an overhead tray chain. The awkward, up and down motion of lifting and placing these trays (up to 40 lbs) on the conveyor put workers at high risk of musculoskeletal injury. In addition to directly breathing in the extensive fumes, vapours, and dust (formed as a result of pyrolysis) workers handled hundreds of chemically coated cores per hour wearing gloves that provided inadequate protection and deteriorated quickly. Thus, there was the potential for dermal exposures as well as the risk of inhalation of dust containing residues of resins and release agents.

Disa Operator: Responsible for setting cores in the core setter prior to the two halves closing before the pour. The operator manually handled each core when setting them in place. There was risk of inhalation of dust containing residues of resins and release agents in the core dusts covering the cores. Operators would also be exposed to CO from the sea coal ignition and were known to fall asleep at their work stations, an indication of CO poisoning.

Auto Pour Operator: Positioned at a computer control panel, the worker operated a control station both behind, and elevated above, the Disa Operator to determine the timing and volume of pour as moulds passed under the pour box. He also controlled the speed of the mould line to ensure moulds remained pressed together. The auto pour operator was subjected to exposures of smouldering smoke and fumes from metals and resin/release agents. It was noted, these workers frequently experienced headaches and extreme heat since their work involved servicing the pour box and pulling hardened over-pour waste above the mould line into a box under the operator, in addition to directly breathing in the extensive fumes, vapours and dust formed as a result of pyrolysis.

Metal Transfer Operator: Responsible for maintaining a full auto pour at all times—which involved moving a large ladle back and forth from an Ajax furnace in the Melt Department to the auto pour box. This entailed securing the ladle under the furnace, filling it remotely, and then pouring it into the fill spout of the auto pour, adding inoculants as required. The ladle was then returned to its standby position for the next auto pour refill. Worker exposures included metal fumes and smoke combined with very high heat stress and physical effort, as well as the potential for serious burns. Workers were exposed to silica dust migrating from the shakeout and grinding department in addition to directly breathing in the extensive fumes, vapours and dust formed as a result of pyrolysis.

Moulding Utility Worker: Essentially a replacement or relief worker role to allow operators to take breaks without shutting down operations, as well as preparing patterns for product change and general clean-up. Exposures would be the same as replaced workers throughout a shift. He would also be breathing in extensive fumes, vapours, and dust formed as a result of pyrolysis.

Utility workers were assigned cleaning tasks which involved sweeping and use of an air gun to blow off dust and debris from floors and machines.

When assessing exposures, it must be kept in mind that production took place in the context of high volumes of melt and resinous sand used to produce castings. A multiplicity of air contaminants was produced during thermal decomposition of the mould and core materials both during and after pouring (as curing took place). In a study simulating foundry conditions using green sand moulds, researchers identified that CO concentrations often served as an indicator of general emission levels (i.e., peaks and troughs) over time. Peak emissions occurred shortly after mould pouring with the emission rate decreasing gradually until shakeout, when CO levels suddenly rose again to a second peak (Scott et al, 1976). There was general consensus that moulding and shakeout processes made the most contribution to CO concentrations at the plant, noting however, that CO gas was ubiquitous throughout the plant because most operations involved incomplete combustion.

Ventilation and PPE Issues

At the time of plant expansion, engineering controls were not upgraded to take into account increases in toxic emissions. Numerous MOL reports requesting information from the company with regard to ventilation were ignored leading inspectors to finally order the company to develop detailed plans for exposure control. According to a subsequent MOL report, the company did not comply and exposure conditions worsened (Appendix D, MOL Report #: 91H406EOBA). Further, the plant lacked LEV (Local Exhaust Ventilation) in many departments putting increased pressure on the general ventilation system, already underperforming due to widespread use of fans.

The only PPE provided by the company were goggles, face masks, and cotton or rubber gloves. In the early years the use of PPE was not always adhered to—or enforced. In later years, workers in the Melt, Mould, and Finishing Departments were provided with organic or fine particulate cartridge type masks.

Summary of Mould Department Chemical Exposure Risks

1. Inhalation and absorption of: sand mix ingredients/decomposition by-products; isocyanates; phenols; phenol formaldehyde resins; bentonite; resins; polymeric release agents; CO_2; CO; heavy metals (Pb, Cd, FeO, Mg, Mn); PAHs; graphite; and silica and grinding particulate from the grind operations in Finishing. General atmosphere heavily laden with smoke and dust.
2. Worker symptoms and complaints: eye/nose/throat irritation; frequent headaches; CNS; fatigue; falling asleep at workstation/drive home; nausea; sinus irritation/infection; severe skin irritation and rashes linked to bentonite; and difficulty breathing and lung congestion (See Appendices: D, E, F).

FINISHING DEPARTMENT: Cooling, Shakeout, Clean and Grind, Rust-Proofing

General Description

The Finishing Department was the final stage in production of metal castings. The finishing process began as freshly poured metal castings contained in sand moulds were cooled on a moving conveyor for approximately 60 minutes. The moulds were "violently shaken" to separate the sand from the castings before continuing through an extensive vibrating and blasting process. When cool enough to handle, castings were manually cleaned, trimmed, ground, polished and rust proofed to meet customer specifications (with regard to size, shape, strength, and durability). Finally, the newly cast brake parts were inspected to ensure there was no damage or defects. This department, which had several components, employed from 16 to 20 workers on three shifts, seven days per week – with employees working on average 48 to 60 hours per week.

Production Processes

The finishing process involved the following procedures:

1. The cooling process;
2. The shakeout and blasting process;
3. Manual separation of sand from the castings;
4. Manual grinding, cleaning and polishing;
5. Manual mixing and application of rust proof coatings;
6. Tagging and packing the castings; and
7. Clean up.

The Cooling Process: After molten metal was poured into the moulds, they slowly moved forward in groups of ten along "pour rails" as part of the Disamatic process (a process equipment developed by the Disamatic Company). The moulds were lubricated during the pour before reaching the rails to ensure smooth movement. Fifteen feet of pour rails carried the moulds into a "Roberts" conveyor. The "Roberts" (an enclosed metal conveyor belt approximately 100 feet in length) held 100 moulds, depending on size – cooling as they moved slowly by rail for approximately 60 minutes. The moulds were then placed in two large drums for additional cooling. Note: There were two cooling drums to service the three mould lines, with one, servicing both line #1 and #2.

After this initial cooling process, castings and sand remained hot and smouldering at approximately 800 degrees F. It was only at shake out that both castings and sand cooled down to approximately 100 degrees, and could then be handled.

The Shakeout Process: After leaving the "Roberts" conveyor, castings, loose sand, and large sand clumps dropped from the moulds onto a slotted vibrating conveyor called the "Grizzly." There, much of the sand separated and dropped through the slots onto a conveyor below. Castings and remaining attached sand were dropped from the Grizzly onto a second shaker conveyor that continued through an area called the "Dead Zone" (described below). The castings, with clumps of sand still attached, bounced violently along the long vibrating conveyor to further break-up the remaining sand mould. As it separated, much of this resinous sand dropped off in the Dead Zone forming a thick film of very fine sand on floors and surfaces. The Dead Zone covered an area of the plant 40′ x 100′ x 35′. Major parts of the shakeout operation occurred in the Dead Zone where the majority of the resin-treated sand and sea coal dropped onto the floor to be shovelled and swept up later by utility workers.

Reclaiming Sand for Re-Use: During shakeout, a separate but parallel process of reclaiming the newly released sand, for reuse in the moulding process, occurred. A portion of the still smouldering sand was dropped from the vibrating "Grizzily" onto a conveyor—then carried to a bucket elevator (referred to as a "skip hoist") where it was transported as "used sand" into a large storage silo. This recycled sand would then be mixed with clay, sea coal, and water in large high-speed mixers in preparation for its re-use in the mould-casting process. Sand could be recycled and processed numerous times before it was deemed "unsuitable." Reprocessing of the mould sand was overseen by Sand Lab Technicians, who monitored, sampled, and tested the sand during mixing—making required adjustments to ensure uniformity and proper content of the newly "recycled" sand mix.

As loose sand was directed for recycling, newly formed castings were dropped onto a rubber conveyor and fed into a rotating cooling drum. This rotary drum (sixty feet long and fifteen feet in diameter) had a capacity of thirty tons of sand and six tons of castings contained in a "fluidized system." As newly freed castings were "pushed out" of the drum, they were loaded into the conveyor system. The cooling drum rotated at about 3.2 revolutions per minute.

After exiting the cooling drum, castings fell onto an inclined rubber conveyor, then dropped into a hopper that fed them into a second drum called a Didion Drum. Here metal ingots inserted into the moulds, prior to the pour, "tumbled" over the castings, removing built up sand and flash. This "cleaning media", as it was called, consisted of four-sided pyramid-shaped metal ingots about 2"x 1".

Grinding and Finishing Process: Once roughly cleaned, castings were taken to a large cleaning area where 15 to 20 workers utilized numerous tools including: two pneumatic chippers, an auto grinder, five stationary pedestal grinders, and four hand-held grinders to carry out more detailed cleaning of rough spots on the castings.

Each of the stationary/auto grinders had a grinding wheel thirty-six inches in diameter and approximately three inches thick. Auto grinders were used mainly to trim the outer diameter of the castings while hand grinding was used for the inner diameters. Hand grinding was carried out by four workers on each side of a four-foot wide, rubber, conveyor belt.

After rough grinding and polishing, castings were sent to four or five rotating inspection and finishing tables, approximately thirty-six inches in diameter. There finish-grinding, sanding and buffing took place, followed by a final inspection.

Worker Exposures in the Finishing Department

Exposures During the Cooling Period: During cooling, the extremely hot moulds were smoky and smouldering, continually off-gassing toxic gases/fumes and exposing workers monitoring the movement of fresh mould along the cooling conveyor. Near by workers were also exposed to high concentrations of silica dust. Workers in the area were continually inhaling and absorbing large amounts of pyrolysis combustion by-products from resins and release agents contained in the newly moulded sand as it continued to smoulder. These combustion by-products included: heavy metal fumes from the melts; amines; ammonia; formaldehyde; benzene; benzo-pyrene; acrolein; antimony; chromium; carbon monoxide; lead; Nickel; Zinc; sulphur oxides; PAHs; Magnesium; and Manganese (NIOSH, 1985). The shakeout was extremely noisy with noise levels over 100 dBA (Appendix D: MOL Report#s: A2507; 86F0594AOB; 13779KEDA).

Importantly, worker exposures during cooling and shakeout included heavy concentrations of carbon monoxide gas produced by incomplete combustion particularly as the moulds broke apart. This was noted in the hygiene literature on foundry casting and documented in MOL reports of CO monitoring (Scott, 1976; NIOSH, 1985; Appendix D, MOL Report #s: 1101569; 104884; 52290). It was observed that the levels of CO would come down at the end of the first cooling period, and rise again during the violent shakeout as sand broke off the mould.

Manual Separation of Casting: Following separation from sand moulds and exiting the rotary drum, castings moved onto a vibrating conveyor where workers manually retrieved them, separating remaining gates and risers with hammers, chisels, scrapers and grinders before placing them back onto the conveyor. This was a very dusty operation as workers created large amounts of silica dust while chipping and grinding to remove the mould sand, risers and gates. Castings were then guided into one of three wheelabrators and blasted with steel shot for approximately 20 cycles, or 30 minutes. This was a very dusty operation because door gaskets on the machines leaked, being continually in a state of disrepair. As well, the open flow of castings moving out of the drum released additional amounts of silica dust into the air.

Exposures during Shakeout: The shakeout process was extremely dusty—literally creating clouds of dust that made it impossible to see. One worker recalled: ***"I tried to find my work mate while working in the dead zone. I called out for him and only spotted him when I saw the white of his teeth. The black dust was so thick, and he was covered in black sand, so that I couldn't spot him, until he smiled."*** The Independent observation of a pattern worker was supportive: "***Dust levels so high you could barely see the workers in shakeout. Masks not enforced in the early period. Before then, I don't think there was any ventilation at all in the shakeout area ... There was no mask enforcement for contract workers. Paper masks were worn forever, but (eventually) got some improvement with cartridge masks.***"
It is important to note, that for 24 hours a day, the three Wheelabrators continually blasted castings with steel shot, as the machines processed thirty-two castings per minute (for three shifts) with fifteen to twenty employees working nearby (48 to 60 hours per week, often seven days a week).

A MOL report documented silica levels in the area 8 times higher than the OEL, with inspectors concluding that Wheelabrators were "a significant source of high silica levels" (Appendix D, MOL Reports #s: 05081LAOB; 29-00014-0001-1976-1978; 12282DAOB). Workers in the finishing area were exposed to dusts, fumes, and smoke containing a wide range of PAHs and binder residues, as well as silica dust coated with various heavy metals in addition to carbon monoxide.

For products made of softer metals, the less frequently used 30 ft. long Panghorn Drum would "more gently" separate sand from the castings. This machine leaked considerably more silica dust than the leaky Wheelabrators (particularly at the access door, and points of entry and exit).

Exposures in Grinding and Finishing: Once roughly cleaned, castings were taken to a large area where 15 to 20 workers utilized numerous tools including: pneumatic chippers, an auto grinder, five stationary pedestal grinders, and four hand-held grinders to carry out detailed cleaning of rough spots on the castings. There was high risk of exposure to metal dust during this operation, as well as to other exposures in the general atmosphere, associated with curing of the metal castings.

The enormous amount of chipping, grinding, sanding, and polishing carried out by 15 to 20 workers 24/7, produced an intense concentration of silica dusts, metal dusts, and fumes—in addition to phenolic resins fumes and grinding grits held together with epoxy resins. This operation produced enormous amounts of silica dust, grinder-grit dust, and metal dust, with grinders handling approximately 1000 castings per hour. In addition to inhaling large amounts of silica dust, workers were frequently hit by grinding debris coming from those working opposite them along the conveyor belt.

After rough grinding and polishing, castings were sent to four or five rotating inspection and finishing tables (approximately thirty-six inches in diameter). There finish-grinding, sanding and buffing took place, followed by a final inspection. Work at the finishing tables produced fine respirable particulate.

Due to the friction caused by the high-speed grinder, this contaminant mixture "broke down" into fumes and fine particulate. Metal contaminants, as well as release/binding agents, were contained in the fine particulate. It is important to note that the silica particulate/dust was already coated with metal from the interaction of molten metal contacting the sand mould. This high level activity continued for an entire 12-hour shift (often seven days a week), without local exhaust ventilation to mitigate exposures. Typically, workers and by standers were exposed to extreme concentrations of fine particulate composed of multiple, potentially toxic, chemicals. By standers to these exposures included: auto pour operators, metal transfer operators, and Disa operators working adjacent to the grinding area.

In the company's first decade, the core department adjoined the grinding department, exposing core workers to grinding dusts, and exposing finishing workers to vapours and fumes from the core room including: TMA, MDI, metal cleaner, and dust, containing graphite.

Exposure to Rust Proofing Chemicals: Prior to storage, utility workers sprayed or "washed" the finished brake part using a rust proofing solution (#FN-J1-7.5-0) that was mixed manually in a pail (at a 1:10 ratio of product to water). This step was added when production increased and delivery linked to demand was instituted by most auto producers, resulting in products being stored outdoors (by suppliers) for longer periods of time. Workers were exposed to rust proofing solution via both inhalation and absorption.

Exposures in the Dead Zone: Resin-treated sand used in the mould consisted of bentonite heated to 1427C, which at that temperature is transformed into both cristobalite and tridymite. It is likely that these two pyrolysis-related by-products contaminated the Dead Zone. As one NWAC member stated: ***"You had every type of emission in the Dead Zone. They would shake out moulds filled with sand and dust from cores as well as fumes from smouldering molten iron"*** (Appendix D, MOL Report #: 32525).

In conclusion, worker exposures in the dead zone included: silica, resin residues, PAHs, and heavy metals in addition to risk for exposure to CO, amines, benzene, lead, and antimony. A fine powdery black or purple dust was visible in the air, on surfaces, and covering those who worked there. As one NWAC member commented: ***"Workers there for any length of time came out totally blackened from head to toe."*** A second worker noted, ***"You couldn't see five feet in front of you because of all the black sand falling."*** One NWAC member said he was informed by an outside building specialist that exposure to this dust would do ***"irreparable damage to one's lungs."***

While workers were officially prohibited from entering the Dead Zone, maintenance personnel regularly entered the Dead Zone to repair machinery (the conveyor system particularly), spending considerable time carrying out these repairs. Since repairs often involved welding, workers were simultaneously exposed to welding fumes and gases in addition to moulding dusts in the dead zone. Informally, the dead zone was a popular shortcut for many employees, as well as a popular route for fork lift operators who spent up to two hours daily traveling through the zone while carrying out work responsibilities (e.g., picking up and emptying sand from various shakeout processes).

Exposures In "The Crow's Nest" And #3rd Mould Line: A different route to shakeout was taken by sand castings in mould line #3 which was elevated from the other lines. A worker was assigned to a workstation called the "crows-nest," accessed by climbing a ladder. There the worker would grab parts coming off line #3, placing them on a conveyor belt that carried the castings down and into a Wheelabrator or Panghorn machine. This process was worker controlled using a diverter switch. The worker's exposure to castings heavily coated in sand and resins, while continually handling them, was made worse by a replacement air duct blowing forced air directly onto his face and workstation, surrounding him in a cloud of silica dust.

Ventilation and PPE in the Finishing Department

The Finishing Department was viewed as a major source of air pollution and contamination throughout the plant, existing primarily in the form of fine silica dust and resin residues. Workers attributed much of the ubiquitous black dust (that many "tried" to wash off prior to going home) to shakeout contamination. Despite the enormous amount of contaminated dust generated, the finishing department relied only on the plant's general, largely inadequate, ventilation system, to protect workers.

The company's procedure manual specifically identified only one piece of equipment as hazardous, the pedestal grinding machine. They included detailed information on its health hazards with explicit instructions on the use of required PPE (in particular, the use of an air supplied respirator). With this exception, no other respiratory protection was specifically identified in the Neelon (2003/04) Procedure Manual dated three years prior to the plant closing. The Manual did, however, recommend goggles, gloves and aprons for most work processes, included under the heading "equipment," not as PPE.

Dust control and housekeeping were poor to barely adequate. PPE initially consisted of surgical masks, which was later upgraded to N-95 paper masks—with Racal air supplied helmets with face masks in use during the last few years of operation. A very ineffective mechanical floor sweeper was available to workers in the Finishing Department, but, as one worker noted: ***"this kicked up more dust than it swept up, usually leaving a trail of dust behind it."*** The majority of clean up was carried out by broom and shovel, and without utilization of dust supressing materials to help cut down airborne dusts (Appendix D, MOL Report #s: 89L415EOBR and 91H406EOBA).

Pedestal grinders were equipped with dust collectors, which were ineffective in reducing or preventing exposures. One worker noted: *"Large grinders had their own dust collectors, but dust escaped anyway because of the high velocity of these grinders."* With the exception of these Pedestal grinders, no other types of grinders, including hand held grinders, had local exhaust ventilation. Reasons for the lack of LEV may be related to economic costs and plant efficiency. As one NWAC member noted: *"Occasionally, the (shakeout) system would get clogged. Someone would have to go into the shaker, throw off hot castings, and shovel off sand to get it working again. That was one reason why they never put in dust collectors; if there was a back-up (of dust), they would have to first remove them (the LEV)."*

Risk Exposures by Job Category

The Finishing Department consisted of 12 to 15 workers per shift including: operators, grinders, sorters, inspectors and utility workers. According to the Procedural Manual their tasks included the following:

Machine Operators: responsible for set up/operation/maintenance of the Didion drying drum, Wheelabrator and Pangborn "shakeout" machines. Additional Brinnell testing, (i.e., testing the composition and integrity of cast metal) and administrative tasks were conducted by machine operators, including weighing and tagging of finished products.

These workers experienced intense silica exposures, evidenced by the clouds of dusts generated by the shakeout operations, made worse by the extended time (e.g., 12 hour shifts and overtime) spent in the area. In addition, the three machines that they operated were the worst offenders for silica leakage from their poorly sealed doors.

Grinders: responsible for set up/operation/maintenance of both mechanized and manual grinding machines/processes. These workers were substantially exposed to metal laden dust and grit from all three grinding operations. Also, they would be exposed to grinding wheel dust particulate and resin adhesives that held the grit together.

Sorters: responsible for directing product movement to the correct rework and storage location as well as testing and finishing tasks that could be done by grind/sort/inspect workers. As by-standers, they were exposed to dusts and other chemicals in whatever area they worked in.

Inspectors: responsible for inspecting individual castings as well as testing and finishing tasks designated for grind/sort/inspect workers; they were exposed to intense concentrations of silica and grinding dusts.

Utility workers: responsible for providing break time for other workers and filling in where needed. Other tasks including hand mixing rust proofing solution/filling machines, in addition to testing and various finishing tasks. In providing relief, they carried out a variety of tasks involving chipping hardened material or metal from the surface of the castings, rough and finish grinding, utilizing: pneumatic chippers, a large auto grinder, four pedestal grinders, and four hand-held grinders for detailed cleaning and smoothing of castings. These tasks placed them at high risk of exposure to chemicals associated with close handling of metal and sand contaminants in the department. They were additionally exposed to fumes and vapours while performing rust proofing tasks.

Forklift drivers: responsible for picking up and emptying sand from various shakeout processes in the dead zone, exposing them to chemical fumes including resins in addition to metal coated dusts and CO throughout the department.

Summary of Finishing Department Chemical Exposure Risks

1. Inhalation, absorption, ingestion of heavy metal/resin coated silica grinding dust (Pb, Ni, Zn, Mg, Mn, Cu, Fe) CO, formaldehyde, PAHs, BTEX, Stoddard Solvent, grinding silica particulate. Inhalation silica coated with phenol formaldehyde resin and metal and welding fumes; heat stress and high noise levels;
2. Worker symptoms and complains: upper respiratory tract irritation (eyes/nose/throat), congested lungs, frequent headaches, and difficulty breathing. Skin irritation and rashes were also experienced by many workers.

MAINTENANCE DEPARTMENT

General Description

The Maintenance Department was staffed by 15 to 20 workers responsible for inspection and repair of all mechanical, electrical, and computer-based machinery/equipment in the operation of the foundry. In addition to the maintenance shop, they worked in all other departments being exposed to contaminants generated in the departments they serviced. The duration of exposures and their intensity varied, depending on the extent of repairs and time required.

Maintenance staff included: electricians, mechanics, technicians and an engineer (supervisor). Day shift included: one electrician, two mechanics, one supervisor, and two production workers. The night shift included a somewhat smaller component of maintenance workers.

Maintenance Responsibilities By Department

Departments where maintenance frequently worked included: Disamatic and core machines in Mould and Core Departments, Wheelabrators and vibrating conveyors used during shakeout, and the various grinding machines in Finishing Department. Maintenance workers spent a great deal of time carrying out these repairs in the highly contaminated Dead Zone. Mould, Core, and Finishing Department/machines had the worst silica dust levels in the plant. Maintenance staff would regularly service and repair cranes in the Melt Department and auto pours in Melt/Mould Departments. This involved chemical exposures of long duration, often while working in confined spaces. Chemicals they were exposed to included: metal cleaners, solvents, lubricants and adhesives. In performing certain tasks, maintenance staff were subjected to additional exposures, in particular during: welding repairs, preventive maintenance, and daily inspections prior to commencement of production.

Welding Operations: Welding was a significant part of work done by maintenance staff. These operations took place throughout the plant on a project-by-project basis. Stick welding and Oxy-Acetylene were the predominant welding processes used for weld repairs and cutting. During on-site operations, there was no local exhaust ventilation, thus work areas were shrouded in a smoky blue haze that is characteristic of welding fumes. During such projects there was considerable bystander exposure to these fumes. (In addition to maintenance workers, refractory personnel also carried out welding during cutting and repairing refractory, especially ladles and furnace walls. Exposures linked to welding fumes in refractory were complicated by workers' cutting through many different toxic refractory materials identified in the MSDS section of the report).

With expansion, the old maintenance shop became a welding shop for fabricating slag poles and testing spoons. Exhaust ventilation consisted of a dryer vent tube placed beside the work and then vented, unfiltered, to the outside. The room was small and quickly filled with welding smoke.

The few welding operations that could be conducted in the larger maintenance shop had limited+ ventilation provided by "smoke eaters" used to extract fumes at source. Workers described them as minimally effective in extracting welding fumes, because they were not cleaned or changed on a regular basis.

One of the worst welding operations involved burning out the backs of auto pours. Smoke from that procedure was extremely intense described by workers as ***"enormous amounts of red, black and brown smoke, with fumes and particulate circulating in the mould department, and surrounding areas in the plant."***

Large scale and major plant-wide welding operations were generally carried out by welding contractors from the surrounding area, and if possible, during plant shut downs. Concentrations of welding fumes were never sampled at Neelon, nor were chemical contents identified. Local welding projects were prevalent in all departments throughout the plant, and for the most part took place in unvented and open areas. Thus, workers in all departments were at some time exposed to welding fumes. In summary, maintenance workers were regularly exposed to smoke and fumes from welding, in addition to whatever contaminants were present in the areas where they worked.

Welding Chemical Exposures: Welding fumes are produced when metals heated above their melting point vaporize and condense into fine particulate. This report relies upon the industrial hygiene literature to determine potential concentrations of toxic exposures and the identification of specific contaminants. In this regard, we rely on IARC's most recent monographs on welding fumes. IARC classifies Welding Fumes as a Group 1 carcinogen. Chemicals and physical agents associated with welding operations include: NO, CO, argon, helium, ozone, MgO, Cr, Cd, FeO, Pb, Zn, Ni, UV and EMF radiation. Absorption and secretion of Cr, Ni and Mg has been reported in people exposed to welding fumes. Also present in welding operations are numerous PAHs associated with the burning of organic contaminants on metals being welded. In addition, workers would have employed solvents including trichloroethylene to degrease and clean metals in preparation for welding which can result in formation of phosgene. In IARC's latest review of welding, the (IARC) working group stated, there is strong evidence that welding fumes induce chronic inflammation and are immunosuppressive (IARC, 2017).

Melt Department: Maintenance workers indicated that servicing and repairing cranes occupied a great deal of time and were among the worst exposures in the melt department. Crane repairs involved exposure to extreme heat, metal fumes, furnace dust, and PAHs in addition to metal cleaners, solvents, and greases. Work in this department involved scaling the rails approximately 10 feet above the mouth of a furnace where concentrations of metal fumes and other emissions were very high. Maintenance workers were subjected to smoke, metal fumes, silica dust, carbon monoxide, and PAHs in Melt. They spent considerable time in this department because cranes frequently broke down and often involved intricate repairs.

Dead Zone: Maintenance workers experienced intense exposures to silica dust coated with binders and release agents, CO, and PAHs during routine inspection of equipment and while making repairs to the conveyors. In addition, they were subjected to intense noise and vibration. The dead zone was highly contaminated from the shakeout processes with maintenance staff spending considerable time in this area.

Shakeout/Wheelabrators: Maintenance workers were exposed to intense vibration and noise during repair of conveyors and while working inside large Wheelabrator machines. This work involved intense exposure to silica dust leaking from warped doors during the cycle, as well as repairs made inside confined (unvented) spaces.

DISA and Auto Pour Repairs: Maintenance workers were subjected to intense silica exposures while making general repairs and adjustments to computer-based systems on the Disa line which was located adjacent to the shakeout/grinding operations in the Finishing department. Workers were also exposed to CO and PAHs, prevalent in these areas.

Grinding area: Depending on the nature of repairs required, maintenance workers could be exposed to enormous quantities of dust composed of grinding grit particulate, metal dust, and silica, related to the amount of time spent on the repairs.

Plant building structure: NWAC members identified that upper beams of the building were always encased in large quantities of accumulated dust from the various operations—which were frequently disturbed by cranes moving along the rails, or furnace explosions, both which caused the beams to shake. The accumulated dust that rained down was highly contaminated with heavy metals, PAHs, and silica, further contaminating the work environment. This risk of exposure was greatest for maintenance workers required to work in these contaminated upper areas on cranes and machines located above the mouth of the furnaces.

Ventilation and PPE Issues

Maintenance personnel, like other workers throughout the plant, depended mainly on general ventilation. Workers identified wearing hard hats and N-95 paper masks into the 1980s, with organic cartridge type respirators introduced in the 1990s. Not all workers wore respirators provided by the employer.

Multiple Exposures: It is important to note that maintenance workers were at high risk of intense multiple chemical exposures due to the work they performed in the various departments in, addition to exposure to toxic fumes and gases from welding operations they performed.

These departmental exposures included: 1. Core Department - silica, CO, isocyanates (MDI), graphite, phenol, formaldehyde, amines (TEA), toluene, xylene, PAHs, acrolein; 2. Moulding Department - PAHs, CO, silica, phenols, MDI, heavy metals; 3. Melt Department - Heavy metals (Pb, Ni, Zn, cd, Be, An, Mg, Cr, Cu), silica, CO, sulfur, RCF, N, PAHs, BTEX; Shakeout/Finishing Department - Silica (metal and binder resin), phenol, acrolein, CO, sulfur oxides, MDI, thermal decomposition products, sulfur oxides to note the major hazardous chemicals and gases maintenance workers were exposed to in carrying out their tasks. In addition, maintenance staff performed extensive welding that involved exposure to welding fumes and gases that included the following hazardous chemicals: NO, CO, argon, helium, ozone, heavy metals (Mg, Cr, Cd, Pb, Zn, Ni, Be), UV and EMF radiation, PAHs, solvents (trichloroethylene, toluene, benzene, methyl ethyl ketone). Based on IARC's latest review, Welding is classified as a Group 1 Carcinogen (IARC, 2017). This places Maintenance workers at particularly high risk of occupational disease.

Summary of Maintenance Department Chemical Exposure Risks

1. Inhalation and Absorption: welding fumes (PAHs, silica, BTEX, phenols, metal solvents and lubricants; highly toxic Dead Zone dust (silica, phenol formaldehyde resins); and, heavy metals (Pb, Ni, Cd, Zn, Mg, Mn), BTEX, PAHs) were major, daily, exposures. Maintenance workers also inhaled and absorbed chemicals prevalent in the departments they serviced. Working in confined spaces with solvents (e.g., Stoddard Solvent - alkyne petroleum distillates), cleaners, and lubricants worsened the inhalation and absorption of toxic chemicals. Multiple toxic exposures were associated with welding in the dead zone which was heavily contaminated with toxic chemicals. Maintenance workers were also exposed to high noise and heat levels with the added pressure to make their repairs quickly.
2. Worker symptoms and complaints: headaches, eyes/nose/throat and lung inflammation, coughing, lung congestion, difficulty breathing, skin rash, dermatitis and hearing loss.

ADMINISTRATIVE OFFICES/LUNCH ROOMS

Significant By Stander Exposures

During the foundry's first decade (1975-1988), a number of administrative offices were located over the melt department arc furnaces. There were frequent complaints by professional personnel about air quality and the intrusion of fumes, smoke, and dusts into their offices from furnaces located below.

It was discovered that several occupants of these offices had significant body burdens of heavy metals including lead and antimony. According to laboratory results, the level of antimony in the urine of one such occupant was 10 times the permissible limit. This group of administrative and managerial workers should be contacted regarding possible harmful effects of past exposures at the Neelon plant (Appendix D, MOL Report #: 23718; See Appendix E, Body Burden and Air Concentrations).

Lunchrooms: Two (closely situated) lunchrooms, used by all workers, were located between the Core Room and Disamatic moulding machines. Neither was fully segregated from these two departments, both of which generated significant levels of contaminants that would enter lunch rooms every time doors opened and closed. As one committee member noted: ***"In lunch room #1, the door swung open from the sand lab and Disa Line #1, right there with emissions coming in. In lunch room #2 it was connected to the core room, and all those ISOs were there… so, we weren't segregated at all."***

PLANT WIDE EXPOSURES

The Significance of Multiple Chemical Exposures

Health hazards identified in foundries include both chemical exposures (silica, metal dusts and fumes, carbon monoxide, thermal decomposition products, PAHs) and physical hazards (heat, noise, vibration, UV and EMF radiation, and handling of dangerous and potentially explosive, molten metal). Significant physical hazards are linked to high stress levels which exacerbate the impact of toxic chemicals on workers' bodies. Numerous chemicals associated with foundry work are known or probable carcinogens. **NIOSH identified that: 7 out of 29 chemicals used**

in mould and core production were known/potential carcinogens; 13 out of 33 chemicals used in the melt operation were known/potential carcinogens; 15 out of 35 chemicals present in pouring of moulds were known/potential carcinogens; and 16 of 27 chemicals used in shakeout and finishing were known/potential carcinogens (NIOSH, 1985). Based on the tremendous number of chemicals used in foundry work, and large percentage that are known/potential carcinogens, **IARC has classified foundry work itself as a Group 1 carcinogen (IARC, 2012).**

The Neelon foundry was essentially an open concept operation. With the exception of some offices, control rooms, labs, and lunchrooms—production processes were not separated by walls, nor did they have their own (local) ventilation systems. Each department (Melt, Core, Mould, and Finishing) employed, in large amounts, multiple toxic chemicals, that were unique to a department or overlapped with other departments (often in different forms, e.g., dusts, fumes, and/or gases). The widespread use of fans (to control heat) in all departments (arbitrarily, and uncontrollably) spread dust, fumes, and gases from department to department—making the identification of specific chemicals and in specific amounts, difficult, if not impossible, to both qualify and quantify.

Air sampling at Neelon, was limited to those substances that required monitoring under the Designated Substances Regulation (asbestos, silica, lead, isocyanates, benzene, arsenic, vinyl chloride) and, on occasion, to identify/confirm a health problem (measurements taken for CO, TEA, PAHs, formaldehyde). Thus, we have significant, but limited, information to "confirm" the presence and concentrations of certain chemicals. Since the company closed in 2007, OELs/TLVs have been lowered for several chemicals, demonstrating that OELs themselves, are not evidence or health-based limits—and are unduly influenced by corporate interests (i.e., the application of the ALARA principle "As Low as Reasonably Achieveable") (Casselman B and Ziem G, 1988; Roach SA and Rappaport SM, 1990; Ziem G and Davidoff L, 1992). We can assume, older limits allowed far greater exposures than today's limits would allow. Workers' risk of exposures was made worse by the fact that they received little instruction on the hazards of chemicals used and/or were exposed to—as well as inadequate central and localized ventilation and absence of proper PPE.

In summary, the Neelon foundry was essentially an open concept operation; production processes were not separated by walls or contained by ventilations systems. This is evidenced in the frequent MOL and worker reports that illustrate cross contamination between departments. For example, reports show that workers in the Finishing Department experienced exposures originating in the Core Department (including: TEA, MDI, metal cleaning vapors), while workers in both Core and Moulding Departments experienced exposures from shakeout and grinding operations in the Finish Department (including: silica, CO, and grinding particulate). This was apparent from worker descriptions of the plant's dusty and dirty atmosphere and strong odours, and their filing of MOL reports identifying (similar) adverse physical symptoms.

Discussion

This retrospective review of chemical exposures at Neelon Casting, documents worker exposures to a multiplicity of carcinogens, chemical irritants, and other chemical toxicants, experienced at significantly high levels. These chemicals used, and produced, in foundry production have well-known adverse and carcinogenic health effects, and are associated with a number of occupational diseases endemic to the foundry industry, specifically cancerous/non-cancerous respiratory disease and cardiovascular illness and death. Such exposures are well- documented in the epidemiological and industrial hygiene literature (HSE, 2017; NIOSH, 1985; IAPA, 1985; Campo et al, 2020; Chenjing et al, 2018; Freire et al, 2020; Holtzer et al, 2020; Hye et al, 2015; Kelleher et al, 2000; Kmita et al, 2018, 2019; Lee et al, 2015; Mgonja, 2017; Michaud et al, 1993; Riaz et al, 2017; Scott et al, 1976; Sen et al, 2019; Tong et al, 2019; Tossavainen, 1976; Chen et al, 2020; IARC, 2014).

The Health Impact and Production of Occupational Disease: In the fifteen years since Neelon closed its doors, a wide range of likely occupational diseases and illnesses have developed among former Neelon workers, including those who have died. Since USW and OHCOW began collaborating on the Neelon Casting occupational disease intake process in August 2020, approximately 289 diseases have been identified. These include: 47 cancers, 102 respiratory diseases, 49 circulatory conditions, 24 nervous system & sense organ disorders, 22 musculoskeletal injuries, 5 mental health conditions, 5 endocrine/metabolic/immunity disorders, 4 genitourinary diseases, 5 digestive system issues, 4 other types, and 25 cases monitored for health only.

During this investigation we reviewed obituaries identifying deaths among former Neelon employees as reported in the local Sudbury press and collected by Jessica Montgomery and former workers. While these were limited in number (22 death notices), we were struck by what appeared to be an abnormally high number of deaths among younger workers, ranging in age from late 30's to late 50's. In this regard, we note that of 22 death notices where the worker's' age was identified, 17 were between the ages of 36 and 59 years (77%), several died in their early 60s and just 2 of 22 workers lived beyond age 70. This is mentioned to point to the need for further research and documentation into the issue of premature death among the Neelon workforce having an occupational link.

Our review of the occupational disease literature on foundries strongly indicates that the incidence of disease and premature death among Neelon workers is not an artefact but a reflection of occupational diseases produced worldwide in this industry, including what went on at Neelon Casting for over 30 years. The historic literature on foundry work stands as confirmation of what needs to be viewed as a global, workplace disease tragedy. Importantly, a review of the foundry industry reveals a rich literature on engineering controls that are not new to the industry. There is a comprehensive, historic literature that provides engineering designs and specifications for effective control of very toxic exposures in foundry work (NIOSH, 1985; HSE, 2017; Safe Work Australia, 2013; ACGIH, 1998). Unfortunately, for former Neelon workers, such recommendations were ignored/unknown by both government and the company.

Chemicals Used/ Produced are Highly Toxic with Known Adverse Health Effects: Many chemicals used and produced at Neelon (and foundry industry, generally) are highly toxic. In a Chemical Health Effects Table in Appendix C (Adapted from NIOSH, 1985) listing the range of chemicals prevalent in foundry production, their known health effects, and target organs, we provide documentation of their toxicity. These various chemicals are rated in the medical and scientific literature as: carcinogenic to humans, mutagens, irritants, neurotoxins, fetal toxins, endocrine disruptors, asphyxiates, lung and upper airway irritants, and kidney and liver carcinogens, as well as linked to: gastrointestinal cancers and disorders; leukemia/blood disorders; chronic obstructive pulmonary disease; cardiovascular disease; emphysema; silicosis; asthma; dermatitis; and pneumoconiosis to mention the more well-known, adverse effects and diseases associated with foundry chemicals (See also: Oudyk, 1983; Freire BM et al, 2020; Bauer AK et al, 2018; Mgonja, 2017; Cooke J et al, 2017; and deVocht F et al, 2009).

Exposure to Complex Mixtures and their Impact on Health: Exposures at Neelon Casting were complex and not amenable to a simple one chemical, one disease assessment. Many articles and primary documents reviewed in the preparation of this report begin with the premise that foundry work involves substantial exposure to multiple carcinogens and chemical irritants, simultaneously. A recent Australian study of the prevalence of exposure to multiple carcinogens for Australian workers in general, estimates that 81% are exposed to one or more carcinogens, and 29% are exposed to more than 5 carcinogens at work (McKenzie J et al, 2020). We have no precise empirical data of the number of toxic chemicals workers at Neelon (or in specific departments) would have been exposed to, but based on our data it is highly likely that nearly all workers were exposed to 100 or more possible carcinogens on a daily basis—whether from direct tasks or bystander exposures. Many of these chemicals were both inhaled and absorbed through the skin and have adverse effects on similar target sites—in particular, the lungs, respiratory tract, kidneys, liver, and bladder. Some, like benzene and formaldehyde, are known endocrine disrupting chemicals, while others mimic estrogen—or trigger the initiation of estrogen, a known tumour promoter. In addition, the intense production of carbon monoxide has a powerful effect on both central nervous and cardiovascular systems. Increasingly, it is recognized that multiple exposures must be considered an additional, significant, risk factor in the overall assessment of disease production for foundry workers (Demers and Del Bianco, 2013; Demers, January 2020; NORA/NIOSH, 2004; Ibarluzea et al, 2004; Moroni B et al, 2014, Michaud D,1993; Mohamed RS, 2020).

There are numerous studies providing ample evidence of adverse health effects under multiple exposure conditions. In a study involving the impact of environmental Xenoestrogen on breast cancer risk from pesticides containing a variety of estrogenic chemicals, researchers found that no single chemical could be positively and statistically associated with the increased risk of breast cancer—but did find a statistically significant elevated risk (OR= 5.67 (95% CI 1.59-20.21) in the highest tertile of the Total Effective Xenoestrogen Burden (TEXB-a) in adipose tissue and increased risk of breast cancer among women with low Body Mass Index (BMI) showing a statistically significant dose/response trend. The researchers suggest that this was due to a combined effect of several organohalogens and the complex interactions between chemicals, endogenous and exogenous hormones, and their natural ligands and receptors. The authors conclude that the assessment of adverse effects **must analyze the combined effects of compounds and their biological interactions** (Ibarluzea et al, 2004). In a previously mentioned study, researchers found a synergistic effect of simultaneous exposure to silica and triethylamine on a lung function parameter, specifically a decrease in forced vital capacity (FVC) (Zarei et al, 2017). Evidence of the impact of trichloroethylene (TCE) on noise induced hearing loss (perhaps a potentiating effect of a chemical on a physical agent) has been acknowledged, as well as the synergistic impact of asbestos on tobacco smoking and increased risk of lung cancer (NORA/NIOSH, 2004). The study by Bauer et al, demonstrates the co-carcinogenic properties of low weight PAH and their interaction with Benzo-a-Pyrene (Bauer et al, 2018). A study by Mohamed RS et al (2020) showed how certain founding metals (Fe and Zn) can act as co-coagulants placing iron and steel workers at high risk of CVD. Similarly, Moroni et al (2014) demonstrated how exposure to carbonaceous materials and metal particulates (e.g., graphite contaminated quartz in conjunction with metal particulate is linked to oxidative stress and inflammation) can have synergistic effects due to concomitant exposures, which plays a key role in lung injury in the foundry industry.

According to IARC, foundry work has very diverse chemicals and processes resulting in occupational exposure to a wide variety of substances including: substantial exposures to silica; carbon monoxide; airborne polycyclic aromatic hydrocarbons (PAHs from thermal decomposition of carbonaceous ingredients added to foundry sand); airborne chromium and nickel; and bindery chemicals including phenol, formaldehyde, isocyanates and amines. After reviewing numerous studies, IARC classified foundry work as a Group 1 carcinogen— but has not addressed the question of mixed exposures directly (IARC, 2014). **Yet IARC's review and designation of founding as a Group 1 carcinogen based on that evaluation, is a tacit acknowledgement of the impact of multiple exposures to carcinogens as both a causative agent and potent risk factor for occupationally induced cancer.**

Exposures to Contaminants were Complex, Intense, and Chronic: Worker exposures to foundry contaminants were marked by their complexity, intensity, and chronicity. These are verified in body burden measurements of metabolites of PAHs, BTEX, and the presence of heavy metals in blood and urine samples documented in bio-monitoring literature and in samples of Neelon workers analyzed by the Ontario Ministry of Labour (See Campo et al, 2020; Freire et al, 2020; Jafari et al, 2020; Mehri and Juneja, 2004; Mohamed et al, 2020; Neslihan and Nuren, 2010; Peng et al, 2019; Riaz et al, 2017; Ribeiro et al, 2006 and MOL and JHSC reports in Appendices D and F). **In summary, these many studies cited provide scientific evidence and support for the work of the NWAC in documenting workers' chemical exposures and their claim that illnesses and diseases suffered, and in the context of their co-workers' deaths, are in fact, work related. This study documents, and is based on, the real-life experiences of workers—the work they performed, the materials they used, and the actual daily conditions under which they worked.**

Biological Sampling Revealed High Levels of Five Chemicals and Evidence of Others: The somewhat limited (e.g., small number of chemicals tested) data available from testing and sampling at Neelon Casting conducted by the MOL, OHCOW, and hygiene consulting firms over the years, reveals consistently high levels of lead, antimony, silica, triethylamine, and carbon monoxide, and considerably lower concentrations of isocyanates and formaldehyde linked to phenol formaldehyde binders and resins. While in lower concentrations, these measurements do indicate the presence and exposure to these contaminants, both rated as carcinogenic to humans. These lower readings were contested by workers who argued that the test conditions were not representative of actual conditions and were interfered with by the use of oscillating fans. Comparisons between biological concentrations and air concentrations have always been problematic. Some researchers have been able to make correlations that are reliable, while others have found correlations unreliable or unrepeatable. It is not our intention to make such comparisons given the limited amount of sampling and analysis, but we thought it important to at least indicate that workers were definitely exposed.

Limitations of OELs and Hygiene Monitoring In Disease Prevention: While we have argued in several studies that the TLVs published by the American Conference of Government Industrial Hygiene are not health based and protective, we do maintain that the introduction of strong, health based, standards—not influenced by corporate interest and strongly enforced, can be instrumental in advancing worker health (DeMatteo and DeMatteo, 2020, 2017).

With respect to the weaknesses in OELs to provide protection to workers, it is instructive to note a statistical/ modelling study, carried out by Keil et al, 2019, on the impact of lowering the silica standard on lung cancer mortality. The authors engaged in estimation of the number of cancer mortalities that might be avoided if the Silica exposure standards were lowered from 100ug/m³ (OSHA standard from 1989-2016) to 5ug/m³ (OSHA standard set in 2016)—and even lower. They used data on 65,999 workers pooled from multiple industries and estimated the impact of lowering the standards on lung and all-cause mortality. Assuming the elimination of occupational exposure is possible, the authors' estimated 20.7 fewer deaths per 1000 workers in their pooled cohort by age 80 (65,999 workers) from lowering silica exposures from 100 ug/m³ to 5ug/m³ (95% confidence level: 14.5-26.8) including 3.91% fewer deaths owing to lung cancer (95% confidence level: 1.53-6.30). The results of these intervention calculations indicate substantial reduction in deaths from all causes and lung cancer are possible, and that occupational exposure limits for silica can be further strengthened to reduce silica related mortality. They also illustrate the extent to which current risk analysis for occupational limits can be improved, particularly with respect to healthy worker bias, which underestimates the true risk. Their work provides supportive evidence of the widely held contention that OELs are not protective or health-based limits, thus are not a reliable criterion upon which to base work relatedness analysis (Keil et al, 2019; Castleman and Ziem, 1988; Hansson, 1998).

An example of over exposure at Neelon is illustrated by the current OEL for triethylamine that is now 51 times lower than the OEL used by the MOL during its hygiene monitoring at Neelon in the 1980s (See Appendix D, MOL Reports/OHCOW Reports, 1999). While (MOL) hygiene monitoring at Neelon done in the 1980s is limited, it provides important evidence of significant exposures and intake of toxins that contributed substantially to a worker's body burden of chemical toxins. For example, sampling conducted by OHCOW in 1999 showed that: Lead levels were several times higher than the OEL and exceeded the adjusted OEL of 0.025mg/m³ ranging from 8% of the OEL to 64% over the OEL (0.00214 mg/m³ to 0.04mg/3; antimony levels in urine and blood were 10 times higher (1.2ug/g-3.64ug/g creatinine) than normal (0.120 -0.364 ug/g of creatinine). In addition, CO levels, as measured on personal samplers and stationary monitors, were between 16 to 60 times higher (400 ppm to 1500 ppm) than the OEL of 25ppm; silica levels were several times higher than the OEL, while the presence of copper, chromium, iron, zinc, nickel, cadmium, sulphur, magnesium, and manganese—was demonstrated, but in lower concentrations (Appendix E: Air and body burden data).

Pervasiveness of Silica Sand in Its Many Sizes and Forms: The most prevalent, and extensive, toxic exposure at Neelon was silica respirable crystalline (silica RCS), which was ubiquitous at the plant—literally everything was coated with silica of varying particle sizes; the atmosphere presented as a haze of fine suspended silica dust, soot, fumes, smoke and vapour from the pyrolysis processes taking place in Melt and Mould Departments. Other departments contributing to the high level of silica dust, and toxic atmosphere, were the Core and Finishing Departments that contributed their own chemical sand mixes and/or further spread such contaminants throughout the plant. The latter process was greatly facilitated by the plant's open concept design, with few walls to isolate different departments and work processes. The practice of using compressed air hoses to "blow-off" metal cleaner, sand, and binder residues from machines and floors in the Core, Mould, and Pattern departments remained air borne with oscillating fans facilitating its dispersal far beyond these departments.

Recent studies have examined in detail the (additional) presence of metal coating and resins on silica sand linked to the addition of reclaimed sand in the mould mix. In documenting this additional source of sand contamination, researchers identify that the toxicity of silica sand increases relative to the percentage of reclaimed sand in the mix (by as much as three times). This is a major finding with significance in linking multiple chemical exposures to illness and disease but also in identifying a (previously unknown) factor that has a multiplier effect

on the toxicity of crystalline quartz silica. Moroni et al (2014), point out that risk assessments in cast iron foundries tend to ignore possible lung injury by concomitant exposure to carbonaceous and metal particulates. Metal exposures have likely been underplayed in previous silica-related risk assessments of foundries. Recent studies indicate that metal exposures play a significant role in the production of disease in foundries. In bio-monitoring studies of foundry workers, Campo et al (2020), found that workers were exposed to metals at levels exceeding biological exposure limits, particularly for cadmium. Similarly, Cappellietti et al, 2016, identified metal particulates as an important pollutant linked to excess mortality for tumor, lung cancer, ischemic heart disease, liver disease, and excess "all cancers."

In this regard, exposure to metals, silica, TEA and phenol/formaldehyde was a single multiple chemical exposure that formed simultaneously and should be viewed as potentially synergistic, additive, and/or having potentiating effects. Importantly, the work of Bauer et al (2018) demonstrates the co-carcinogenic properties of low molecular weight PAHs and their interaction with Benzo-a-Pyrene which increases the carcinogenic risk. This research has significance for Neelon Casting workers, where this exposure combination was highly prevalent. As well, the work of Zarie et al, 2017, demonstrating potential synergistic effects of concomitant exposure to TEA and Silica on lung function, adds additional weight to these synergistic potentials. While all workers at Neelon were exposed to this multiple-chemical covered silica sand, it was finishing, refractory, and maintenance workers who were especially exposed—in large amounts, and for extended periods of time.

Pyrolysis, and Addition of Reclaimed Sand, Increase Contaminant Exposure Risks: There is a growing body of industrial hygiene data on numerous contaminants, both generated and released, as a result of the high-heat pyrolysis process that materials undergo during foundry production foundries (Dungan and Reeves, 2007; IARC, 2009; HSE, 2017; Safe Work Australia, 2013; Oudyk, 1983). These processes produce a broad range of polycyclic aromatic hydrocarbons (PAHs) and benzene, toluene, ethyl-benzene, xylene (BTEX), formaldehyde, isocyanates, acrolein, amines, ammonia, CO, CO_2, carbon black (soot), hydrogen sulfide, oxides of nitrogen, phenol, sulphur oxides, iron oxides, welding fumes, amines and oolitic silica. Pyrolysis studies have identified organic compounds from the pyrolysis of sea coal (and gilsonite) in foundry sand that includes generation of benzenes, phenol and PAHs. Some of these by-products have been identified and measured at Neelon, but the list is not comprehensive. Importantly, scientists have recently identified that the addition of reclaimed sand to new mould sand increases the volume of these by-product gases up to three-fold. By adding reclaimed sand, additional amounts of inactive binder are introduced into the moulding sand, thereby increasing the volume of BTEX and PAH emissions, thus constituting a higher risk to the work environment than previously assumed (Holtzer et al, 2020).

The pyrolysis process produces numerous heavy metals in the form of particulate and fumes, and importantly, is present as metal coatings fused on sand grains formed during mould pouring—a process that occurs as extremely hot molten metal first makes contact with the mould sand. This phenomenon is extensively acknowledged in the hygiene literature, as well as the Neelon Procedures Manual (2003-04) related to the handling and treatment of oolitic sand. Fumes and coatings of the following metals, formed during pyrolysis, have been identified in foundry work: antimony, lead, chromium, cadmium, iron, tin, magnesium, manganese, beryllium, nickel, zinc, copper, molybdenum and zirconium (NIOSH, 1985; Oudyk, 1983; Cook et al, 2017; McManus, 1985; HSE, 2017; Safe Work Australia, 2013; Ribeiro and Filho, 2006).

Risk Factors Contributing to Occupational Diseases at Neelon Casting

We highlight a number of risk factors due to their significant contribution to occupational exposures and production of disease at the Neelon plant. While they do not fall into neat categories, they are physiological and psychosocial in nature, linked both to work practices and the unique nature of the materials used or produced in the foundry production processes. What follows is a brief description of the role they play in exposure and disease processes.

Risk Factor #1: Extensive Worker Exposures to Metal and Binder Coated Sand: An important aspect of silica generation and exposure (and its association with occupational diseases) we emphasize is the fact that sand particles being separated from metal casts for reuse during finishing were coated with heavy metals and residues of phenol formaldehyde resins. These contaminants are recognized as hazardous in the literature (Holtzer et al, 2020; Holtzer, 2016;

Moroni, 2014; Michaud, 1993), as well as in Neelon's own work Procedural Manual. They are a product of the mould pouring process at the point when molten metal makes contact with the mould sand. The presence of heavy metals attached to sand particles adds a significant dimension in exposure to silica dust. The metal coatings on sand particles potentially enhance the toxicity of the crystalline silica, both additively and synergistically.

Risk Factor #2: A Harsh Work Regime and its Health Impact on Workers: Toxic exposures at the foundry took place in the context of extremely demanding work regimes. Average weekly work schedules ranged between 48 and 60 hours and included shift rotations and night work. In their, often extended, workday, workers received a twenty-minute lunch break, and two, ten -minute smoke or relief breaks. Due to low pay rates and financial pressures linked to stagnant wage rates, many workers did not take vacation time, choosing to work during vacations for additional income. This meant lengthy periods of exposure with insufficient recovery time from both high, and long, duration of chemical exposures. Work was carried out under extreme psychological, and physiological, stress, e.g., extreme heat; physically demanding work; high noise levels; air contaminants linked to respiratory congestion and difficulty breathing; production quota pressures; and exceedingly dangerous work. These known stressors add significantly to the biological load that worker's bodies endured—thus aggravating the effect of contaminants on their bodies (Oudyk, 1995).

Risk Factor #3: A History of Weak Exposure Controls: As described previously, exposure controls were very weak. From the day the plant opened, the ventilation system was inadequate—leading to the use of open doors and fans to control temperatures and, there were few effective local exhaust ventilation systems to extract toxic fumes, gases, dusts, and vapours at the point of production. The provision and effective use of protective equipment was inappropriate, weak, inconsistent, and poorly enforced. Many times, the PPE provided failed to protect against the particular hazards (e.g., poor quality gloves) or these devices were compromised by the impact of chemicals/particulates (e.g., clogged filters).

Risk Factor #4: Multiple and Concomitant Chemical Exposure Risks: Failure of the WSIB and the Ontario Ministry of Labour's Occupational Health and Safety Division, to acknowledge the role of multiple chemical exposures in the production and prevention of occupational disease is a major obstacle in the compensation of workers and in disease prevention, generally.

Conclusion

In closing, these many studies cited, together with the in-depth analyses of the conditions under which production was carried out at Neelon, form a substantial body of evidence in support of the work-relatedness of the diseases that have been documented in Neelon workers. Incidences of diseases, and premature deaths, among Neelon workers is not a chance event, but a reflection of occupational diseases produced, world-wide, in this industry. The epidemiological and industrial hygiene literatures provide confirmation that Neelon was part of what must be viewed as a global, workplace disease tragedy.

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** Indicates reference is included in Appendix J (annotated reference section) which includes a summary and/or description of study findings)*

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Appendix A: Research Methodology (Expanded)

Using Qualitative and Participatory Research Methods in Occupational Health

The research team used a qualitative approach to gathering and assessing information necessary to develop rich, detailed, exposure profiles of the industrial processes undertaken at Neelon Casting, similar to that undertaken previously with workers at the General Electric and Pebra/Ventra Plants in Peterborough, Ont.

Qualitative and "mixed" research methods in industrial hygiene and epidemiology have been used successfully in similar industrial circumstances where there are: diverse groups of workers holding multiple jobs; numerous, complex industrial processes; and exposures that have changed over the years (McDonald et al, 2004; Marano et al, 2000, Morgan et al, 1998; Alexander et al, 1996, DeMatteo and DeMatteo, 2017 and 2019). Rather than rating individual exposures, this research focuses on profiling the production processes and their exposure points, along with workplace factors that put workers at greater/less risk of being exposed to hazardous chemicals. This approach is best able to address the challenges specific to Neelon's production system and limitations in the availability and reliability of "hard' exposure data from industrial hygiene monitoring. As well, detailed descriptions of worker exposures in many industries are limited at best. Published research seldom contains data reflecting the typical, day-to-day conditions experienced by workers.

To address these issues, a Participatory Action (worker/community) Approach was employed using qualitative methods. The mainstay of this research effort was the Neelon Advisory Committee made up of former Neelon workers and retirees with participation from both Local #2020 of The United Steel Workers Union and the Occupational Health Clinics for Ontario Workers (OHCOW) staff – with retired health researchers acting as facilitators. This created a "permanent" focus group that met weekly or biweekly for 2-3 hours per meeting from late October 2020 to May 2021. Due to Covid 19 restrictions, meetings were conducted via computer using the Microsoft Team Program set up by Andrew Zarnke from OHCOW. This program provided the Committee with a user-friendly web site where information could be downloaded and shared among Committee members and where meetings were recorded and could be accessed by Committee members. (Meetings were subsequently transcribed by the researchers and shared with members for discussion and confirmation as well as serving as primary reference for the information contained in this report including "quotes").

Between meetings, Advisory Committee members and other former Neelon workers (or family members) took it upon themselves to track down numerous documentations including: maps of the plant, MSDSs, photographs, names of deceased workers, and contacting workers with specific knowledge consenting to be interviewed by the researchers. In addition, Committee members frequently took it upon themselves to seek out additional information including: Neelon company files and MSDSs (Lori Pilot); literally "mountains" of critical documentation (Mike Quenneville); hand drawn plant diagrams pre- and post-expansion and transcribing a French language study of Foundry dust into English (Ron St Germain); creation of professional quality computer floor plans of the plant and insertion of names of machines and other details in plant photos (Daryl Park); and tracking down contact information/sources for missing MSDSs (Paul Lachance). Committee members used the Neelon Retirees' facebook page to seek information, leading to many ex-workers, or family members, sharing information contained in this report. A number of former Neelon workers submitted testimonials to Jessica Montgomery, the former USW Local #2020 Compensation Representative, documenting their experiences and chemical exposures while working at Neelon Casting, which are incorporated into this report.

During our meetings there was a relaxed and respectful atmosphere and sense of shared ownership and responsibility. This is reflective of workers' strong bonds and shared history, but also because they were the experts and this was their project. Importantly, the depth of their knowledge and common work experiences facilitated a "questioning, challenging, confirming, consensus" dialogue that was both productive and personally satisfying due largely to the shared commitment that we do this task well.

Information Sources And Research Process

This project relied upon three basic sources of information on industrial processes, work conditions, and the nature and extent of chemical exposures for this retrospective exposure assessment including:

Focus Group—Advisory Committee

The Advisory Committee consisted primarily of former Neelon workers employed at the plant between 1975 and 2007—with most beginning their employment in the early 1980s as the plant underwent two major expansions (going from less than 40 to more than 300 employees by the 1990s). Worker members were employed between 15 to 30+ years at Neelon, with the majority working more than 25 years before the plant closed. This committee consisted of 5 to 6 members who met regularly.

Focus Group Meetings were organized with reference to the industrial processes and working conditions for each department with attention paid to details regarding: chemicals, equipment and materials being fabricated; the volume of production; work tasks and how materials were handled; descriptions of work conditions; exposure controls; access to safety information; work practices; housekeeping; sensory experiences; and adverse health symptoms associated with different exposures.

The dynamic associated with focus group methods (especially an ability to both enrich and challenge the information presented) and consideration of particular processes or issues lent itself to rich discussion and in-depth understanding of the complex work environment that was Neelon Casting. Throughout, we applied the "constant comparative" method associated with qualitative research, where information collected is continually contrasted and compared with previous information for its consistency and truth-value (i.e., reliability and validity). We continually sought agreement and group consensus to achieve accuracy of information.

Supportive Documentation

Additional documentation of exposure conditions at Neelon Casting was obtained from: 1) the Ontario Ministry of Labour (MOL) Inspectorate reports/investigations, 2) Joint Health and Safety Committee (JHSC) minutes/reports, 3) union or employee/employer correspondence, 4) Other information sources, which included: Multiple mappings of the plant, both formal and informal; a large number of plant photos; A 2003/04 Neelon CastingWork-Procedural Manual; numerous OHCOW health assessment studies/documents; 40 MSDSs; worker testimonials; worker legal and medical documents; union records of worker complaints; disease and injury compensation claims; newspaper clippings; company promotional documents; and broad ranging literature and internet searches related to foundry production, included process videos recommended by worker-members of the committee.

The inclusion of these multiple sources of documentation reinforces what workers say about their workplaces and work experiences. In addition to supporting worker-based data, they expose a pattern of recalcitrance on the part of the company (under its various ownerships) towards making necessary improvements, especially to ventilation, both generally at plant level. This added oral documentation provides evidence of refusal to adhere to the law with regard to providing workers and their union with information requested and to which they were entitled.

Industrial Hygiene, Occupational Health, and other Literature Reviews

Documentation was sought through reviews of the scientific literature documenting industrial processes and observed exposures from published studies of similar work environments as well as general information identifying and describing various industrial processes. In this way, we were able to corroborate the description of work processes and exposure conditions through the process of "triangulation" (Lincoln and Guba,1985; Needleman and Needleman, 1996; Patton, 1990) a major validation technique used in qualitative analysis. A higher level of informational reliability was achieved in the use of different approaches to information gathering including 1) The richness and dynamic of focus group-based discussion and consensus 2) Both quantitative and qualitative data gathered through review of official government (MOL) reports, JHSC minutes, and employer documents; and 3) Additional knowledge gained through review of industrial hygiene, occupational health, and other literatures.

Perspective on ACGIH TLVs and Protectiveness of OELs

In reviewing the industrial hygiene literature, the Advisory Committee gained insight into the documentation of American Conference of Government Industrial Hygienist (ACGIH) occupational exposure limits referred to as Threshold Limit Values. This was important because these were constantly referred to when hygiene monitoring was carried out as the assured level of safety. A broad review of the literature reveals a major problem with the assumption that these exposure limits afforded the workers' protection if concentrations were below the TLV. A large quantitative study noted the tendency for exposure limits to decrease over time, but found wide variation among limits for the same chemical in different jurisdictions (Shenk et al 2008). Beryllium is a case in point. For years the TLV was set at 2.0ug/m^3, but is now proposed by the ACGIH to be lowered to 0.05ug/m^3, based on the fact that despite levels being kept below the old TLV, beryllium disease continues to rise (Harmsen, 2010). Indeed, nuclear fuel industry scientists have raised concern that this limit may be difficult to achieve (and not lead to lowered incidence of disease).

Critical reviews of the scientific documentation upon which TLVs are based, identify that only a minority of studies show no adverse health effects below the established limit and that TLV levels were heavily influenced by industry to keep costs and liabilities down (Castleman and Ziem 1988; Markowitz and Rosner 1995; Roach and Rappaport 1990). More recently, Keil et al calculated that lowering the TLV/OEL for silica would have a dramatic impact on reducing workers' death rates from exposure to a reduced silica level in the order of 20 reduced deaths for every 1000 workers (Keil DB et al 2018).

Finally, another limitation of TLVs/OELs is their dependence on air sampling which only estimates how much of a chemical enters the body through inhalation. Yet many chemicals are more readily absorbed and/or ingested, leading to a serious underestimation of the body burden of an exposure. As well, air sampling may not be representative of actual exposure conditions with direct read instrumentation having a wide margin of error. More complex measurements require regular calibration and laboratory analysis performed by certified analytical laboratories, with proper statistical analysis carried out, to assure valid and reliable results. In the final analysis, the most reliable indication of over exposure is the adverse health effect symptoms experienced during exposures—whether the exposure is from direct handling or as by-stander to the exposure (Senn 1991; Ziem and Davidoff 1992).

Limitations of regulatory toxicology and its impact on standard setting

Regulatory toxicology suffers similar tendencies to understate adverse effects as a result of questionable paradigms used for testing adverse effects, and is also vulnerable to corporate influence. This is played out in the current rift in the scientific community between regulatory toxicologists who rely on computer simulations called "physicologically based pharmacokinetics" (PBPK) modeling and health effects researchers including endocrinologists, developmental biologists, and epidemiologists who draw their conclusions from direct observations of how chemicals actually affect living things. While the debate may seem esoteric, the outcome will have a significant impact on occupational and environmental health. It is shaping how governments regulate these important areas of public health and how workers are protected (or not) from toxic exposures. It is also shaping how we assess disease causation from these exposures (Brown and Grossman 2015; Rappaport and Kupper 2008; Huff 2007). The literature is replete with instances where PBPK studies were used to make chemicals appear safer. For example, industry funded/associated research institutes such as CIIT/Hammer, utilizing PBPK modeling methods have down played risk and delayed regulation or implementation of more rigorous exposure limits for a number of widely used and commercially lucrative chemicals. These include formaldehyde, trichloroethylene, BPA, methylene chloride, styrene, acrylonitrile, to name a few (Brown and Grossman 2015). James Huff provides numerous examples of the impact of industry influence on occupational and environmental public health research by not only funding research, but in creating its own infrastructure for health research (Huff

2007).

Limitations of regulatory epidemiology

In considering these different approaches to a comprehensive understanding of the health impact of exposures in complex industrial processes, a word about the inherent limitations of epidemiology and toxicology is in order. For example, epidemiological studies often suffer from poor research design, misclassification of exposures, and insufficient statistical power to detect a health risk. Together, these factors are largely responsible for underestimating the extent of risk and premature conclusions for lack of association. For example, numerous studies reviewed by Goldbeg and Lebrecht, found non-significant excessive risk because there was insufficient power to detect a risk of a particular magnitude. In their review of 115 occupational breast cancer studies these authors found that the median number of breast cancer cases was 19, with an average of only 64 cases. Only five studies had more than 100 cases (considered the minimum number where statistically significant differences can be detected). They noted that even though 75% of studies had statistical power above 80%, the small number of cases seriously limited the ability to detect risks in subgroups and test for exposure trends (Goldberg and Lebrecht 1996). The challenge for researchers lies in overcoming the inherent limitations of the dominant scientific paradigm for establishing causation.

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Appendix B: Foundry Processes and Chemical Hazards*

(*BOLD=KNOWN/POTENTIAL CARCINOGENS; (F) FUMES; (D) DUST)

MELTING	POURING	SHAKEOUT	FINISHING
ACROLEIN	ACETYLENE	ACETYLENE	ACROLEIN
ALUMINUM OXIDE	**ALUMINUM (F)**	ACROLEIN	**ALUMINUM (D)**
AMONIA	**ANTIMONY (F)**	**ALUMINUM (F)**	**ANTIMONY (D)**
BENTONITE CLAY	**ASBESTOS**	**BERYLLLIUM**	**BERYLLIUM (D)**
CARBON DIOXIDE	**CADMIUM (F)**	CARBON DIOXIDE	**CHROMIUM (D)**
DIPHENYLMETHANE	**BERYLLIUM (F)**	**CADMIUM (D)**	CARBON MONOXIDE
DIISOCYANATE	CARBON DIOXIDE	CARBON	COPPER (D)
DIMETHYLETHYLAMINE	CHLORINE	MONOXIDE	**IRON (D)**
ETHYL ALCOHOL	**CHROMIUM (F)**	COPPER (F)	**IRON OXIDE (D)**
ETHYL SILICATE	CARBON MONOXIDE	CRESOL	**FORMALDEHYDE**
FORMALDEHYDE	COPPER (F)	**CHROMIUM (F)**	**LEAD (D)**
FURFURL ALCOHOL	DIMETHYLPHENOL	DIMETHYL-PHENOL	MAGNESIUM (D)
GRAPHITE	**HEXACHLOROETHANE**	**DIPHENYL-METHANE**	MAGNESIUM OXIDE (D)
HEXAMETHYLENE-	HYDROGENCHLORIDE/	**DIISOCYANATE**	MANGANESE (D)
TETRAMINE	FLUORIDE/SULFIDE	ETHANE	METAL DUSTS AND
HYDROGEN CHLORIDE	IRON (F)	ETHENE	OXIDES
HYDROGEN CYANIDE	IRON OXIDE	**FORMALDEHYDE**	**MOLYBDENUM (D)**
ISOPROPYL ALCOHOL	LEAD (F)	HYDROGEN SULFIDE	**NICKEL (D)**
METHYL ALCOHOL	MAGNESIUM (F)	**IRON (F)**	**PAHs**
MICA	MAGNESIUM OXIDE	IRON OXIDE	**SILICA**
PHENOL	MANGANESE (F)	**ISOPHORONE**	**SULFER OXIDES**
PHOSPHINE	METHANE	LEAD (F)	TELLURIUM (D)
SILICA	**MOLYBDENUM (F)**	MAGNESIUM/OXIDE	**THERMAL DECOMPOSITION**
SODIUM SILICATE	**NICKEL (F)**	MANGANESE (F)	**PRODUCTS**
SULFUR DIOXIDE	NITROGEN	**MOLYBDENUM (F)**	TIN (D)
TALC	**NITROGEN OXIDES**	**NICKEL (F)**	VANADIUM (D)
TRICHLOROETHANE	TELLURIUM (F)	**NITROGEN OXIDE**	VIBRATION
TRIETHYLAMINE	TIN (F)	**PAHs**	ZINC (D)
XYLENE	TIN OXIDE	**SULFUR OXIDES**	ZIRCONIUM
	TITANIUM (DUST)	TELLURIUM (F)	
	TITANIUM (F)	TIN (F)/OXIDE	
	VANADIUM (F)	TITANIUM	
	ZINC OXIDE (F)	TOLUENE	
	ZIRCONIUM (F)	VANDIUM (F)	
		ZIRCONIUM (F)	

Appendix C: Chemical Health Effects Table (NIOSH, 1985)

CHEMICAL AGENT	PROCESS/USE	TARGET SITE	HEALTH EFFECT
Acetylene	Melting and pouring emissions, cutting and torching	Intoxicant, unconscious-ness, asphyxia, loss coordination	CNS
Acrolein	Core ovens, decomposition product, pouring and shakeout where oil sand cores are used.	Eye, nose and throat Irritation, tearing and pulmonary edema	Eyes, lungs and upper airways
Aluminum/ aluminum oxides	Melting and pouring inoculants, core or mould wash, refractory for furnaces and ladles	Respiratory effects, pulmonary fibrosis, cancer	Lungs
Ammonia	Core making decomposition products of nitrogen containing binders	Respiratory irritant, gastritis, laryngeal and lung edema	Lungs, airways
Antimony	Metal alloy for copper and lead, inoculant in steel/iron melt	Pulmonary congestion, heart, kidney and liver adverse effects, dermatitis, rhinitis	Kidney, liver, skin, nose, lungs
Asbestos	Furnace lining and protective clothing and refractory brick	Asbestosis, lung cancer, mesothelioma	Lungs
Bentonite clay	Core/mould binding agent	Lung and upper airway irritant	Lungs
Benzene	Core wash and decomposition product	Leukemia, CNS effects, depression, dermatitis	CNS, skin, blood
Beryllium	Melting and pouring copper alloy. Contaminant from scrap metals	Berylliosis, lung cancer, dermatitis	Lung, skin
Cadmium	Alloying element, protective coating	Metal fever, poisoning, emphysema, pulmonary edema, renal changes, carcinogen	Lungs and kidney
Cereal	Binder material	Irritation of eyes, nose and throat	Lungs and upper airways
Chlorine	Degassing agent for noous metals	Irritation of eyes, nose and throat, pulmonary edema, congestion, anoxia	Mucus membranes and lungs
Chromium	Melting, pouring and grinding of low alloy and stainless steel	Nephritis, lung cancer, skin ulcers, dermatitis, allergic reaction, lung	Kidney, lung, skin
Chromium cont.	Chrome alloys, chromite sand constituent	Irritant	(see above)
Copper	Melting, pouring and grinding of copper alloys	Acute respiratory irritation, metal fume fever	Lungs
Cresol	Pouring decomposition product green sand mould	Dermatitis, kidney, hepatic damage, CNS, depression, cough	Skin, kidney, liver, CNS, lungs
Diphenylmethane diisocyanate (MSI)	Binder component for urethane binders, decomposition product	Skin irritant, occupational asthma	Respiratory tract, eyes
Dimethylethyl-amine (DMEA)	Catalyst for cold box binder systems	Skin irritant, occupational asthma	Eyes, lungs, and skin
Dimethylphenol	Decomposition product from melting and pouring	Necrosis, nausea, neurological impairment, renal and hepatic damage	GI tract, CNS, liver, kidney
Ethane	Melting, pouring and shakeout decomposition product	Asphyxia	Lungs
Ethene	Melting pouring and shakeout decomposition product	Asphyxia	Lungs

CHEMICAL AGENT	PROCESS/USE	TARGET SITE	HEALTH EFFECT
Ethyl Alcohol	Constituent in hot coating in shell moulding	Liver and heart muscle lesion, gastritis	Liver, heart
Ethyl silicate	Binder	Eye and respiratory tract irritant, kidney, liver and lung changes	Eyes, kidney, liver, lungs and skin
Formaldehyde	Emission in moulding, pouring and shakeout areas from decomposition of binders	Headache, allergic reaction, pulmonary edema, eyes and skin irritant carcinogenic	Lungs, eyes, and skin
Furfuryl alcohol	Component of furan resin binders	Tearing, irritant, allergenic	Eyes, Skin
Graphite	Mould release agent, foundry	Graphite pneumoconiosis, cancer	Lungs
Hexachloroethane	Degassing and grain refining agent	CNS, depression, irritant, carcinogen	CNS
Hexamethylenetetramine	Degassing and grain refining agent	CNS, depression, irritant, carcinogenic	CNS
Hot Environments	Melting, pouring, shakeout, core ovens, heat treatments, welding, cranes	Heat Stress and exhaustion/cardiovascular and respiratory strain, heat stroke	Heart, lungs, circulatory system, liver and kidney
Hydrogen chloride	Mist produced in degassing and fluxing of metals	Irritant, burns, tooth erosion, nasal and oral mucosa ulceration, respiratory irritant	Skin, teeth, mucosa and lungs
Hydrogen cyanide	Decomposition of nitrogenous binding agents	Dermatitis asphyxia, death, neurological changes	Skin, CNS, cardiovascular system, liver
Hydrogen fluoride	Decomposition product of flux	Eye, nose, and skin irritant, skin ulcers, bone, GI effects	Skin, eyes, nose, bones
Iron and oxides	Melting, pouring and grinding of iron and steel, shakeout, sand and core wash additives	Pulmonary irritant	Lungs
Isophorone	Decomposition of melting and pouring	Respiratory irritant, dermatitis	Lungs, mucosa
Isopropyl alcohol	Solvent for core and mould washes	Mucous membrane irritant	Mucosa
Lead	Alloy agent to copper based alloys, melting and pouring, grinding of lead, iron and steel	Kidney, blood, GI and CNS effects	Kidney, blood, CNS, GI tract
Magnesium and oxides	Welding and pouring of ductile (nodular) Iron and magnesium, core wash and refractory	Metal fume fever	Lungs
Manganese	Alloying element in iron and steel, melting, pouring and grinding of ferrous alloys and sand addition	Pulmonary diseases, pneumonia, CNS changes	Lung, CNS
Methane	Emission from ovens, furnaces, pouring & shakeout	Asphyxiant	Lungs
Methyl alcohol	Decomposition of grinding or core washes containing methyl alcohol, pouring and shakeout	Narcosis, dermatitis, blinding, metabolic acidosis, mucosa irritant	Skin and CNS
Mica	Mould release agent	Nodular fibrosis	Lungs
Molybdenum	Melting and pouring of iron and steel	Pneumoconiosis, gout	Lungs
Nickel	Fume from melting pouring/grinding of	Dermatitis, lung and nasal cancer	Skin, lungs, nose
Nitrogen	Furnace effluent	Anoxia	CNS
Nitrogen and oxides	Melting and pouring	Methemoglobinemia, irritant, edema, dyspnea	Blood, Lungs

CHEMICAL AGENT	PROCESS/USE	TARGET SITE	HEALTH EFFECT
Noise	Shakeout, furnaces	Hearing loss and damage, neurological effects	Ear and CNS
Paraffin wax fumes	Grinding wheel uses	Cancer	Skin, lungs, stomach
Phenol	Binder constituent, decomposition product of binder	Animal carcinogen and mutagen, skin cancer, liver, CNS, and kidney changes	Skin, liver, kidney, eyes
Phosphoric acid	Furan resin catalyst	Eye, skin and respiratory tract, irritant, dermatitis	Skin, liver, kidney, eyes
PAHs (benzo-pyrene, cresol, benzo(a)pyrene, methylbenzanthracene, naphthalene	Pouring decomposition product of sand moulds	Animal carcinogen and mutagen, skin eruptions, liver and kidney damage, dermatitis, cataracts, nausea, hematuria	Skin, liver, kidney, eyes
Silica	Moulding, coremaking, shakeout, furnace, ladle and furnace refractory cleaning room	Dermatitis, eye and skin burns, respiratory irritant	Lungs
Sodium silicate	Sand binder, ladle and furnace refractory binder	Dermatitis, eye and skin burns, respiratory irritant	Lungs
Talc	Release agent, binder constituent	Ralcosis, modular fibrosis carcinogenic	Lungs
Tellurium	Alloying agent for ferrous and non-ferrous metals	Respiratory irritant	Lungs
Tin and oxides	Alloying element, melting and pouring emissions	Stannosis, pneumoconiosis, dermal lesions	Lung and Skin
Titanium	Alloying element for aluminum and deoxidant for ferrous alloys	Mild pulmonary irritant	Lungs
Toluene	Decomposition product of moulding	Dermatosis, CNS depression, respiratory tract and mucous membrane irritant	Skin, CNS, lung and mucosa
1,1,1-trichloroethane	Core and mould wash solvent	CNS depression, liver and kidney damage, lung and skin irritant	CNS, liver, heart, lungs, lymph nodes, skin
1,1,2-Trichloroethane	Core and mould wash solvent	CNS depression, liver and kidney damage, lung and skin irritant	CNS, liver, heart, lungs, lymph nodes, skin
Triethylamine (amines)	Catalyst in cold box biner system	Irritant, edema, sensitization	Eyes, lungs
Ultraviolet radiation	Melting and pouring	Skin and ocular effects, skin cancer	Skin and eyes
Vandium	Alloying element for ferrous alloys	Conjunctiva irritant, nasal mucosa, dyspnea, bronchitis, fatigue	Eyes, skin, lungs
Vibration	Cleaning and feeling	White finger HAVS	Fingers and arms
Xylene	Core wash and binder solvent, decomposition product	Narcosis, irritant, pulmonary edema	Skin, mucous membrane, lung, CNS
Zinc oxide	Melting, pouring and grinding of zinc, galvanized metals and brass	Metal fume fever, dermatitis	Lung and skin
Zirconium and oxides	Deoxidizer for ferrous alloys, ladle refractory, foundry aggregate, mould and core wash refractory	Allergic granulomas	Skin

(Adapted from NIOSH, 1985 Foundry Report)

Appendix D: Ministry of Labour (MOL) Reports And Orders Issued

Date	Case Number	Issue
MELT DEPARTMENT		
07/16/1981	**39681CAOB**	**FURNACE FUME TESTS**
Tests carried out by MOL to assess air quality in the plant particularly for metal fumes: e.g., copper, zinc, iron, lead. All levels were below the OEL. However, the unio n contests these results and request further testing. MOL explores the components of a medical surveillance program at the plant. There was no pre-employment screening except for the MOL chest x-ray surveillance program. Also mentioned in this regard were exposures to noise, phenol-formaldehyde and silica.		
09/24/1981	**A-4035**	**METAL/SILICA TESTING**
Copper-6.5 to 18.0 ug/m^3; Iron-240-1000 ug/m^3; lead-9.0 to 74 ug/m^3; zinc-8.6 to 54 ug/m^3; silica-five of 8 samples exceeded the OEL.		
10/14/1981	**25481HAAB**	**FURNACE FUMES**
Test for metals, respirable silica, total particulate: Copper-0.01-0.03(catwalk next to furnace and near arc control were highest); lead-0.02-0.14(catwalk and labourer highest); iron-0.4-1.7 (catwalk, melt ctl, labourer highest); zinc-0.01-0.09(catwalk, ctl, labourer); total particulate-10.8-15.8 (catwalk, arc operator, labourer highest); Silica 15 samples core, molding, shakeout-0.02-35 mg/m^3(highest: auto pour, labourer, grinding, Wheelabrator operator and helper, moulding 8'level).		
04/19/1981	**37681CAOB**	**METAL AND Si SAMPLES**
Levels for metals, copper, lead, zinc, iron were below the OEL.		
02/15/1982	**32282OEOA**	**SMOKE AND FUMES**
Noted that Arc furnaces give off excessive smoke and fumes during charging. New dust collector installed and employees wearing dust masks and respirators.		
06/30/1982	**32282BEDA**	**FUMES FROM ARC**
02/07/1983	**28083BEAA**	**ARC FURNACE EMISSIONS**
Request made for sampling of furnace emissions. A repeat request File # 322828EOA dated June 30, 1982. Sources of metals indicated: pig iron, crushed automotive engine parts, structured steel, fero-manganese, ore, particulate carbon, and miscellaneous cast iron scrap. Melting over 24-hour cycle daily with 15 to 20 charges per cycles.		
08/18/1983	**12282DAOB**	**SILICA ASSESSMENT**
Silica concentrations in excess of the OEL, majority of samples in the range of 0.1 and 0.3 mg/m^3 with the exceptions of offices, sand lab, welding shop and the channel furnace; personal samples much worse 0.92, 0.85 mg/m3 e.g., Wheelabrator, auto grinding, pedestal grinding.		
09/15/1988	**88I205EAAV**	**COMPLAINT SMOKE AND DUST**
Complaint about excess smoke and dust escaping from twin arcs at capacity. Visit by MOL.		

Date	Case Number	Issue
08/15/1989	**89G164AOBR**	**LEAD, IRON, PARTICULATE TEST**
Lead levels exceeded for the crane operator (0.19mg/m^3), iron and total particulate below OEL. Other lead area samples exceeded the OEL (0.14, 0.18, 0.17, 0.20 mg/m^3) indicating that existing local exhaust ventilation is inadequate. Noted that there is a leak at the furnace lid and should be sealed with sand. Exhaust ventilation should be balanced between the two furnaces and the dust collection system maintained regularly. Some facts: two Arcs measure 9′ diameter x 8′ deep in an area 130′ x50′ x35 high. Capacity at 16,000 lbs. 12 workers in melt dept. 3 8hr shifts. Wear half masks NIOSH approved for dust fumes and mists (TC-21C-196) produce significant amount, of fumes collected by a canopy hood for each furnace may not align properly with main exhaust duct so volume removed is reduced. A significant amount, of fumes escape from #2 furnaces when both are operating. Leaks also result from poor seal between lid and furnace.		
01/18/1992	**13045**	**CRANE STABILITY**
Investigated concern about the crane stability on the crane runway.		
07/15/1992	**7274**	**MELT EXPLOSION**
Explosion caused by pit area not kept clean of debris and water build up in the pit. No injuries only equipment damaged.		
11/22/1993	**18456**	**DUST EXPOSURE**
High dust levels in the Wheelabrator area allowed to build up and leaking from warped door on Wheelabrator.		
6/17/1994	**18458**	**HEAT STRESS**
Employer violating the heat stress control program. Workers in melt deck feeling ill in 115F. Not allowed to take break to cool down. Ergonomist called in.		
06/27/1994	**94332GAAR**	**HEAT STRESS CONTROLS**
The MOL provided an assessment of heat stress levels in the plant in several areas of concern. The WGBT measurements were quite high and physical demands would have a great impact for heat stress. JHSC/Mgt. develop a heat stress program. Jobs assessed for workloads that would have an impact on metabolic heat were: coreless operator, metal transfer operator, Arc operator, lead hand, operator (melt deck), auto grinder. WGBT readings are well above the guideline from the ACIGH TLV tables. Workers can sustain a hazardous rise in body temperature. Hot conditions during work on the cranes or at any heights also pose a risk—dizziness and risk of falling. The consultant points out however, that there are other factors that affect heat load, e.g., the effects of wearing PPE (respirators, dust masks that will result in the worker breathing warmer air and work slightly higher to breathe and affect the basal metabolic rate. The employer on many occasions violated the administrative guidelines for controlling heat stress under high heat conditions.		
10/26/1994	**23718**	**ANTIMONY POISONING**
Instrument technician located near furnace found with antimony in body 10 times over a normal concentration. Worker suffering extreme fatigue, nausea. Other worker undergoing antimony in urine tests. Union demanding air tests.		
02/03/1995	**24133**	**FAULTY LADLE**
Worker refused to use ladle re violation of Reg. 94 clarification sought		
03/07/1996	**32168**	**SKIN RASH**
Worker refused to clean pit due to rash developed from chemicals in the pit. Deemed by MOL to likely endanger.		
09/12/96	**37736**	**BY-PRODUCTS OF SULFUR BLAST**
Work refusal concern over composition of sulfur blast by-products—SO2 gas exposure is high and not attempt made to reduce the SO2 concentration. Mask is not seen as adequate protection.		

Date	Case Number	Issue
10/24/1997	**45417**	**WORKER BURNED SLAGGING**
Worker suffered severe burns from slag spitting out during charging and other workers have to stand on hot slag when chipping hardened slag from door.		
07/20/1998	**53054**	**HEAT STRESS**
``Company agreed to newer heat stress plan, but is not being followed. Still using old plan. Ten- minute break every hour not followed. New workers not trained in the new program.		
06/10/00	**71182**	**HEAT STRESS**
Employer refusing to follow the heat stress mitigation plan agreed to by all parties.		
11/13/00	**75921**	**LADLE FALL MOLTEN METAL**
A ladle fell off the monorail and went through the floor. Employer refused to report and alarm did not go off to warn of a spill.		
03/06/02	**1010250**	**LOCKOUT PROCEDURE**
Lock out procedure not adequately understood by worker. Employer did not advise of revised procedures. carrying out his duties.		
11/14/03	**1046255**	**FURNACE EXPLOSION**
Furnace explosion when charge loaded. Cause unknown. Likely contaminant in the charge.		
12/06/03	**1046932**	**FURNACE UNSTABLE**
Work refusal over missing wedge to secure furnace. Order issued to secure furnace.		
12/30/03	**1047774**	**LOSS OF CONSCIOUSNESS**
Worker laying bricks in furnace lost consciousness for 10 minutes. Might have hit head when he fell. Worker confused when sent to hospital. Worker likely over-come by toxic fumes or insufficient oxygen levels.		
06/27/05	**1071392**	**HEAT STRESS STOPPAGE**
Bilateral work stoppage over extreme heat in plant—employer certified member would not support the refusal MOL called to resolve.		
03/09/06	**1088861**	**UNSAFE FURNACE**
Furnace loaded over capacity and is unsafe.		
04/06/06	**1092181**	**EXCESS SMOKE**
Several work refusals over 3 days with no resolve. Smoke coming from ladles during pour going into the back of the core room.		
CORE DEPARTMENT		
08/18/1977	**77HO23CO00**	**COMPLAINT RE: CORE FUMES TEA/ISO**
Worker complaint of chest congestion from exposure to chemicals in core making: isocyanate binders-phenolic resin and MDI; liquid nitrogen (N) and triethylamine catalyst. **Worker's symptoms consistent with known adverse health effects** of these chemicals and inspector concludes that exposures to these chemicals is in fact most likely given the physical attributes of these chemical (i.e., vapour pressure) and the current ventilation system. Recommends regular monitoring, training, air supplied respirators, and spill response and avoidance.		
11/30/1977	**SAME AS ABOVE**	**MONITORING SI, MDI, TEA**
All Si samples were above the 0.1 OEL. MDI below the 0.02 ppm OEL, and TEA below the 25 ppm OEL limits.		

<table>
<tr><th>Date</th><th>Case Number</th><th>Issue</th></tr>
<tr><td>10/13/1978</td><td>F. HOLMES</td><td>SI ISSUE DEBATE</td></tr>
<tr><td colspan="3">October 20, 1977 5 of 5 samples were over the limit for Si exposure; April 6, 1978 work refusal; May 26, 1978 Si orders issued to control Si levels.</td></tr>
<tr><td>04/10/1979</td><td>16978FEOB</td><td>SI EXPOSURE</td></tr>
<tr><td colspan="3">Furnace floor man, auto pour operator, Disamat operator, wheelaborator, forklift operator. Area samples: muller panel, auto pour control, de-spruce, rotary shakeout, mould conveyor, control panel rotary accumulator 3.20 to 0.50 mg/m^3.</td></tr>
<tr><td>06/06/1979</td><td>16978FEOB</td><td>SI AND MDI EXPOSURES</td></tr>
<tr><td colspan="3">Sampling on April 10, 1979, show all 3 samples above the OEL. Highest levels in wheelaborator and de-spruce conveyor. There was no local exhaust ventilation to control dust created as the sand castings vibrate on the metal conveyor. The auto pour operator is exposed to dust produced at the muller for the entire shift. Need to control dust at auto pour area, wheelaborator take off area, de-spruce conveyor and the muller. Measurements: Si-0.5-3.2 mg/m^3; Muller-0.50-1.70 mg/m^3.</td></tr>
<tr><td>04/28/1980</td><td>02080DMAA</td><td>COMPLAINT NOSE BLEEDS</td></tr>
<tr><td colspan="3">Worker in core department experiencing nose bleeds related to chemical fumes and dusts in the core making department: suspected chemicals: TEA, ISO, ISOCURE, PHENOL/FORMALDEHYDE RESINS, SI. The worker removed and placed sand cores from the core oven on pallets. Core oven fumes, vapours suspected source of these emissions.</td></tr>
<tr><td>11/25/1980</td><td>A2499</td><td>MDI, TEA, FORMALDEHYDE</td></tr>
<tr><td colspan="3">Sampling conducted re: Adverse symptoms reported by 5 workers out of 21, e.g. nausea, headache, nosebleeds, irritated nose, eyes and throat</td></tr>
<tr><td>10/16/1980</td><td>A-2499</td><td>TEA, MDI, PHENOL, FORMALDEHYDE</td></tr>
<tr><td colspan="3">Monitoring levels reported: Phenol-0.16mg/m^3; Formaldehyde-0.09 ppm; MDI-0.006</td></tr>
<tr><td>12/04/1980</td><td>0208DMAA</td><td>MDI, TEA, FORMALDEHYDE</td></tr>
<tr><td colspan="3">Core oven workers experiencing nose bleeds and symptoms. Dr. Gregor's comments in face of sampling of MDI, TEA, FORMALDEHYDE below the OELS: feed area for ovens found open cup of Isocure, poor housekeeping, strong irritating odour from core ovens, these symptoms were raised at the JHSC, no pre-employment screening, request repeat sampling for these chemical.</td></tr>
<tr><td>06/09/1981</td><td>OHB09080DEOB</td><td>CONCERN OVER CORE CHEMICALS</td></tr>
<tr><td colspan="3">Levels of MDI, TEA, PHENOL continue to read below the OEL, while Si readings are above the OEL. Concern is raised about conditions during test that may interfere with the sampling process—e.g., cooling fans, and wall exhaust units running, using compressed air to blow off dust during testing. TEA-<0.2; FORMALDEHYDE 0.03-0.09ppm; MDI-<0.007-0.01 mg/m^3.</td></tr>
<tr><td>01/05/1981</td><td>No file #</td><td>CHEMICAL EXPOSURE</td></tr>
<tr><td colspan="3">Minister of Labour Robert Elgie involved in the issue of over exposure at the Neelon plant. Also, Bud Germa MPP for the area complained of over exposures to phenol formaldehyde resins. According to Germa, the chemicals used are TEA in conjunction with nitrogen being bubbled through the TEA. "I am advised that the binding agent used is carcinogenic. This procedure I am told is causing blurred vision among employees of this plant." He also demanded that the workers be tested for the presence of these chemicals in their bodies. This, however, was never conducted, only relying on air samples

During the period between January 5th and August 6th there were continued complaints about toxic exposures at the plant and protest about sampling accuracy. Note that Silica levels for the most part exceeded the OEL is most parts of the plant see report dated February 26, 1981 as well as levels of carbon monoxide discovered in the early 1990s. Workers were demanding re-testing to reflect actual conditions and worse case sampling.</td></tr>
</table>

Date	Case Number	Issue
01/09/1981	**09080DEOB-M**	**SILICA TEST RESULT**
Dr. Gregor responded to the test results for Silica found to be elevated. Recommends that all workers in this department wear NIOSH approved respirators. With respect to the measurements for TEA, MDI, Phenol, and formaldehyde showing levels below the TLV, he concludes that: "…one could not expect any significant health hazards from these substances." This is a classic conclusion not based on evidence. Rather it is a bureaucratic response that precludes further empirical study (author). See Casselman and Ziem regarding the poor scientific bases for setting TLVs and OELs.		
11/03/1981	**25481HAAB**	**TESTING FOR METAL**
MOL monitoring of concentrations for Cu, FeO, Pb, Zn, were found not above the OEL. However, reference in this report is made to Si levels exceeding the OEL throughout the plant—nine of 13 samples exceeded the OEL. Air sampling in grinding and core have been in excess while concentrations in areas around auto pour and Disa have ranged above and below the OEL, but on the whole the levels remain high and are growing according to the MOL report. See October 14th 1981 report below. The inspector notes that the test may have been adversely affected because ceiling exhaust fans were off. And notes that total particulate concentrations were in excess of the 10 mg/m^3 OEL. See October 14, 1981 below. Suggests that ventilation system needs to be critically examined to determine source of these high levels. Suggest that the muller/mixer may be a source. The report goes on to say that the areas that require respiratory protection go far beyond what Dr. Gregor had indicated in his previous report Feb. 26, 1981, and that medical surveillance should be followed.		
04/26/1982	**05081LAOB**	**SILICA EXPOSURE**
Silica concentrations samples for several areas: core, Disa, forklift, auto pour, Wheelabrator, arc furnace, channel furnace attendant, utility man. 5 of 8 exceeded the OEL. Range from 0.08-0.47 mg/m^3. Wheelabrator highest followed by auto pour operator, utility man, Disa operator, channel furnace attendant.		
10/28/1982	**A-8786/A8785**	**MDI SAMPLING**
Levels of MDI (0.98 and 1.2 ug/m^3) were below the detection limit and no levels of TEA above 0.1 mg/m^3. No levels of formaldehyde (2 ug/m^3) above detection limit.		
11/08/1982	**03682JAAB**	**CHEMICAL FUMES CORE**
05/09/1983	**27283BEAA**	**Si, WELDING, FURNACE FUMES**
Inspector sceptical silica exposures have improved with improvements in ventilation given that the plant has expanded production considerably. There is also concern that the lead levels in the Arc furnace area are in excess of the 0.15mg/m^3 as a result of test carried out on March 2,		
Inspector also observed considerable expansion in several areas that will have an impact on exposures these include: additional core making equipment, sand conveyor on the mezzanine floor, and additional conveyors and turntables installed in the grinding and finishing area. Increase of new Arc furnace with two induction furnaces and dust collection system not functioning. New maintenance area constructed. See comments in May 4, 1983 (07482GAOB) report of excess lead exposures (0.23-0.19 mg/m^3). Notes also indicate that 3M Model 8710 respirator worn by workers offers not protection against lead fumes. Recommends issuing orders for local exhaust ventilation for welding operations. Also recommends orders to establish a lead assessment and control program.		
06/20/1984	**32084FAOB**	**MDI, PB, TEA, SILICA**
Review of early monitoring lead and silica/identifying the need for a control program. The company was opposed to a lead, silica and ISO control program. MOL medical consultant recommended an order to mandate a lead control program as per Section 7 of the Lead Control Program. Previously 36 employees' lead in blood revealed concentrations ranging from 0.16-0.2 to 0.56-0.6. Potable water supply was also tested: 0.02-0.06 ppm of lead. Dust samples also taken. MOL medical consultant, Dr. Gregor, also disagreed with conclusion that no ISO control program was needed.		

Date	Case Number	Issue
12/03/1984	32084FAOB	MONITORING PB, ISO, MDI TEA, Si
02/27/1985	85C109AOB	MDI EXPOSURES CORE/AUTO POUR
Re-tested MDI levels based on possible amine interference, but did not report the amine levels which if significant and persistent as claimed would be a serious hazard to these workers. Retested levels could not confirm levels found in report #37084KAOB. Question from authors: Why wouldn't hygienist accept original report of MDI levels? Were amines levels measured? This is not a credible report. Employer has been arguing against an ISO program along with the MOL, even though the medical consultant believes there should have been one.		
04/01/1985	85C109-0	MDI EXPOSUES
Thirteen samples taken in the core area. None of the samples showed the presence of MDI at or above the detection level of 1.0 ug/m^3.		
11/01/1989	EAR 89I060/89H160MAAV	TEA ASSESSMENT
Investigation into worker complaint for adverse health effects from chemicals used in the core department. Medical consultant, Dr. Walter Woychuk's report evaluating data from previous test for TEA and MDI. Samples did not show levels exceeded the OEL. Sampling carried out by a private testing company, IMET INC., as well as a grab sample using dragger tubes. NOTE from authors: It is important to note that despite these levels being below the OELs, workers continued to experience adverse effects as set out in the hygiene literature, as well as previous reports indicating that amine levels were likely affecting sampling for MDI. And workers reported that their bodies exuded a distinctive odour of the TEA even after they were away from work for several days. Core Dept description worth citing: 200' x 200'x 35' high on two levels. On level 2 silica is mixed with polymeric resin with solvents (i.e., Isocure I 315 HR), polymeric MDI isocyanate with solvent i.e., Isocure II 608 and an alkyl resin solution (i.e., Isoflo) in 3 high-speed mixers. Mixture is automatically fed into the 8 core machines located on the ground floor. Inside the core machine TEA vapour is blown on the core and acts as a urethane catalyst to harden the core. The core is then dipped into one of two water base graphite tanks and place in to one of two drying ovens at 223 F for 5 minutes. About 330 lbs. of liquid TEA is used per day from a 500gal storage tank. And nitrogen gas is also blown through the TEA liquid in an enclosed system. The cores are then transferred to a storage area until ready for casting dept. There are 45 production workers—6 core operators, 6 core handlers, 3 core storage workers on 3 eight hour shifts M-F. Workers at greatest risk to TEA are 36 core operators and core handlers and core dept laborer. Local exhaust for 8 machines, 2 ovens and 3 mixers. Warm weather 9' garage door kept open 50' from core room.		
01/08/1997	38679	SPRAY USED IN CORE DEPT
Seven workers experienced eyes, mouth, nasal irritation from using new sprayer system from Ashland Co. Investigation into the MSDS for the new product. Ingredients are not known.		
08/12/1998	52865	RE: ACCIDENT
Worker caught in conveyor.		
09/29/1999	64649	ISOCYANATES
Worker concerned about ISO exposures and was accidently sprayed with it when a hose leaked. Request MOL investigate.		
12/20/1999	86002	WORK REFUSAL
Worker refused to operate machine he fears being re-injured after a recent injury.		
03/01/05	1061972	ADVERSE REACTION TO CHEMICAL
Worker experiencing adverse reaction to chemicals used in the core department resulting in rashes, hives, and swollen face. 10 to 12 other workers have made complaints of skin irritation.		

<table>
<tr><th>Date</th><th>Case Number</th><th>Issue</th></tr>
<tr><td>11/14/06</td><td>1101569</td><td>HIGH CO LEVELS</td></tr>
<tr><td colspan="3">Levels of CO AT 800 to 900 ppm. Sensors are malfunctioning. Employer not providing data on levels</td></tr>
<tr><td>03/06/07</td><td>104884</td><td>HIGH CO LEVELS</td></tr>
<tr><td colspan="3">High concentrations of CO at 1750 ppm and over. One worker sent to hospital with headaches and nausea. This is an ongoing problem and may turn to work refusal</td></tr>
<tr><td colspan="3">MOULD DEPARTMENT (see other reports in Plantwide/Multiple site section)</td></tr>
<tr><td>04/10/1979</td><td>16978FEOB</td><td>Si EXPOSURES</td></tr>
<tr><td colspan="3">Furnace floor man, auto pour operator, Disamatic operator, Wheelabrator, forklift operator. Area samples: muller panel, auto pour control, de-spruce, rotary shakeout, mold conveyor, control panel rotary accumulator 3.20 to 0.50 mg/m^3.</td></tr>
<tr><td>04/26/1982</td><td>05081LAOB</td><td>SILICA EXPOSURE</td></tr>
<tr><td colspan="3">Silica concentrations samples for several areas: core, Disa, forklift, auto pour, Wheelabrator, arc furnace, channel furnace attendant, utility man. 5 of 8 exceeded the OEL. Range from 0.08-0.47 mg/m^3. Wheelabrator highest followed by auto pour operator, utility man, Disa operator, channel furnace attendant.</td></tr>
<tr><td>07/23/1987</td><td>87G 250EOAP</td><td>REVIEW SILICA ENG CONTROLS</td></tr>
<tr><td colspan="3">MOL request to review silica engineering control that will be impacted by the planned expansion of the molding department slated to be ready by February 1988. Expansion involved an additional 34,000 feet to the building's footprint, a new mold line with 3rd auto pour furnace and Disamatic molding machines.</td></tr>
<tr><td colspan="3">Company did not provide detailed engineering controls or diagrams only CFM specs without the details of pick-up points and exhaust hoods and duct work. Without this data the MOL concluded that additional silica exposure protection for workers was not required.</td></tr>
<tr><td>06/16/1998</td><td>52290</td><td>CARBON MONOXIDE EXPOSURE</td></tr>
<tr><td colspan="3">Workers exposed to high levels of carbon monoxide (CO). Some testing done, but controls not adequate. This is an ongoing issue that has not been resolved.</td></tr>
<tr><td>09/24/03</td><td>1044331</td><td>GROUND FAULT IN DISA</td></tr>
<tr><td colspan="3">Worker refuses to work Disa that continues to trip circuit breaker.</td></tr>
<tr><td colspan="3">PLANT WIDE/MULTIPLE AREAS</td></tr>
<tr><td>12/11/1984</td><td>37084KAOB</td><td>MDI, FORMALDEHYDE, TEA</td></tr>
<tr><td colspan="3">Follow up testing at the auto pour and metal transfer area. MDI levels ranged from 0.002 to 0.040 ppm. Auto pour was the highest at 0.040, 0.022, 0.003, 0.002; metal transfer was at 0.025 ppm. Formaldehyde was at ,0.009 at the auto pour; TEA levels ranged between <1.0 to < 4.0 ppm with metal transfer and auto pour operator at the highest.</td></tr>
<tr><td>02/26/76</td><td>ISB</td><td>FUMES AND DUST ASSESSMENT</td></tr>
<tr><td colspan="3">Assessment carried out by professional engineer, D.A. Browne indicated the size of workforce as 22 production workers and 20 salaried personnel. Produced 20 tons/day but capable of 100 tons on 2 shifts. He noted three critical areas of exposure: Disamatic, grinding area, and vibrating steel conveyor. Company used 36,000 lbs of sea coal and 91,000 lbs. of bentonite per month. Inspector observed several areas where silica dust is prevalent, e.g., shakeout conveyors, pedestal grinders lack exhaust ventilation and poor housekeeping noted, silica leaking from Disamatic molding machines, VelvaDry spraying booth in the core department poorly maintained causing dust accumulation. Also noted the use of 2-part Isocure binder at a rate of 375 and 350 for Part 1 and Part 2 respectively containing diphenyl-methante diisocyanate and triethylamine (TEA) as serious hazardous chemical that should be monitored and controlled. The machines did not have local exhaust ventilation, but did have general ventilation. General ventilation provided by 3 roof fans at 7,000 CFM each. *This did not address the melting department, auto pour, pattern shop.</td></tr>
</table>

Date	Case Number	Issue
06/16/78	**SAME AS ABOVE**	**ASSESS DUST IN CLEANING DEPT**
Major source of dust is from vibrating conveyor leading from rotating drum to wheelaborator. Two of 16 samples for Si were above the OEL of 0.1 mg/m^3. Workers exposed are those removing the gates and risers from the castings as they are placed into the skip hoist since castings contain sand and the dust is not controlled at this point. The auto pour operator is exposed to Si dust generated by the muller one floor above and the conveyor leading to the Wheelaborator as well as from the sand pile next to the operator's station. The Disa operator is exposed at one half the OEL. Inspector noted that while the muller is automatic the technician has to adjust the content of sand and the muller does produce a small amount of dust during mixing. The forklift operator is also exposed at 70% below the OEL—e.g., feeding the wheelaborator, taking returns and gates to furnace, supplying Disa with cores. Ladle transfer operator is about 30% of the OEL. Area between rotary drum and cooling conveyor was 8 times the OEL previously and is not down to 0.02 mg/m^3. Inspector notes an anomalous reading near the inspection table (highest reading) where little dust is generated.		
04/10/79	**16978FEOB**	**Si EXPOSURES**
Furnace floor man, auto pour operator, Disamat operator, wheelaborator, forklift operator. Area samples: muller panel, auto pour control, de-spruce, rotary shakeout, mold conveyor, control panel rotary accumulator 3.20 to 0.50 mg/m^3.		
06/06/79	**16978FEOB**	**SI AND MDI IN SHAKEOUT/CORE**
Sampling on April 10, 1979 show all 3 samples above the OEL. Highest levels in wheelaborator and de-spruce conveyor. There was no local exhaust ventilation to control dust created as the sand castings vibrate on the metal conveyor. The auto pour operator is exposed to dust produced at the muller for the entire shift. Need to control dust at auto pour area, wheelaborator take off area, de-spruce conveyor and the muller. Measurements: Si-0.5-3.2 mg/m^3; Muller-0.50-1.70 mg/m^3.		
08/15/80	**13779KEDA**	**EXCESSIVE NOISE**
Noise level reading were taken from several areas of the foundry. Most readings show that noise levels were mostly at or above the current OEL ranging from 70 dBA to 105 dBA+. The majority of the readings were in excess of the 85 dBA TWA limit.		
12/16/80	**A-2507**	**EXCESS SI LEVELS**
Five of 7 samples were in excess of the 0.10 mg/m^3 OEL. Range from 0.19 to 0.56 mg/m^3. Worse cases were: Wheelaborator, grinder, brinell operator, hardness tester, cooling cylander.		
11/03/1981	**25481HAAB**	**TESTING FOR METAL**
MOL monitoring of concentrations for Cu, FeO, Pb, Zn, were found not above the OEL. However, reference in this report is made to Si levels exceeding the OEL throughout the plant—nine of 13 samples exceeded the OEL. Air sampling in grinding and core have been in excess while concentrations in areas around auto pour and Disa have ranged above and below the OEL, but on the whole the levels remain high and are growing according to the MOL report. See October 14th 1981 report below. The inspector notes that the test may have been adversely affected because ceiling exhaust fans were off. And notes that total particulate concentrations were in excess of the 10 mg/m^3 OEL. See October 14, 1981 below. Suggests that ventilation system needs to be critically examined to determine source of these high levels. Suggest that the muller/mixer may be a source. The report goes on to say that the areas that require respiratory protection go far beyond what Dr. Gregor had indicated in his previous report Feb. 26, 1981, and that medical surveillance should be followed.		
04/26/1982	**05081LAOB**	**SILICA EXPOSURE**
Silica concentrations samples for several areas: core, Disa, forklift, auto pour, Wheelabrator, arc furnace, channel furnace attendant, utility man. 5 of 8 exceeded the OEL. Range from 0.08-0.47 mg/m^3. Wheelabrator highest followed by auto pour operator, utility man, Disa operator, channel furnace attendant. Auto grinding, pedestal grinding.		

Date	Case Number	Issue
05/09/1983	**27283BEAA**	**Si, WELDING/FURNACE FUMES**

Inspector sceptical that silica exposures have improved with the improvements in ventilation given that the plant has expanded production considerably. There is also concern that the lead levels in the Arc furnace area are in excess of the 0.15mg/m^3 as a result of test carried out on March 2, 1983. Also welding shop has no exhaust ventilation and welding is carried out in the open areas without local exhaust ventilation.

Inspector also observed considerable expansion in several areas that will have an impact on exposures these include: additional core making equipment, sand conveyor on the mezzanine floor, and additional conveyors and turntables installed in the grinding and finishing area. Increase of new Arc furnace with two induction furnaces and dust collection system not functioning. New maintenance area constructed. See comments in May 4, 1983 (07482GAOB) report of excess lead exposures (0.23-0.19 mg/m^3). Notes also indicate that 3M Model 8710 **respirator worn by workers offers not protection against lead fumes.**

Recommends issuing orders for local exhaust ventilation for welding operations. Also recommends orders to establish a lead assessment and control program.

02/07/83 **WELDING FUMES**

Located in a 6-metre x 5 metre area at the north wall and no mechanical ventilation. Welding primarily oxy-acetylene cutting, arc welding and mechanical hot and cold bending, cut-off and drilling.

Ventilation and heating; only source of ventilation was over an electrical bench adjacent to a fabrication room. Two fans of 50 cm in diameter, replacement air via raising the receiving door. Ceiling forced air heating provided.

Worker complaints about toxic fume migration from the fabricating area. At least one worker full time, some specialty welding with "NI-HARD". Numerous maintenance staff occupy adjacent room with segregated ventilation with lunch room.

05/09/83 **27283BEAA** **SI, WELDING, FURNACE FUMES**

Inspector sceptical that silica exposures have improved with the improvements in ventilation given that the plant has expanded production considerably. There is also concern that the lead levels in the Arc furnace area are in excess of the 0.15mg/m^3 as a result of test carried out on March 2, 1983. Also welding shop has no exhaust ventilation and welding is carried out in the open areas without local exhaust ventilation. Inspector also observed considerable expansion in several areas that will have an impact on exposures these include: additional core-making equipment, sand conveyor on the mezzanine floor, and additional conveyors and turntables installed in the grinding and finishing area. Increase of new Arc furnace with two induction furnaces and dust collection system not functioning. New maintenance area constructed. See comments in May 4, 1983 (07482GAOB) report of excess lead exposures (0.23-0.19 mg/m^3). Notes also indicate that 3M Model 8710 **respirator worn by workers offers not protection against lead fumes.**

Recommends issuing orders for local exhaust ventilation for welding operations. Also recommends orders to establish a lead assessment and control program.

12/03/1984 **32084FAOB** **MONITORING PB, ISO, MDI TEA, SI**

Results of test show: **Silica levels** in all areas except for the furnace area exceeded the OEL. Personal samples exceeded the OEL—Wheelabrator and grinding, core area and cooling tower had personal sample exceeding 0.2 mg/m^3; lead concentrations were high for production trainee and crane operator and area samples in the Ajax area had lead concentrations of 0.34 mg/m^3. **All other samples for MDI, TEA, formaldehyde, zinc, iron, and total dust were below the OEL, except that 3 samples of MDI at the mezzanine level exceeded the MDI OEL of 0.005 ppm, with 0.008. 0.008 and 0.007.**

08/25/1986 **86F059AOB** **SILICA/NOISE/ LEAD**

Silica levels found high for Wheelabrator operator 0.58 mg/m^3, auto grinder 0.3 mg/m^3 and cooling tower on mezzanine level 0.33mg/m^3. Lead sampling below the OEL. Noise levels high above the 90 dBA but ranged from 77-78 dBA on melt deck up to 102-104 dBA at shakers and grinding area.

<table>
<tr><th>Date</th><th>Case Number</th><th>Issue</th></tr>
<tr><td>05/30/86</td><td>86F059AOB</td><td>LEAD, SILICA, NOISE TESTS</td></tr>
<tr><td colspan="3">Report provides a concise history and diagrams of the 2nd pour line. Test carried out for lead, silica and noise throughout plant and refers to previous survey Sept. 1984—EAR 32084 FAOB. Lead levels found in the melt deck area. Lead in blood levels generally below 0.7mg/L range from 0.6mg/L for brick liner and melt department to 0.10 mg/L for lab workers mostly female. Make note of drop in the business market and 7% layoff.</td></tr>
<tr><td>10/01/1990</td><td>89L415EOBR</td><td>LEAD/SI/ISOCYANATES</td></tr>
<tr><td colspan="3">MOL visit to initiate reassessment for exposures to lead, silica, isocyanates due to the expansion of production in the molding department with the expansion and inclusion of a third line, and its impact on all other areas that well now have to meet the demand for materials to the molding department. In this regard the MOL concludes that the existing lead, iso, and silica control programs are inadequate. For example, the MOL notes that the new line brought in in 1989, has its own shakeout conveyor and rotary tumbler independent of the other two lines. But after the rotary tumbler the castings are directed to the previously existing shakeout conveyors and Wheelabrator shot blasting area where the castings are cleaned and sorted and inspected. However, the engineering controls provided to the finishing area are essentially the same as when only two lines were operating. This will likely enhance silica exposures that are already high e.g. 0.20, 0.58, 0.30 mg/m^3. Engineering controls have not kept pace with the increased volume of silica.

At the same time, more metal is being used and more cores are being produced that will increase exposure to lead and isocyanates. Lead levels are already high, and with a 30% increase in production existing controls are not adequate.</td></tr>
<tr><td>08/07/1991</td><td>91H406EOBA</td><td>SI/LEAD/ISOCYANATES</td></tr>
<tr><td colspan="3">Follow up from the previous visit. MOL noted that the employer made no attempt to re-assess exposures under new expanded production conditions. MOL notes that the company did not provide details of its engineering controls nor provide an assessment of the new exposure conditions. The Ministry provided details of what must be contained in an adequate control program for each of these chemicals. The medical consultant also advised that the ISO levels needed to be reassessed given the high readings found, and the need to take into account direct contact with the ISO and absorption.</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td>11/22/1993</td><td>18456</td><td>DUST EXPOSURE/WHEELABRATOR</td></tr>
<tr><td colspan="3">High dust levels in the Wheelabrator area allowed to build up and leaking from warped door on Wheelabrator.</td></tr>
<tr><td>06/27/1994</td><td>94332GAAR</td><td>HEAT STRESS CONTROLS</td></tr>
<tr><td colspan="3">The MOL provided an assessment of heat stress levels in the plant in several areas of concern. The WGBT measurements were quite high and physical demands would have a great impact for heat stress. JHSC/Mgt develop a heat stress program. Jobs assessed for workloads that would have an impact on metabolic heat were: coreless operator, metal transfer operator, Arc operator, lead hand, operator (melt deck), auto grinder. WGBT readings are well above the guideline from the ACIGH TLV tables. Workers can sustain a hazardous rise in body temperature. Hot conditions during work on the cranes or at any heights also pose a risk—dizziness and risk of falling. The consultant points out however, that there are other factors that affect heat load, e.g. the effects of wearing PPE (respirators, dust masks that will result in the worker breathing warmer air and work slightly higher to breathe and affect the basal metabolic rate. The employer on many occasions violated the administrative guidelines for controlling heat stress under high heat conditions.</td></tr>
<tr><td>01/11/1995</td><td>23196</td><td>DUST/ WHEELABRATOR/SHAKEOUT</td></tr>
<tr><td colspan="3">The Wheelabrator leaking silica sand as a result of a warped door not sealing.</td></tr>
<tr><td>03/16/1996</td><td>32525</td><td>WORK REFUSAL DEADZONE</td></tr>
<tr><td colspan="3">Refusal to work in dead zone without proper test of the atmosphere, which is highly contaminated with resinous sand from moulds and core sand</td></tr>
<tr><td>07/20/1998</td><td>53054</td><td>HEAT STRESS</td></tr>
<tr><td colspan="3">Company agreed to new heat stress plan, but is not being followed. Still using old plan. 10 minute break every hour not followed. New workers not trained in the new program.</td></tr>
</table>

Date	Case Number	Issue
09/02/03 Foul odours from an adjacent waste dump causing nausea.	**1043580**	**FOUL ODORS**
03/18/03 Worker complaint of fumes from the core and moulding departments entering the lunch room. Company not responding to workers' complaints about fumes.	**1036670**	**FUMES IN LUNCH ROOM**
03/17/04 Employer obstructs H&S rep from attending the beginning of testing as per the ACT.	**1049627**	**HARASMENT OF H&S REP**

MOL ORDERS FILED WITH NEELON

(Ministry Of Labour Orders Issued to Neelon Under The OHSA)

In addition to the MOL plant visit-reports, the union obtained a summary of orders issued between 1991 and 2007. These are briefly presented as citations for contraventions of specific sections of the Act and Industrial Regulations. These orders only give the section of the act and regulation violated and do not provide a detailed context for the issuance of the order. For example, the summary report that an order was issued under Section (6)(a), a stop work direction, but no details are provided to indicate what kind of hazard was being address to warrant the stop order.

We summarize these orders in brief fashion; a copy is available upon request. We note, that 130 orders were issued to the company to address established hazards in industrial production. Some of these were specific to the foundry industry. For example, orders were issued under O.R 851 for violations of Sections: 90(1) for insufficient width of gangway for the travel of molten metal; and Section 87 (1) to ensure that molten metal does not make contact with damp, rusty or cold surfaces to prevent explosions. In line with this, the company was under order O.R. 851 (11) to keep gangways free of obstructions.

In effect, these document recurrent contraventions of routine safety measures required by the Act and regulations. These addressed: requirement to keep records of exposures; requirements to keep records of lockout procedures, machine guarding, measures to prevent eye and skin injury, and skin contact with toxic chemicals; requirements to maintain proper guardrails to prevent falling and contact with molten metal; requirements on the use of certified electrical equipment, proper maintenance of all equipment, provide instruction and training of workers on the hazards and how to handle these safely; storage of compressed gases, prohibition on the use of compressed air to clean dust of surfaces; unsafe use of conveyors and overhead protection; and the requirement to keep exposure records as required by the ACT.

These orders to address these serious and recurrent contraventions of the Act and its Regulations, provides some insight into the health and safety culture promoted by the employer at this plant and the negative health and safety impact on the Neelon workers.

These violations of the legal requirements to protect the health and safety of employees as well as a health and safety culture that left an awful lot to be desired, is also documented in worker and worker representative reports of "supervisors not taking health and safety seriously" and not addressing hazards adequately.

Appendix E: Review Of Body And Air Sampling Data

Section 1) Numerical Value Body Burden/Air Sampling Report Results by Department

Section 2) OHCOW Sampling and Hygiene Assessments (PB, SI, TEA)

Section 3) Descriptive Body Burden/Air Sampling Report Results by Date

1. Numerical Value HYGIENE Results by Department:

Melt Department

09/24/81 A-4035 <u>Metals in air concentrations</u>
Cu 6.5-18.00 ug/m^3
FeO- 240-1000 ug/m^3
Pb-9.0-74 ug/m
Zn-8.6-54 ug/m^3

10/14/81 25481HAAB <u>Metals in air concentrations</u>
Cu-0.01-0.03 ug/m^3
Pb- 0.01-0.14ug/m^3
Fe-0.4-1.1ug/m^3
Zn-0.11-0.09ug/m^3
Si-0.02-35mg/m^3

08/15/83 12282DAOB <u>Metal /Silica</u>
Si-0.1-0.3mg/m^3
Si-0.92, 0.85mg/m^3

08/15/89 12282DAOB
Pb-0.9mg; 0.14; 0.18;0.17;0.2 mg/m^3

10/26/94 23718 <u>Antimony (in urine)</u>
Antimony levels reported by the MOL as 10 times the normal body concentration:
Referent population concentration: US Center for Disease Control (CDC) 2018/19 normal levels-0.120-0.364ug/g of creatinine in urine.
Level measured: 1.2-3.64 ug/g creatinine

09/12/96 37736 SO2
SO2-reported as high but no units reported.

05/04/83 07482GAOB Pb
Pb-0.23-0.19mg/m^3

Core Department

04/10/79 16978FEOB Si
Si-3.2-0.50mg/m^3

06/06/79 (same as above)
Si-0.50-3.2mg/m^3; 0.5-1.70mg/m^3

10/16/80 Tea, MDI, Formaldehyde
Phenol 0.16mg/m^3
Formaldehyde-0.09ppm
MDI-0.006 ppm

06/09/81 OHB0908ODEOB TEA, Formaldehyde, MDI
TEA-0.2mg/m^3
Formaldehyde-0.03-0.09ppm
MDI-0.0V

11/03/81 25481HAAB Cu, FeO, Pb, Zn
Cu; FeO; Pb; Zn; below the OEL (no units provided)
Si-13 samples above the OEL (no units provided)

04/26/82 05081LOAB Si
Si- o.08-0.47mg/m^3

10/28/82 A-8786-A8785 MDI
MDI-0.98-1.2ug/m^3

06/20/84 32084FAOB Pb in air and blood
Pb/BL- 0.56-0.6; 0.16-0.2 ug/L
Pb(air)-0.02-0.16ppm

Moulding Department

11/14/06 1101569 CO
CO-800-900PPM (OEL=25PPM

03/06/07 104884 CO
CO-1700 ppm

04/10/79 16978FEOB Si
Si- 3.20-0.50mg/m^3

04/26/82 05081LAOB Si
Si-0.08-0.47mg/m^3

09/24/03 1044331 Si, Pb, MDI
Si-0.2mg/m^3

Pb-0.34mg/m^3
MDI-008-009ppm (TLV=.005ppm)

12/11/84 37084KOAB MDI, formaldehyde, TEA
MDI-0.002; 0.04; 0.022;0.003;0.002;0.025 ppm
Formaldehyde-0.009ppm
TEA-1.0-4.0 mg/m^3

Plant Wide Survey/Unspecified

06/16/78 N/A Si
Si-16 samples 8 times greater than the OEL of 0.10
05/09/83 27203BEAA Pb
Pb- greater than 0.15; 0.23;0.19mg/m^3

12/03/84 32084FAOB Si, Pb, MDI
Si-0.33mg/m^3
Pb- 0.34mg/m^3
MDI-0.005; 0.0008;0.007

08/25/86 86F059AOB Si
Si- 0.33mg/m^3

05/30/86 86FO59AOB Pb, Si
Pb- <0.7mg/L; 0.6-0.10mg/L
Si_0.20; 0.58;0.30 mg/m^3
MOL comment: Pb and Si control program inadequate

12/13/02 N/A CO
CO levels high in Core and Mould Departments
CO-40-60ppm

2002-2003 CO levels high in core and mould department

08/25/03 N/A CO
CO- 47-49 ppm

01/02/07 N/A CO
CO-supervisor tampering with area monitors for CO.

01/30/07 N/A CO
CO-25-30 and 35-40 ppm no alarm sounding at action levels and stationary monitors reading less than personal monitors.

03/2001 NA CO

CO- supervisor subverting CO monitors by blowing in fresh air at the sensors; Levels reaching 400ppm

10/01/90 89L415EOBR Pb, Si
Pb-0.7mg/L (0.6/L-0.7/L); Lab staff=0.1mg/L
Si- 0.2;.0.58;0.30mg/m^3
MOL: Si and Isocyanate control program inadequate

OHCOW Sampling and Hygiene Assessments (Pb, Si, TEA)

Gauvin, Albinger, Keller and Wakely

Lead Sampling and Assessment:

1. Three of six personal samples exceeded the adjusted TLV-TWA from 8% of the TLV of 0.025 to 64% over the TLV. Levels ranged from: 0.00624 to 0.04mg/m^3.
2. Two of four area samples exceeded the TLV from 17% of the TLV to 246 % over the TLV.

Silica Sampling and Assessment (Rcs):

1. Four of six personal samplers exceeded the adjusted OEL of 0.025 from 20 % of the TLV to 44% over the TLV. Measurements ranged from 0.02 to 0.036 mg/m^3
2. Two of the four area samples exceeded the adjusted TLV of 0.025mg/m^3 from 51% of the TLV to 28 % over the TLV. Measurements ranged from 0.02 to 0.046 mg/m^3.

Triethylamine (Tea) Sampling and Assessment:

1. All personal samples exceeded the adjusted OEL of 1.035mg/m^3 from 23 times higher to 51 times higher. Measurements ranged from 24.66mg/m^3 to 53.27mg/m^3
2. All area samples exceeded the adjusted TLV of 1.035mg/m^3 from 23.8 times higher to 51.5 times higher. These ranged from 24.66mg/m^3 to 53.27 mg/m^3
3. AIR AND BIOLOGICAL HYGIENE SAMPLING (INCLUDES PROFESSIONAL COMMENTS) BY YEAR

1979

Air Quality (particularly MDI) Assessment Report – May 28, 1979 -MOL/OHB-W Alleway

Silica

Personal and Area air samples taken for silica. At time of sampling, no grinding taking place. Testing delayed to allow for completion of foundry expansion.

Silica: 6 personal samples taken including furnance floor man (0.06), *auto pour operator (0.29), Disa operator (0.09), *wheelabrator takeoff/inspection table (0.13), *wheelabrator operator/conveyor sorter (0.32), forklift operator (0.06). 5 area samples taken: *muller control panel (0.15), *auto pour deck control (0.11), *conveyor control panel beside wheelabrator #2 (0.17), between rotary shakeout and moulds conveyor (0.09), on control panel by rotary accumulator conveyor and Desprue conveyor (0.05). * over-exposure

MDI

2 area samples taken: upper deck by tank storage (<0.001), main floor in front of core machine (0.001)

Letter Nov 5, 1979: Re: Follow-up meeting between Neelon management and JG Collinson on appropriate masks for silica. Company had been issuing orinasal respirators with organic vapour cartridges and dust filters. "I informed the company that this type of cartridge system was not required, that filter and retainer was sufficient to protect employees from the dust in the foundry." This was supported by a letter from the Wilson Safety Products company in Reading Penn via Ms. R. Kennedy who confirmed that No. 1210 respirator which consists of the R685 face piece together with 2-R10 filters and 2-R682 retainers is approved by NIOSH for protection against dusts. Crystalline silica is included in this group.

1980

Field Visit Report to assess MDI, TEA, phenolic-formaldehyde, silica and heat – March 31, 1980 – MOL/OHB – T Gregor

Visit initiated to assess work environment due to new (2 months) worker's complaint of recurring bleeding from the nose.

Air sampling for MDI, TEA and phenolic-formaldehyde will be requested in this area. This request is made on grounds that the employee complaining of recurrent nose bleeds works on removing the cores from the conveyor coming out of the core oven. TEA is used as the catalyst in the mould and core making area. It was noted there was an irritating odour in this area when each core was pressed out.

Request made for Air Sampling for MDI, TEA, Phenolic-formaldehyde, silica in Core – Neelon Manager, S Bere
(in response to complaint of eyes/throat irritation and nausea, by 5 of 21 workers in core oven area. Process used is an Isocure process patented by Ashland Chemicals). Date of request was Oct 31, 1980. (Complaints coincide with opening of third core line).

Remark by T Gregor: Report sampling requested because 3 core machines are now in full operation and health complaints have been voiced by the workers.

RESULTS IN FOLLOW-UP REPORT BY TJ GREGOR (Dec 4, 1980) at OHB indicates that Triethylamine (TEA), formaldehyde and MDI were sampled. Nine area and three personal samples of each were done in core making area and they were all well below their respective TLVs. As such, no significant health hazard should exist.

Comments: 1. Feed area for core ovens situation on floor above and it was noted there was a cup of Isocure, open to the atmosphere. 2. First core oven area seemed to have a very strong odour and further air sampling to be carried out. 3. Company having difficult time obtaining a physician. Thus, pre-employment exams do not always exclude employees with respiratory allergies. 4. Visit initiated by union request. 5. Company is looking at an air cleaning unit which has potential for cleaning air of TEA and MDI. They are also thinking of installing a phosphoric scrubber in this area to further improve working conditions. 6. Company policy is if there are complaints to stop line and make respirators available. In addition, respirators are available to all men at all other times.

Noise survey – Aug 15, 1980- MOL/OHB-JG Collinson

The results of noise survey conducted at this cast iron foundry. The results indicate that the noise level in the plant generally varies between 80-85 dBA. Exception is casting inspection area where noise levels of 86-100 dBA were recorded (castings transported on vibratory conveyors). Unmuffled compressed air exhausts on the Disa mould machine, the sand Muller, and Shalco core machine produced noticeably higher noise levels during the exhaust cycle. Consider installing some sort of muffler on these exhaust outlets, was offered.

Silica Samples Assessment by RC Read – Nov 17, 1980 – MOL/OHLab

Unidentified locations sampled ranged from 0.03 – 0.45 mg/m^3. Those exceeding TWA ranged from 0.22 – 0.45 mg/m^3.

1981

Health Surveillance Practices/Field Visit Report – July 22, 1981 – MOLOHB – DM Bourgeois

Company has been in operation 6 years. Of 200 employees, 50 are salaried. Turnover rate approximately 2 per month and median age is 25 yrs.

Current Health Practices:

- First Aid Training: 27 certified including all supervisors and foremen.
- Health Assessments: No schedules for pre-employment nor periodic health evaluations although specific exams are carried out including yearly chest x-rays and pulmonary function testing due to silica exposures. Recently first audiometric testing program completed for employees.
- Basic principles of a comprehensive employee health surveillance program were discussed and materials left. Role definition of nurse identified.

Metal and Quartz Analysis – Sept 8-11, 1981 – MOL/OHB - F.Lo

Metal: (5 samples taken in micrograms, not in usual mg/m^3 standard formula with no indication of where testing was done, presumably at, or around, the Arc furnace)

Copper: 6.5, 8.7, 10, 18 ug/m^3

Iron: 240, 430, 440, 1000 ug/m^3

Lead: 9.0, 22, 18, 74 ug/m^3

Zinc: 8.6, 20, 16, 54ug/m^3

RCS (15 samples in mg/m^3)

0.04, 0.15, 0.18, 0.18, 0.14, 0.20, 0.08, 0.05, 0.08, 0.05, 0.04, 0.11, 0.03, 0.08 mg/m^3

Review of (silica, furnace fumes, total particulate) Exposure Assessment Report (of M Dutka, Oct 14,1981)- Nov 3, 1981 – MOL/OHB – JG Collinson

Report indicates that concentration of copper, lead, zinc and iron oxide not in excess of max levels but report measures metals individually and in micrograms and there is no total particulate result identified (TWA for particulate is 10mg/m^3). Lo notes "the roof fan above arc was not operating and had an adverse effect on particulate concentration in the area. Further sampling will be conducted by OHB when fan is in operation to reassess."

Silica concentration throughout foundry is in excess of TWA of 0.1 mg/m^3. Of 13 personal and two area samples, eight samples recorded concentration in excess of the TWA. Notes fluctuating concentrations around auto pour and Disa which should be explored, perhaps source is muller? Concentrations especially high in grinding and existing exhaust should be critically examined.

Orders were "suggested" under Section 145 by inspector.

LETTER TO ROBERT ELGIE, MINISTER OF LABOUR – FEBRUARY 2, 1981- FROM NDP MEMBER BUD GERMA RE: CHEMICALS IN CORE DEPARTMENT.

I am advised that chemicals used in core department include TEA used in conjunction with nitrogen. I am advised that the binding agent used is carcinogenic. This procedure, as I am told, is causing blurred vision among employees of this plant. I am writing to Request that your ministry initiate a program whereby the 15 current employees and 10 former employees can be tested to determine the negative effects, if any, of their exposure to those chemicals.

1982

Silica Air Sampling Assessment Report – MOL/OHB DF Burke - Mar 26, 1982

15 personal samples taken **(mg/m^3): Core Area Attendant (**0.09), Disa Operator (0.17), Fork Truck (0.10), Auto pour (0.23), Wheelabrator/conveyor Attendant (0.47), Arc operator (0.08), Channel Furnace Attendant (0.11), Utility (0.18), auto grind control panel (0.08), Desprue conveyor electric panel (0.12), core making near oven (0.07), Arc near attendant station (0.05), Auto pour operator (0.20), Channel furnace west wall (0.12), Disa operator station (insignificant).

MOL/OHB Summary of Burke report by JG Collinson on May 6, 1982, include following comments:

Airborne concentrations of silica were in excess of maximum level in Ontario. 5 of 8 personnel exceeded the TWA and 3 of 7 area samples exceeded the TWA. Highest personal level was for forklift operator and utility man. Highest level was recorded for Wheelabrator/conveyor attendant.

Metal Fume Testing in Arc furnace June 30, 1982- MOL/OHB – JG Collinson

Testing requested for copper, lead, zinc iron oxide, total particulate during operation of two arc furnaces once the second is commissioned in August.

Air Testing for Formaldehyde, Methylene Bisphenyl, Isocyanate MDI, Triethylamine - Dec 9, 1982 – MOL/OHB – JG Collinson

Location: Heated core storage area

Formaldehyde and MDI = 6 samples

TEA = 4 samples

Results: "In almost all cases the results were below detection limit and in every case below the TWAE.

1983

Silica (plant wide), Welding fume (weld shop), Particulate/lead (furnace area) Air Testing – May 9, 1983 – MOL/OHB - JG Collinson

Focus on New Maintenance Area (Noted: "fumes migrate from fabrication to entrance fans at maintenance work stations")

Comment: company visited many times by OHB especially re: silica exposures, notes dust collector not working due to malfunction of bag shaking mechanism.

Comment: Testing shows quartz exposures to be in excess of TWAEL in many places for several years. Company says with expansion improvements made but “I am skeptical” things have improved.

Comment: Air-Sampling for total particulate, lead, zinc and copper on March 2, 1983 indicated excess of lead in arc furnace area (0.15 mg/m^3).

Comment: Weld shop lacks exhaust ventilation; consider local exhaust ventilation to control weld fumes.

Comment: Airborne concentration of total dust was 9.5 mg/m^3, slightly below TWAE of

10 mg/m^3. Airborne concentrations of iron, zinc and copper identified is well below allowable levels of 5.0, 5.0, and 0.2 mg/m^3 respectively.

<u>Silica Air Sampling - Aug 18, 1983 – MOL/OHB – JG Collinson</u>

(Silica survey follow up to previous May, 1983 report)

Report of L. Lawrence indicates that airborne concentration of quartz in excess of maximum allowable throughout the plant with the exception of offices, sand laboratory, weld, and channel furnace area, with the majority in range from 0.1 to 0.3 mg/m^3 with the exception of wheelabrator operator (0.92mg/m^3) and #6/#8 pedestal auto grind operator (0.82 mg/m^3).

Levels remain at which existed in March 1982, date of last survey.

<u>1984</u>

<u>Lead, Silica, and MDI levels review – June 20, 1984 – MOL/OHB – M Polny</u>

Earliest Lead testing that identifies need for Control Program. ISO testing conclusion is control program not needed but Medical Consultant disagrees.

Meeting held with company re: their concerns about the implementation of medical surveillance program for lead and silica based on data they collected on worker blood concentrations. Samples collected from 36 management and hourly employees. Results indicated lead concentrations ranging from 0.16 – 0.2 to 0.56-0.6 mg/L. Company plans to take more blood samples in Sept. In addition, samples of potable water in plant analyzed for lead content and found to contain 0.02-0.06 ppm. Dust samples also tested for lead. Company not convinced source is arc furnaces. With 8% lead content in dust samples on roof beam movement in area by bridge crane may disturb dust increasing air borne lead concentration.

After review of test results, plan was to: Institute Lead Surveillance Program; continue the Silica Surveillance Program; do not move forward with Isocyanate Control Program (author of report disagrees) but follow-up with OHB will review this.

<u>Silica, Lead, Copper, Iron, Zinc, Total Dust, Formaldehyde, TEA, MDI Air Testing - Nov 2, 1984- MOL/OHB – F Bouma</u>

Results: Silica: High Personal concentrations in mg/m^3 for Disa Operator (0.15) and for workers sweeping and sorting discs (0.18) grinding (0.36 and 0.24), and utilities man (0.40), and core trainee (0.17). High area concentrations noted at Disa Control Panel (0.12) and Mezzanine Control Panel (0.25 mg/m^3)

Lead: High Personal concentrations for Furnace trainee in mg/m^3: (0.19), and crane operator (0.15) Copper, Iron, Zinc, Total Dust, Formaldehyde, Tea, MDI concentrations all below TWEA

MDI and Formaldehyde Air Sampling - Dec 11, 1984 – MOL/OHB – F Bouma

Re: Auto pour and metal transfer areas

MDI: 6 samples were taken (no location) with the following readings in micrograms: 21, 5.4, 11, 40, 1.5, and 1.3 ug/m^3. No analysis, or comments, provided.

Formaldehyde: 2 samples were taken, both reading levels below 2 micrograms.

1985

Surveillance Program for Silica and Lead March 15, 1985 – MOL/OHB – TJ Gregor

OHB visit to finalize silica surveillance and identify modifications to lead program as well as evaluate the need for isocyanate surveillance

Findings from Air testing: Air lead levels highest in furnace areas as are blood samples prompting immediate need for respirators in area. Dust respirators enough in plant except in induction and arc furnace where lead fumes also present need for upgraded respirators, e.g., NIOSH approved toxic dust and fume respirators for lead in furnace area.

Blood levels for lead done in June 1984 and November 1984. The values ranged from 0.60 – 0.27mg/L in June and 0.60 – 0.23mg/L in November.

Note: author of report states “I feel the isocyanate question has not been adequately answered.” The results from recent air sampling done by OHB are not available.

Dust samples from Melt dept floor had 8% lead, steel beams had 3.5% lead and lesser in other areas. Management considering vacuum system.

MDI Air Sampling – April 1, 1985 – MOL/OHB – F Bouma

13 Samples were analyzed for MDI; none showed the presence of MDI at or above its detection level of 1.0 micrograms.

Silica and Lead Sampling Report – December 3, 1985 – MOL OHB – JG Collinson

Review of exposure assessment report of F Bouma findings:

1. Air sampling for silica, results in greater than 0.1mg/m^3 in all areas except furnace area. wheelabrator/grind area, core area, cooling tower had personal and area samples in excess of 0.2 mg/m^3. There appears to be a downward trend compared with August 19, 1983 results although silica concentrates above 0.2mg/m^3 in some areas.
2. Personal lead samples on production trainee and crane operator in furnace area revealed lead concentrations at or above exposure limit of 0.15 mg/m^3 and area sample in Ajax area produced concentration of 0.34 mg/m^3. Lead concentration in rest plant well below TWAE.
3. Air borne concentrations of: copper, iron, zinc, total dust TEA, and formaldehyde in all parts of plant well below TLVs.
4. Airborne concentration of MDI (ISO) in core area below TWAE but at mezzanine level 3 samples around Chute C and main control panel were: 0.008, 0.008, and 0.007 ppm respectively which are above the standard of 0.005 ppm. On basis of this Iso Assessment should be reviewed and Control program implemented.

1986

Silica and Lead - May 5, 1986 - MOL Occ Health Branch - B. Nurse

Testing focused on Control Room Melt Deck

Results:

1. Medical Surveillance program, including education on hazards for silica is not provided to comply with regulations. Baseline chest x-rays and pulmonary function tests conducted on Aug 27-28, 1985.
2. Medical Surveillance for lead is required. According to employer rep, Mr. Tarnopolosky, employee blood levels said to have gradually decreased since Nov. 1984. 1985 results were below .70 mg/L but not received by (company?) physician. Current results show blood levels generally below 0.7 mg/l ranging from 0.6/L for brick liner and melt dept workers to 0 .10 mg/L for bi-stander Lab workers (mostly female).

Comments from Follow-up Audit report June 4, 1986

Concern: possible lead ingestion with the control booth and coffee break area situated adjacent to furnace area. Recommend: positive air pressure, painting of floors, daily wet mopping of area.

Concern: Possible lead exposures to female Lab employees due to lower action level. Air testing result for melt control booth showed 0.04 mg/m^3 for lead.

MDI re-testing at chute "C" on Core Mezzanine: significant levels found previously, not found on retest.

Concerns: Copy of silica results is not sent to examining physician. Periodic medical exams and health education not provided.

Lead, Silica and Noise Testing – Sept 8, 1986 – MOL/IHSB – JG Collinson

Silica: Throughout plant

Lead: Melt deck

Noise: Throughout plant

Results: High personal samples for Silica for 1. Wheelabrator operator and 2. Auto grind operator. High area sample by 3. Cooling tower on mezzanine. Lead sampling all under exposure limit. Noise levels high, and implementing hearing protectors.

1988

Complaint visit – Sept 15, 1988 – MOL/Requst for visit – R Kaushal

Re: excessive dust and smoke from arc furnaces when both operating at full capacity. Fumes generated during melting charge contains lead, iron oxide dust and fume and total particulate.

Report dated Sept 15, 1989 – R Kaushal - Air Monitoring Results Identified 1 personal sample and 2 area samples as above criteria for lead. None identified for air testing for Iron oxide and total particulate.

Comments: Level of smoke and fume dependent on amount of natural ventilation (doors open) and type of metals being melted. Re: Particulate exposure only crane operator over TWAE (> 0.15 mg/m^3). Other two personal samples ranged between 0.07 – 0.08 mg/m^3. Area samples ranged from 0.04 to 0.19mg/m^3. **The area samples also indicate that existing local exhaust ventilation is inadequate to control workers' exposure to lead below the criterion.**

Recommendation: maintain dust collector system regularly. Keep gap between lid and furnace sealed with sand. Local exhaust between 2 furnaces should be balanced.

1989

TEA testing re: worker complaint - November 21, 1989 -MOL/OHSD - R.Wright

Re: TEA Air Testing of 9 workers in Core as result of maintenance worker complaint. Workers tested included: core machine operator; core operator at slip tank, core hander working opposite oven, labourer on mezzanine who transfers TEA from 45-gallon drum to holding tank, Areas tested included two ends of core machine area, and near oven. In sum, testing results were below the TLV-TWA.

Appendix F: Worker Concerns and Complaints

Joint Health and Safety Committee Minutes

Worker Concerns and Complaints

10/29/1999: Complaint concerning improper cooling at the auto pour blowing sand and dust in the area. Workers are experiencing sinus, eye, and ear irritation and infection. Dust witnessed to be escaping from the dust collection system.

12/1/1999: The additional duct that dispenses bentonite at the 202 Roberts is causing the bentonite to become airborne and worsening the dust conditions in the auto pour area. It is noted that the MSDS sheet for bentonite indicates that bentonite is an irritant and can cause silicosis.

12/17/2001: Crane cable snapped when slid off the sheave wheel. Other contraventions noted: disrepair of equipment, improper PPE, poor visibility and lighting, poor clean up and housekeeping, missing rails and trip hazards.

04/27/2002: Defective ladle is turning uncontrollably due to malfunctioning gear box.

07/16/2002: Workers seen smoking and drinking at their work station without proper respirators; no proper lockout procedure being followed and worker using compressed air to clean off coreless furnace and auto pour furnace.

12/13,14/2002: Very high exposures to CO in the mould and core departments. Employer responded by using administrative controls, e.g., rotating workers who had high exposures with workers with low exposures as a guideline to prevent any chance of over exposures. Instead of controlling the CO emissions the employer foolishly spread the exposures.

12/14/2002: Further investigation into the CO levels found a possible cause of these high emissions. Worker discovers two large holes in the duct work. These were repaired and the levels dropped from 40 to 60 ppm to 15-35 ppm. Further investigation found other leaks in the duct work with fumes and smoke coming from mould line rising from below the stairs.

Another possible cause was an imbalance in the exhaust system from line to line. Rectifying the problem on line #1 would adversely affect airflow and extraction on line # 2 and #3

03/04/2003: "D" Bull ladle run out on Melt # during tapping of coreless furnace – molten metal spilled on the floor.

03/14/2003: Very high CO levels in the core and mould areas.

04/03/2002: Work refusal took place over high CO levels.

01/09/2003: Elevated CO levels reported

01/14/2003: Coreless tapping with moisture is causing an explosion hazard

05/02/2003: Workers on catwalk by Ajax #3 while pouring operation going on with no escape route. Aisles too narrow and ladle could hit wall and cause spillage of molten metal on workers who were less than 2 ft. from the ladle.

05/02/2003: Workers not advised that there was water in the pit which presents a potential explosion hazard if melt makes contact with the water.

05/02/2003: A gas leak was discovered on Line #2 due to a faulty gasket on the line.

05/13/2003: Poor lighting at the pour box on Line#3

05/14/2003: Metal transfer bringing back a half full ladle creating a hazard for the melt deck.

05/20/2003: While slagging the auto pour it was noted that workers were sharing PPE; very severe heat stress and very smoky. Smoke should be measured and its constituents identified.

05/02/2003: Line III splash shield and rail loose.

05/13/2003: Spillage protection with grate a fire hazard with respect to the materials used; and the charging platform is warped.

07/21/2003: Supervisor not enforcing the safety rules and policies.

08/14/2003: Working in melt and mould areas without "gator boots".

08/25/2003: Work refusal unsafe ladle and high CO levels of 47-49 ppm on average on Line#1. Heat stress very high, and air quality smoke and dusty.

Subsequent work refusals re: heavy smoke on Lines II and III. Four other work refusals among ladle operators over heavy smoke in the moulding areas due to tapping of coreless furnaces.

04/29/2004: Work refusal over unsafe carts.

07/21/2004: Supply air contaminated with moisture causing filter to malfunction.

05/2006: Work refusal sonic alarm not working

06/15/2006: Open doors are interfering with the exhaust ventilation system, e.g., melt department using fans to cool coreless operators, but blow air over coreless hampering the DC5 and smoke during slagging and tapping. Produces heavy smoke during slagging and tapping; modification of M4 baffles and leaks send smoke, heat and embers in the direction of workers on monorail bay and mezzanine above the Disa. 4 work refusals over heavy smoke; the heat stress policy is ineffective and employer continues to hamper it. There is a backlog of concerns that remain unaddressed by the company.

08/26/06: Ajax tapping station—sonic alarm for the malfunction of the hydraulic pump is not working. This device prevents harm during the tapping procedure should there be a malfunction by alerting the transfer operator.

09/20/2004: Work refusal over hydraulic pump not functioning properly to prevent over fill of iron in the ladle during tapping.

02/08/2006: Worker in the pouring zone without proper PPE.

02/15/2006: Harassment of health and safety representatives. Worker filed a S. 50 reprisal complaint. Issue over proper signal lights for pedestrian traffic during pouring and transferring operations between the Ajax and auto pour station.

04/16/2006: Work refusal over an explosion hazard with load on forklift.

04/07/2006: CO alarm tampered with.

12/06/2006: Explosion hazard as a result of moisture in the furnace.

01/02/2007: Concern over high CO levels coming off all three smouldering moulding lines. Reps requested data from employer in December 2006. Noted that make up air system is being tampered with baffles added to make up air system between line 2 and3 allows access to control air flow, but having a negative impact on the exhaust system.

01/2/2007: No MSDS labels on decanted chemicals. For example, can't get label for inoculant used on 3 moulding lines.

01/02/2007: High levels of CO around the pour box in the mould department

01/15/2007: CO sensors are affected by sensor wiring giving spurious readings

01/30/2007: Shielding curtains over pour box missing and fans interfering with local exhaust to control CO concentrations, consequently, CO levels are high. Worker narrative re: CO over

exposures, and not following CO monitoring protocol. For example, stationary monitors reading less that personal monitors. Workers requested all data from February 16 to 18 as well as workers personal samples. Monitors were reading at 25-30ppm and 35 and 40 ppm and no alarm sounded at stationary sites at these levels.

Worker representative noticed that shift-staff were not wearing personal CO monitors. He inquired with supervision and was told that the CO problem had been addressed and there was no need for the personal monitor, in effect misinforming the worker and endangering his health. During that shift, read outs showed that the levels were approaching the maximum permissible level and in a short while exceeding that level.

02/01/2007, 02/08/2007; 02/21/2007: Reprisal for conducting a work refusal.

03/12/2007: Use of compressed air to clean core department machines and floors, creating air borne silica and dust from the dried graphite dip; Ajax charged without signals in operation. "Man Door" on melt deck left open; ladle bumped into Ajax #3 because of narrow gangway.

04/13-14/2007: see text

05/13/2007: CO contamination on auto pour III—duct is not effective in removing CO and the CO situation is getting worse in the moulding area; sand traps at auto pour 3 building up creating a trip hazard; gas lines at Line#3 test bar station left on; shovelling at DIsa, exhaust blow and disturbs sand in box. Employer not enforcing safety rules and policies; Red Tag phone in audible due to sand hopper vibration; poor lighting on the catwalk #1 and poor communication on Lines #2 and #3; new pattern cart blocking egress; "Kronos" from lunchroom to work area with ISO, Si and graphite.

List of concerns: Slagging ladles-excess heat, no cool off time, Slag falling on floor producing excess smoke, slagging not ventilated, slag box filled with other materials that could present an explosion hazard or release of toxic contaminants, pulling slag toward work; refusal to transfer iron melt, ladle striking Ajax, can't clean area under the Ajax; work refusal on Line #1 because of extreme heat stress, use of Cer wool, oil leaks on Disa, view and walkway obstructed. Work refusal on Line #1 due to excessive smoke, Cer wool, heat stress, too much slag and poor lighting.

Workers registered complaints about the lack of enforcement of safety measures and the lack of response to safety and health issues. Some complaints such as poorly maintained torches had not been dealt with in 2 years.

Work refusals continue over excessive smoke as a result of too much iron in the in the charges.

March 2007: Series of unsafe conditions and activities: Ladles transferred when full is very hazardous and against safety policy and rules; personal CO alarms not functioning; Ajax alarm not working, no splash guards, no WHMIS labels, work refusal; no adequate pedestrian traffic control in hazardous areas; concern with viewing window being obstructed, poor lighting, trip hazards, poor housekeeping, ladles not secured properly, CO and smoke continues to be problematic as well as the provision of adequate PPE.

Joint Health and Safety Committee Reports 1999-2003

Joint Health and Safety Committee reports and minutes were available for the years 1999 to 2003. These were very abbreviated reports indicating the department, the issue who was to address it and the disposition of the issue with respect to resolution. These were a combin-ation of check lists, brief one to two sentence statements of the issues in preformed report sheets.

09/1999 Melt Deck: Lock out procedures not available in the melt department when repairs being carried out on furnaces by maintenance and/or refractory staff.

10/1999 Mould Department: Problem with airborne exposure to clay dust (bentonite). Workers are experiencing severe skin irritations at levels likely to exceed the OEL.

12/1999 Finishing Department: Introduction of Racquel Helmets in the finishing department on a 3-month trial basis as well as the introduction of eye goggles to protect against eye injury.

01/1999 Finishing Department: Leaks in the Hurricane Washers flooding walk surfaces. Solution leaking not specified.

01/1999 Melt Department: MSDSs requested for raw materials charged or inoculated in the furnace melts. Work refusal took place as a result of dense smoke from the coreless furnaces. Workers wanted to know what they were inhaling. MSDSs not available to workers.

03/1999 Melt Department: Work refusal investigation reveals MSDSs for raw materials do not exist and need to be developed.

01/1999 Melt Department: problem with proper lock out for the hydraulic mechanism on the furnace lids when workers are conducting cleaning underneath the furnaces. Also is problem with expired forklift certification stickers and forklift training.

03/1999 Melt Department: Excessive brown dense smoke in the melt department that also reduced visibility on Melt #2.

03/1999 Melt Department: Comprehensive air sampling conducted and found in table 1 of the report available for the last 10 years. Table not reported in these minutes. Minutes indicate that sampling was done in conjunction with the lead control program. Dust control noted via dust collection modifications, procedure upgrades e.g., seal vessels before start up; and eliminate lubricants on borings and use non-lubricated borings. Develop MSDS for raw materials and sampling protocols. Observed that the pyrolysis of lubricants contaminating raw materials is producing decomposition by-products in worse case testing containing lead and PAHs. Request MSDSs for lubricants found on borings. Proposed to use Gastec color metric tubes to test for amines, petroleum distillates and high and low hydrocarbons. To be carried out by Cambrian College and carry out testing as per MOL list of contaminants by 09/30/00.

03/1999 Lack of training for workers who frequently move from job to job or changes in production processes. Also discussed 03/11/99 training triggers, and 09/24/99 awareness training for mould personnel for CO extraction and personal monitoring. Indicating that CO was a continued problem and workers not clear on the hazard and the monitoring process.

09/28/99 TEA gas handling when it is present and noted that TEA is a predominant problem in the Core Room. Workers are complaining of a blue haze, headaches, and a strong odour.

02/03/99 TEA is controlled by policy requiring machine shut down when TEA begins to leak. Post signs and follow procedure.

09/24/99 Review all products entering the plant including MSDSs for these.

11/26/99 Report on CO concentrations by W.W. MQ concerns not addressed for several months. CO concentrations and goggles were raised.

11/03/99 Finishing Department: White dust masks continue to be used in finishing and grinding. Water leaks noted at the air intake ducts due to snow accumulation; lots of fine dust noted emitted from the entrance of the Panghorn; MSDSs out of date; poor housekeeping noted; elevator shaft missing cover.

11/26/99 Respiratory protecting not maintained and stored properly. Noted that left on lunch room tables and chairs. No lockout procedures on Ajax furnaces. A.L. to develop.

11/27/99 Positive pressure in the lunch room noted; need for testing to address core room issues e.g., TEA, MDI, IAQ report, CO, Arc furnace flareups, and pumping resins in the bulk tank.

11/17/99 Issues over CO monitoring;

12/17/99 Meeting with the MOL regarding CO controls and testing and alarms

12/12/99 Mould Department: Release of fine clay particulate causing skin irritation in 3 employees as well as sand lab technicians. Clay is being discharged by valve on the belt and is overflowing on the floor with employees shovelling clay on floors. Clay is also being discharged and becoming airborne and causing rashes. Cause: failure to follow MOL order to prevent discharge and clean-up. Staff attempted to address this with a jury-rigged cardboard baffle on vent. Noted that air born clay must be prevented during clean up processes.

Noted also was the existence of MSDS on computer files.

2000 Mould Department: Personal CO monitors: need to conduct extra testing on monitors in the melt transfers to ensure that these are the true levels and institute a preventive maintenance program.

2000 Melt Department: Ensure that respirator users carry out proper fit test. Request for JH&SC resources were rejected by employer. MOL order for more tests due to changes in extraction system. Heat stress relief workers prepared for hot summer months.

Mould: JH&S recommends extraction hoods be installed over mould lines and be redesigned. Employer rejected this recommendation as too costly.
All departments ensure rotating workers are adequately trained.

2002 All departments: housekeeping rated fair. Melt very hot and excessive smoke from Arc #2.

03/2001 Supervisor subverted the CO area sensors by blowing fresh air on the sensors to lower the CO readings. CO levels reaching 400 ppm. CO monitors need to be tested properly and lights and alarms must be functional.

JHSC Reports for General Plant Wide Issues

03/1999 Lack of training for workers, who frequently move from job to job, or in response to changes in production processes. Also discussed 03/11/99 training triggers, and 09/24/99 awareness training for mould personnel for CO extraction and personal monitoring. Indicating that CO was a continued problem and workers not clear on the hazard and the monitoring process.

09/24/99 Review all products entering the plant including MSDSs for these.

11/26/99 Report on CO concentrations by W.W. MQ concerns not addressed for several months. Issues of CO concentrations and goggles raised.

11/26/99 Respiratory protection not maintained and stored properly. Noted that was being left on lunchroom tables and chairs. No lockout procedures on Ajax furnaces. A.L.to develop.

11/17/99 Issues over CO monitoring.

12/17/99 Meeting with the MOL regarding CO controls and testing and alarms. All departments to ensure rotating workers are adequately trained.

2002 All departments: housekeeping rated fair. Melt very hot and excessive smoke from Arc #2.

03/2001 Supervisor subverted the CO area sensors by blowing fresh air on sensors to lower CO readings. CO levels reaching 400 ppm. CO monitors need to be tested properly and lights and alarms must be functional.

Appendix G: Review of (Limited) MSDs

Obtained for Chemicals Used in Neelon Casting Production Processes

1. Product Name: BENTONITE

Where Used/Who Exposed: silica quartz additive in mould sand/workers in mould, sand lab, finishing, and maintenance, especially labourers (general ingredient in ambient dust and particulate)

Hazardous Ingredients: Crystalline silica quartz
Decomposition Products: Amorphous silica may transform at elevated temperatures to Tridymite (870 degree C) or Cristobalite (1470 C).

Health Effects/Symptoms/Overexposure: Precautionary Statements: Do not breathe dust/fumes/gas/mist/vapours/spray. Get medical attention if you feel un-well (Category 2 classification. Hazard Statement: May cause damage to organs through prolonged or repeated exposure if inhaled, including: lung diseases, e.g., silicosis and lung cancer. It has also been associated with scleroderma and kidney disease. If engineering controls and work practices cannot keep exposure below occupational limits the proper use of PPE should be determined by an industrial hygienist, based on the specific application of this product.

2. Product Name: BLUE RAM HS PLASTIC

Where Used/Who Exposed: Refractory repair product/workers in Melt, Auto pour, Metal transfer, labs (general ingredient in ambient dust/particles)

Hazardous Ingredients: Mullite, Aluminium Oxide, Cristobilite,Quartz, Phosphoric Acid
Decomposition Products: Under normal conditions of storage and use, hazardous decomposition products should not be produced.

Health Effects/Symptoms/Overexposures: HAZARD LABEL: CAUSES SKIN IRRITATION, SERIOUS EYE IRRITATION, MAY CAUSE CANCER. PRECAUTIONS FOR SAFE HANDLING: ensure good ventilation of the workstation. Obtain special instructions before use. Do not handle until all safety precautions have been read and understood. Take all necessary technical measures to avoid or minimize the release of the product on the workplace. Limit workers. Provide local exhaust or general room ventilation. Wear personal protective equipment. Floors, walls and other surfaces in the hazard area must be leaned regularly. Avoid contact with skin and eyes. Separate working clothes from town clothes. Launder separately. Wash contaminated clothing before reuse. Do not eat, drink, or smoke when using this product. Always wash hands after handling product.

3. Product Name: BPCI SUDBURY PRODUCT NAME CORE WASH

Where Used/Who Exposed: Core Wash product/ workers in Core Room, Finishing, Grinding, (general ingredient in ambient particulate and dust)

Hazardous Ingredients: Magnesium Carbonate, Kaolin, Graphite, Fuller's Earth, Mica, Talc, Quartz
Decomposition Products: None known to company

Health Effects/Symptoms/Overexposure: Not expected to be hazardous under normal conditions of use. However, if allowed to become airborne, may cause irritation of nose, throat, and lungs. May cause skin and eye irritation on prolonged or repeated use

Delayed hazards: Kaolin and Fuller's Earth: Chronic inhalation has resulted in benign pneumoconiosis; pre-existing respiratory conditions may be aggravated. Mica: Can cause fibrosis and aggravate respiratory conditions. Talc: Can cause lung damage. Pre-existing respiratory conditions may be aggravated. Quartz: Can cause cancer, silicosis, and pneumoconiosis in generating silica dust, which is classified by IARC as a human carcinogen. Silica dust may also cause scleroderma or be linked to TB. If airborne contaminants are generated general and local ventilation should be provided to keep exposures below acceptable levels. If these levels can't be met, respirators should be used based on the form and concentration of contamination. See MSDS for TLVs reported for each ingredient.

4. Product Name: CARBON COKE

Where Used/Who Exposed: Silicon powered additive in Furnaces/workers in Melt, Auto pour, Metal Transfer, Ladle workers (general ingredient in ambient dust and particulate)

Hazardous Ingredients: Purified carbon as total dust/respirable dust.

Decomposition Products: On burning, CO, CO_2

Health Effects/Symptoms/Overexposure: Inhalation of dust may result in irritation of mucous membranes. Long-term inhalation may result in pneumonoconiosis.

5. Product Name: CB-A-900

Where Used/Who Exposed: Phenol formaldehyde resin in Core sand/workers in Core, Finishing, Grind, (general ingredient in ambient dust, particulate)

Hazardous Ingredients: Phenol Formaldehyde polymer, Light Aromatic Petroleum Distillate, Phenol, Formaldehyde, 2-Butoxydtyl Acetate, Non-regulated solvent, Vegetable oil, Methyl Ethyl Ketone

Decomposition Products: May form CO, CO_2, phenols, phenolic hydrocarbons (PHAs) and aromatics.
Health Effects/Symptoms/Overexposure: Eyes: irritation, redness, tearing or blurred vision; Skin: prolonged/repeated exposures cause severe irritation, defatting of tissue, dermatitis or possible desensitization. Can be absorbed in toxic amounts, especially from prolonged or repeated exposures. Breathing: nasal and respiratory irritation. Swallowing: gastrointestinal irritation. Phenol: in pure form may be fatal by ingestion, inhalation or skin absorption. It is an irritant of eyes, skin, nose, throat and respiratory tract. Formaldehyde: listed as "probable" human carcinogen through inhalation of fumes, skin absorption, splash on eye or tongue.

6. Product Name: CB-B-920M

Where Used/Who Exposed: resin used in Cores/workers in Core /Shakeout/Grind (general ingredient in ambient particulate and dust)

Hazardous Ingredients: Higher Oligomers of MDI, 4,4-diphenylmethane disocyanate, Di phenyl methane diisocyanate (MDI), Light aromatic Petroleum, Stoddard Solvents, Phosphonic dichloride, Phenyl

Decomposition Products: May form CO, CO_2, phenols, phenolic hydrocarbons and aromatics.
Health Effects/Symptoms/Overexposure: "Eyes: irritation or redness vision. Skin: prolonged/continued use may cause irritation, defatting of tissue, dermatitis or possible sensitization. Breathing: nasal and respiratory irritation. Can result in irritation and corrosive action in mouth, stomach and digestive tract. Swallowing: single dose low, may cause gastrointestinal irritation Maintain adequate ventilation to below TLV. Use of air supplied respirator advised in absence of proper environmental control. Use of protective gloves and eye protection required."

7. Product Name: CER WOOL (Blankets/boards)

Where Used/Who Exposed: Refractory ceramic fiber insulation product made of vitreous aluminosilicate fibre/ workers in Melt, Refractory, Auto pour, Metal Transfer, Mould (general ingredient in ambient dust and particulate)

Hazardous Ingredients: Refractories, fibers, aluminosilicate, Aluminum Foil. "WARNING! POSSIBLE CANCER HAZARD BY INHALATION' GROUP 2-B" IARC

Decomposition Products: None identified

Health Effects/Symptoms/Overexposure: "Pre-existing medical conditions including dermatitis, asthma or chronic lung disease may be aggravated by exposures. Individuals with allergies may experience greater skin and respiratory. Target organs: Respiratory tract (nose and throat), skin. In sufficient quantity may cause mild mechanical irritation to respiratory tract (scratchiness of nose and throat, cough, chest discomfort as well as gastrointestinal disturbances. Skin: mild to severe irritation, including inflammation, rash and itching. Engineering Controls: local exhaust ventilation, point of generation dust collection, down draft work stations, emission controlling tool designs, and material handling equipment designed to minimize airborne fibre emissions.

8. Product Name: DRY ICE

Where Used/Who Exposed: Sand blast agent for core boxes/workers in Core, Pattern, Melt (Ajax) and (general ingredient in ambient dust and particulate)

Hazardous Ingredients: Composition not classified as hazardous. Ingredients include: Silicon, Iron, Aluminum, Carbon, Phosphorus, Sulphur, Calcium as well as proprietary ingredients. Control for dusts required. European limit per eight hours=10mg/m^2; limit for short term=20mg/m^3.

Decomposition Products: Formation of toxic gases may occur in confined, poorly vented spaces especially at high temperatures including hydrogen, phosphine and arsine gases if the product comes in contact with water, moisture, acids or bases. If exposed to hydrofluoric acid or nitric acid, toxic gases such as silicon tetrafluoride or nitrous oxide gases may result.

Health Effects/Symptoms/Overexposure: Avoid dust generating activities and ignition sources in areas with high dust concentrations. Fine dust may cause irritation and dehydration of mucous membrane. Smoking increases risks. If dust stays in the trachea and/or the esophagus, formation of toxic gases may occur. The toxic mechanism is not clarified – the gas is irritating exposed membranes, inhibits the central nervous system and may cause pulmonary edema. Acute poisoning of phosphine is transitory with headaches, skinless, stomach pain, cough and respiratory distress. Skin contact may cause itching and dehydration. There is no data on sensitizing potential. This product may cause irritation of the eyes and reddening with heavy watering.

9. Product Name: FERROMANGANESE, HIGH CARBON

Where Used/Who Exposed: Melt Alloy additive/ workers in Melt, Auto pour, Metal Transfer, Mould (general ingredient in ambient fumes and dust) Hazardous Ingredients: Ferromanganese, High Carbon (other non-listed elements). OSHA classification: skin=2; eye=2B; respiratory sensitization=1A; carcinogenicity= 1A; reproductive toxicity=1A; Target Organ (prolonged)=immune and nervous systems. Label: DANGER (signal word)

Decomposition Products: Thermal decomposition products/miscellaneous other products.

Health Effects/Symptoms/Overexposure: HAZARD STATEMENTS: Causes skin and eye irritation. May cause allergy or asthma symptoms or breathing difficulties if inhaled. May cause cancer. May damage fertility or unborn child. Causes damage to the immune and nervous systems through prolonged or repeated exposure.

PRECAUTIONARY STATEMENTS: obtain special instructions before use. Do not handle unless all precautions are read and understood. Wear protective eye, face, gloves, and clothing. Do not breathe dust, fume, vapours and spray. Do not eat, drink or smoke when using this product. Wash thoroughly, after using product. In case of inadequate ventilation, use respiratory protection. SYMPTOMS: Inhalation/acute: irritation, changes in body temperature, nausea, vomiting, diarrhea, and headache. Inhalation/chronic: irritation, loss of appetite, difficulty breathing, disorientation, difficulty speaking, sleep disturbances, emotional disturbances, hallucinations, mood swings, tremors, muscle cramps, loss of coordination, hearing loss, visual disturbances, lung damage, blood disorders, kidney damage, liver damage, nerve damage, cancer. Skin acute/chronic: irritation/irritation and cancer. Eye acute/chronic: irritation/irritation. Ingestion acute/chronic: gastrointestinal irritation, nausea, vomiting, diarrhea/drowsiness and cancer. Seek immediate medical attention if inhaled, exposed to eyes and/or ingested.

10. Product Name: FERRO SILICON (FESI)

Where Used/Who Exposed: Metal alloy additive/workers in Melt, Auto pour, Metal Transfer, Mould (general ingredient in ambient fumes and dust)

Hazardous Ingredients: Composition not classified as hazardous. Ingredients include: Silicon, Iron, Aluminum, Carbon, Phosphorous, Sulphur, Calcium as well as proprietary ingredients. Control for dusts required. European limit per eight hours=10mg/m^2; limit for short term=20mg/m^3.

Decomposition Products: Formation of toxic gases may occur in confined, poorly vented spaces, especially at high temperatures, including hydrogen, phosphine and arsine gasses if the product comes in contact with water, moisture, acids or bases. If exposed to hydrofluoric acid or nitric acid, toxic gases such as silicon tetrafluoride or nitrous oxide gasses may result.

Health Effects/Symptoms/Overexposures: Avoid dust generating activities and ignition sources in areas with high dust concentrations. Fine dust may cause irritation and dehydration of mucous membrane. Smoking increases risks. If dust stays in the trachea and/or the esophagus, formation of toxic gasses may occur. The toxic mechanism is not clarified – the gas is irritating exposed membranes, inhibits the central nervous system and may cause pulmonary edema. Acute poisoning of phosphine is transitory with headaches, stomach pain, cough and respiratory distress. Skin contact may cause itching and dehydration. There is no data on sensitizing potential. This product may cause irritation of the eyes and reddening with heavy watering.

11. Product Name: ISOCOTE CGW015

Where Used/Who Exposed: Core sand resin/ workers in Core, Finishing, Grinding, (general ingredient in ambient fumes, dust).

Hazardous Ingredients: Talc, complex aluminum, silicates, quartz, graphite, magnesium, aluminosilicate. IARC lung Carcinogen

Decomposition Products: CO, CO_2, various hydrocarbons (PHAs)

Health Effects/Symptoms/Overexposure: Eye and skin irritant. Through breathing, swallowing and or passage through skin symptoms may include: stomach or intestinal upset (nausea, vomiting, diarrhea), irritation (nose, throat, airways). Known lung carcinogen also associated with lung damage, silicosis, scleroderma and kidney disease.

12. Product Name: ISOCOTE CG2022

Where Used/Who Exposed: resin in core sand/ workers in Core, Finishing, Grinding, (general ingredient in ambient fumes, dust)

Hazardous Ingredients: Complex aluminum silicate/s, potassium magnesium aluminum silicate, quartz, graphite, bentonite clay

Decomposition Products: CO, CO_2, various hydrocarbons (PHAs)

Health Effects/Symptoms/Overexposure: Eye and skin irritant. Through breathing, swallowing and or passage through skin symptoms may include: stomach or intestinal upset (nausea, vomiting, diarrhea), irritation (nose, throat, airways). Known lung carcinogen also associated with lung damage, silicosis, scleroderma and kidney disease

13. Product Name: ISOCURE 1-49-48

Where Used/Who Exposed: liquid binder in core/ workers in Core Department, Finishing, Grinding (general ingredient in ambient fumes, dust)

Hazardous Ingredients: none listed. Classified as "irritant". "Contains ingredients which could be harmful if mishandled, therefore caution is advised in handling and use. Contact should be avoided and necessary protective clothing and equipment should be worn. More detailed information is available on request. Special ventilation, safety glasses and gloves required."

Decomposition Products: none listed (likely CO, CO_2, Nx, PAHs (Benzene, Benzo-Pyrene).

Health Effects/Symptoms/Overexposures: none listed.

14. Product Name: ISOCURE 11-612

Where Used/Who Exposed: Liquid binder in cores/workers in Core, Shakeout, Grinding (general ingredient in ambient fumes/dust)

Hazardous Ingredients: none listed. Classified as "irritant". "Contains ingredients which could be harmful if mishandled, therefore caution is advised in handling and use. Contact should be avoided and necessary protective clothing and equipment should be worn. More detailed information is available on request. Special ventilation, safety glasses and gloves required."

Decomposition Products: none listed (likely CO, CO_2, Nx, PAHs (Benzene, Benzo-Pyrene)

Health Effects/Symptoms/Overexposures: none listed.

15. Product Name: LOW CARBON FERRO MANGANESE

Where Used/Who Exposed: Alloy used in Melt/workers in Melt, Auto pour, Metal Transfer, Mould (general ingredient in ambient fumes and dust)

Hazardous Ingredients: Manganese, Iron, Silicon, Carbon, Phosphorous, Sulphur

Decomposition Products: Oxides of Manganese and Iron

Health Effects/Symptoms/Overexposure: hazardous toxic gasses caused by contact with water targets respiratory, reproductive and nervous systems', can cause eye damage. Inhalation can lead to irritation, changes in body temperature, nausea, vomiting, diarrhea, headache, loss of appetite, disorientation, difficulty speaking, sleep disturbances, emotional disturbances, hallucinations, mood damage, nerve damage, lung congestion. Ingestion may cause nausea, vomiting and diarrhea.

16. Product Name: METAL CLEANER 27 MS (TLV not established)

Where Used/Who Exposed: Cleaner, solvent Blend used in Pattern Shop/ workers in Pattern Shop (may also have been used in mould and core department and general ingredient in ambient mist and fumes)

Hazardous Ingredients: Glycol Ether DPM, Butyrolactone, Diacetone Alcohol, Dibasic Ester, Morpholine. Provide sufficient mechanical ventilation (general and local) to maintain exposure below TLVs. A NIOSH approved Air supplied respirator is advised in absence of proper environmental control. Use of resistant gloves, goggles, and impervious clothing and boots.

Decomposition Products: CO, CO_2, various hydrocarbons (PHAs)

Health Effects/Symptoms/Overexposure: Eyes: severe irritation, redness, tearing, blurred-vision, and severe, or permanent, eye damage (liquid exposure). Skin: irritation and chronic dermatitis, Absorption through broken skin produces symptoms similar to those for swallowing. Breathing: inhalation of mist may cause irritation of nasal and respiratory passages. Swallowing: may cause gastrointestinal irritation, nausea, vomiting and diarrhea.

17. Product Name: METHYLENE BLUE (Pro-Lab Diagnostics)

Where used/Who Exposed: Laboratory reagent – green powder mixed with de-ionized water to make a solution; workers in Metal Lab exposed.

Hazardous Ingredients: Methanol (Acute Tox.3 classification) Avoid breathing vapors. Avoid contact with eyes and prolonged skin contact. Avoid formation of mists. Do not eat or drink when using this product.

Decomposition Products: Thermal decomposition or combustion products may include: CO_2, CO, N0x, Hydrocarbons (PHAs) does not decompose when used and stored as recommended.

Health Effects/Symptoms/Overexposure: (targeted organs = eyes and central nervous system). Harmful if inhaled. Causes organ damage. Symptoms following overexposure include: coughing, chest tightness, chest pressure, drowsiness, dizziness, disorientation, vertigo,

18. Product Name: METHYLENE BLUE (Lab Chem product)

Where used/Who Exposed: Sand Lab solution: mixed with nitric acid as an etching solution for workers in both Sand and Metal Labs.

Hazardous Ingredients: Methylene Blue (If swallowed (Category 4); re: aquatic environment (Acute Hazard Category 2), acute toxicity if swallowed,

Decomposition Products: "No information available"

Health Effects/Symptoms/Overexposure: Harmful if swallowed; redness stinging in eye; staining of skin.

19. Product Name: MOTONORILLONITE CAS 1302789 (1997)

Where Used/Who Exposed: melt spray on refractory material/workers in refractory, especially labourers (general ingredient in ambient dust and particulate)

Hazardous Ingredients: Respirable silica, Crystaline silica as quartz

Decomposition Products: No information

Health Effects/Symptoms/Overexposure: No information

20. Product Name: MONOGUN 90

Where Used/Who Exposed: Refractory Material to re-line furnaces/workers in Refractory, Melt, Auto pour, Labs (general ingredient in ambient dust and particulate)

Hazardous Ingredients: Aluminum oxide, non-fibrous, Calcium Aluminate Cement, quartz

Decomposition Products: "No information available"

Health Effects/Symptoms/Overexposure: (GHS US classification: Skin corrosion/irritation Category 2; Serious eye damage/eye irritation Category 2B; Carcinogenicity Category 1A. Wear eye protection, Dust respirator, and protective gloves. "Do not breathe dust. May cause cancer through inhalation. Danger of serious damage to health by prolonged exposure through inhalation. "

21. Product Name: NUTTY GREEN

Where Used/Who Exposed: Skin cleaning Product/ Plant wide (wash areas)

Hazardous Ingredients: None identified (exempt from toxic classification)

Decomposition Products: None identified

Health Effects/Symptoms/Overexposure: None Identified

22. Product Name: PHOSPHORUS RED

Where Used/Who Exposed: rock and powder alloy added to furnaces/workers in Melt, Auto pour, Metal Transfer, Mould (general ingredient in ambient fumes and dust)

Hazardous Ingredients: Phosphorus Red

Decomposition Products: Formed under fire conditions, oxides of phosphorus.

Health Effects/Symptoms/Overexposure: Under heading of Toxicology no date available other than single exposure of acute inhalation (irritation symptoms) and eye exposure (slight irritation). There is some evidence of toxicity in animals but details were not provided.

23. Product Name: POLYDIMETHYL SILOXANE

Where Used/Who Exposed: Mould spray release/Auto pour and Mould operators in particular (general ingredient in ambient fumes, mist)

Hazardous Ingredients: none listed

Decomposition Products: "May form toxic materials: CO, CO_2, various hydrocarbons."

Health Effects/Symptoms/Overexposure: No information

24. Product Name: RAM M 90

Where Used/Who Exposed: Refractory repair putty/workers in Refractory, Melt, Mould, Metal Transfer, Labs (general ingredient in ambient dust/particulate)

Hazardous Ingredients: Magnesia, Alumina, Silica (not classified as hazardous)

Decomposition Products: None identified

Health Effects/Symptoms/Overexposure: Toxicological information: Eye: contact with dust or powder may cause irritation; Skin: repeated or prolonged contact may cause irritation; Inhalation: may irritate the respiratory tract on prolonged or repeat contact and may aggravate pre-existing respiratory conditions; Ingestion: NA, Carcinogenicity: NA, Chronic Effects: prolonged breathing of dust may cause lung disease.
STATEMENT BY MANUFACTURER: Process enclosures, local exhaust ventilation or other engineering process controls may be necessary to keep any air contaminants associated with this product within their TLVs. This is particularly true if user operation generates dust. This product is a proprietary mixture of unique ingredients. It does not have an established limit for airborne concentration, which workers can routinely be exposed to without suffering adverse health effects. The user must review his/her circumstances and then determine what is required to establish a respiratory program. Some type of respiratory protection is recommended even for the best conditions. Actual respirator selection should be made after consultation with a competent health and safety professional.
The information contained in this Material Safety Data Sheet is believed to be accurate. However, SRIC makes no warranty with respect to the accuracy of the information or the suitability of the recommendations and assume no

liability to any user based upon use of the product or reliance upon the information contained in this Material Safety Data Sheet.

25. Product Name: RAM 90 HS

Where Used/Who Exposed: Refractory repair product/workers in Refractory, Melt, Auto pour, Metal transfer, (General ingredient in ambient dust) (HAZARD STATEMENT: Causes skin irritation, causes serious eye damage, may cause cancer)

Hazardous Ingredients: Aluminum Oxide, Aluminum orthophosphate, Mullite, Phosphoric Acid, Quartz

Decomposition Products: Under normal conditions of storage and use, hazardous decomposition products should not be produced

Health Effects/Symptoms/Overexposure: HAZARD LABEL: Causes skin irritation, serious eye irritation, may cause cancer. PRECAUTIONS FOR SAFE HANDLING: Ensure good ventilation of the workstation. Obtain special instructions before use. Do not handle until all safety precautions have been read and understood. Take all necessary technical measures to avoid or minimize the release of the product on the workplace. Limit workers. Provide local exhaust or general room ventilation. Wear personal protective equipment. Floors, walls and other surfaces in the hazard area must be cleaned regularly. Avoid contact with skin and eyes. Separate working clothes from town clothes. Launder separately. Wash contaminated clothing before reuse. Do not eat, drink or smoke when using this product. Always wash hands after handling the product.

26. Product Names: Savage Super Ram, Savage Ram 60, 70 And 85 Including Suffixes As, S, And Qf

Where Used/Who Exposed: Refractory repair product/workers in Refractory, Melt, Auto pour, Metal transfer, Labs (general ingredient in ambient dust/particulate)

Hazardous Ingredients: Crystalline Silica* forms containing: Quartz, Christobalite, and Tridymite.

Decomposition Products: "No known hazardous decomposition products

Health Effects/Symptoms/Overexposure:

HEALTH HAZARDS include:
1. Dry skin, skin irritation, alkali burns, and allergic dermatitis in hypersensitive individuals (acute and chronic);
2. Moderately irritating, if swallowed or inhaled (acute);
3. Significant eye irritation, eye abrasion including serious eye injury from rubbing eyes associated with contact (acute);
4.Physical injury due to steam spalling or explosion of cured product due to improper dry out;
5. Irritation or inflammation to the linings of the upper respiratory tract due to inhalation of dust (acute);
6. Over-exposures to crystalline silica over a period of years may lead to silicosis, and possibly lung cancer due to inhalation of dust (chronic).

SAFE PRACTICES AND CONTROL MEASURES:
1. Care should be exercised to prevent generation of dust during handling, installation, use and tear-out. Avoid skin and eye contact and breathing of dust. Do not ingest.
2. Proper refractory practices MUST BE FOLLOWED for curing, dry-out and firing to service temperature.
3. Wash skin and clothing dust prevention, dust containment, and ventilation supplemented by the use of appropriate NIOSH approved respirators for the exposure conditions.
5. Safety glasses should be used if splashing is likely. Impervious gloves, boots and protective clothing should be used as needed to prevent excessive skin contact.
6. Clean-up of spills should be done in a way to minimize dust, including vacuuming and wet methods.

27. Product Name: SEA COAL (Bituminious Coal)

Where Used/Who Exposed: Additive in mould sand mix/workers in Mould and Lab (general ingredient in ambient dust/particulate)

Hazardous Ingredients: Ash, volatiles, fixed carbon, SI02 (in ash), sulphur

Decomposition Products: Thermal oxidation can include: oxides of carbon, nitrogen and sulphur, partially oxidized hydrocarbon, soot and fly ash.

Health Effects/Symptoms/Overexposure: Prolonged exposure is occupationally associated with pneumoconiosis. Individuals with pulmonary disorder should avoid exposure to coal dust. Pulmonary function could ultimately be diminished. Target organ is Lungs through inhalation. Acute events of inhaling excessive amounts of coal dust include coughing, wheezing and shortness of breath. Chronic effects include chronic bronchitis and emphysema. Wear protective eye wear, gloves, boots, aprons to limit skin contact and wear appropriate respirator in addition to adequate general and local ventilation. Perform regular chest x-rays for exposed individuals and remove those showing pulmonary disorders from dusty environments

28. Product Name: SILICON CARBIDE

Where Used/Who Exposed: Chemical Additive to melt/workers in Melt, Auto pour, Metal Transfer, Mould (general ingredient in ambient dust/particulate)

Hazardous Ingredients: MSDS states that Silicon Carbide is not classified as hazardous ingredient (based on no data available). This chemical is viewed as a nuisance dust. Under exposure controls it requires only general industrial hygiene practice and states that respiratory protection is not required

Decomposition Products: Formed under fire conditions: CO, silicon oxides

Health Effects/Symptoms/Overexposure: Under Toxicology and Health Effects

"No data available" is cited repeatedly while stating that this chemical is considered a nuisance dust. Yet the MSDS states under "handling and storage" that appropriate exhaust ventilation is required at places where dust is formed and that workers avoid breathing vapours, mist or gasses. Then under "exposure controls" it states that general industrial hygiene be practiced with no respiratory protection or special environmental precautions required. Yet under the same heading, regarding skin and body protection, it states that: Nitrile rubber with a minimal 0.11 mm thickness be used and "gloves must be inspected prior to use and proper glove removal adhered to in order to avoid contact with the product" and that body protection must be selected" according to the concentration and amount of the dangerous substance at the specific workplace." Yet under the same heading, under breathing controls, it cites "where respiratory protection from nuisance levels of dusts is desired, use type N95 or type P1 dust masks." SEE BELOW.
NOTE: In October 2014, IARC gathered 21 experts from 10 countries to evaluate whether a selection of nano-materials and fibres cause cancer.

The expert team looked specifically at fluoro-edenite, silicon carbide fibres and whiskers, and carbon nanotubes (including single-walled and multi-walled varieties). A summary of their conclusions for each nanomaterial is summarized below.

Silicon carbide:

- Occupational exposures associated with manufacturing silicon carbide particles, called the Acheson process, were classified as carcinogenic (Group 1) based on sufficient evidence that they cause lung cancer in humans.
- Fibrous silicon carbide was classified as possibly carcinogenic (Group 2B) based on limited evidence in humans that it causes lung cancer.

Silicon carbide whiskers were classified as probably carcinogenic to humans (Group 2A), rather than possibly carcinogenic to humans (Group 2B), because the physical properties of the whiskers resemble those of asbestos fibres, which are known carcinogens.

Virtually all the silicon carbide sold in the world is manufactured. This substance occurs in three forms: particles that are used in industry as an abrasive, fibres that are a by-product of particle manufacturing, and whiskers that are used as durable substitutes for asbestos.

29. Product Name, STODDARD SOLVENT

Where Used/Who Exposed: Moulding Solvent/workers in Mould, Maintenance (general ingredient in ambient fumes/mist)

Hazardous Ingredients: Alkaline Petroleum Distillate

Decomposition Products: No information

Health Effects/Symptoms/Overexposure: May cause eye, skin irritation. Low toxicity via inhalation

30. Product Name: SYNTHETIC HYDROCARBON/CARBOLIC ACID TYPE ESTER

Where Used/Who Exposed: Rotary Screw Compressor in Core Mixing Machines/ workers in Core, Maintenance, Pattern, during cleaning and repair

Hazardous Ingredients: Synthetic hydrocarbon MPSE, De-foamer, Antioxidants, Rust inhibitors, Dye

Decomposition Products: CO, CO_2, and other unidentified fragments when burned

Health Effects/Symptoms/Overexposure: Mildly irritating to eyes and skin, not toxic with inhalation. No PPE required.

31. Product Name: SUPER BONDER 396

Where Used/Who Exposed: Metal glue/workers in Pattern Shop repairing risers

Hazardous Ingredients: Methyl 2-cyanoacrylate, Poly (Methyl methacrylate), Hydroquinone

Decomposition Products: None

Health Effects/Symptoms/Overexposure: Skin contact causes burns, bonds skin rapidly, skin/eye irritant. Downdraft ventilation recommended.

32. Product Name: TEA (Triethylamine)

Where Used/Who Exposed: Catalyst used in Core making/ Core, (major ingredient in ambient core fumes/dust) Hazardous Ingredients: Triethylamine

Decomposition Products: None identified

Health Effects/Symptoms/Overexposure: Eyes: may cause severe damage and even blindness very rapidly. Skin: causes burns, on prolonged contact. Breathing: Excessive inhalation of vapours causes nasal and respiratory irritation and central nervous system effects including dizziness, weakness, fatigue, nausea, headache and possible unconsciousness. Swallowing results in severe damage to mucous membranes and deep tissues can result in death on penetration to vital areas.

33. Product Name: TECHNIKOAT (Refractory resin suspension in water) IARC 2A

Where Used/Who Exposed: Refractory resin suspension in water/workers in Melt, Auto-pour, Metal Transfer, Mould (general ingredient in ambient dust/particulate)

Hazardous Ingredients: Hydrated Aluminum Silicate, Calcinated Aluminum Silicate, Carbon, Magnesium Silicate, Iron Oxide, Silica

Decomposition Products: None identified

Health Effects/Symptoms/Overexposure: HAZARD STATEMENT: "Under normal use not hazardous" Short-term exposure: irritate nose and throat; Long term exposure: can result in silicosis (scaring of lungs). Signs and Symptoms: Inhalation: cough, shortness of breath, irritation mucous membranes of nose, throat, and respiratory tract. Ingestion: Gastrointestinal distress if swallowed in large amounts. In absence of local exhaust requires dust mask/respirator with dust filter.

34. Product Name: TECHNIKURA COREACTANT PT. 2

Where Used/Who Exposed: Core resin/workers in Auto-pour and Mould (general ingredient in ambient fumes/dust)

Hazardous Ingredients: Methylene bisphenyl isocyanate (MDI), Polymeric diphenylmethane diisocyanate, Aromatic Petroleum Distillate, Catalylic Reformer Distillate, Kerosene

Decomposition Products: No Information

Health Effects/Symptoms/Overexposure: Health Effects: Eyes: blurred vision, redness, inflammation, corneal opacity; Skin: irritation, stinging, defatting of skin, dermatitis, allergic skin reaction; Inhalation: Respiratory tract irritation, headache, nausea, dizziness, Respiratory sensitization; Ingestion: Irritation of mouth and stomach and central nervous system, vomiting, diarrhea. Aspiration can cause chemical pneumonitis, which can be fatal.

35. Product Name: Tetrasodium Pyrophosphate

Where Used/Who Exposed: added to mould sand along with Methylene Blue; in metal lab nitric acid was added creating an etching solution used by workers in Sand and Metal Labs. (general ingredient found in ambient dust, fumes)

Hazardous Ingredients: Tetrasodium Pyrophosphate

Decomposition Products: oxides of sodium and phosphorus

Health Effects/Symptoms/Overexposure: Classified as Skin Irritation (Category 2); eye irritation (Category 2A); single exposure (Category 3)/Skin or eye irritation

36. Product Name: THIRD PART ADDITIVE (WHIMIS D-2 classification)

Where Used/Who Exposed: Foundry Cold Box enhancer/workers in Core (general ingredient in dust/fumes)

Hazardous Ingredients: Prenol-Novolac Resin, Oil Modified, Light distillate-hydrogenated

Decomposition Products: None listed

Health Effects/Symptoms/Overexposure: Eyes: Irritation but not injure eye tissue. May cause conjunctivitis; Skin: causes rash and may irritate skin. Breathing: excessive inhalation of vapours can cause nasal and respiratory irritation and central nervous system effects including dizziness, weakness, fatigue, nausea, headache and possible unconsciousness. Medical attention required in event of ingestion or difficulty breathing. Provide sufficient general and local ventilation to maintain exposure below TLVs.

37. Product Name: VELVA DRI GS

Where Used/Who Exposed: Graphite Core and Mould Wash/workers in Core and Mould (general ingredient in ambient dust and fumes)

Hazardous Ingredients: Graphite, no other information

Decomposition Products: No information

Health Effects/Symptoms/Overexposure: No information

38. Product Name: VAINSEAL SILICONE FLUID

Where Used/Who Exposed: Release Agent Core and Mould/operators in Core and Mould (general ingredient in ambient fumes, mist, dust)

Hazardous Ingredients: Amine functional silicone

Decomposition Products: CO, CO_2, Hydrocarbons (PHAs)

Health Effects/Symptoms/Overexposure: Moderate irritation of eye, skin, nasal and respiratory passages, gastrointestinal system

39. Product Name: ZIP SLIP – 125H (no TLV established).

Where Used/Who Exposure: Silicone fluid release agent for Core Box/core operators and labourers

Hazardous Ingredients: Poly dimethyl siloxane fluid, amine functional silicone

Decomposition Products: "May form toxic materials: CO, CO_2, and various hydrocarbons (PHAs).

Health Effects/Symptoms/Overexposure: Eyes: moderate irritation, redness, tearing, swelling and blurred vision; Skin: irritation; Breathing: irritation of nasal and respiratory passages; Swallowing: May cause gastrointestinal irritation. Do not induce vomiting get medical attention. Aspiration into Lungs due to vomiting can cause chemical pneumonitis, which can be fatal; If breathed, remove individual to fresh air.

40. Product Name: 9016-87-9 (Polymeric diphenylmethane di-isocyanates)

Where Used/Who Exposed: Chamber mould release sprayed prior to pours/auto pour and disa operators (general ingredient in ambient fumes, mist, dust)

Hazardous Ingredients: Methylene bisphenyl isocyanate, aromatic petroleum distillate, naphthalene, catalytic reformer distillate

Decomposition Products: No information

Health Effects/Symptoms/Overexposure: eye, skin irritant

Appendix H: Neelon Product Procedural Manual

BY JOB CATEGORY

The Neelon Advisory Committee and Jessica Montgomery, USW representative, provided, along with other documentation, a digital copy of the 2003/2004 Neelon Casting Product Procedural Manual, likely the last of such manuals dated several years before the plant closed. This manual identifies (by department) step-by-step procedures for brake product manufacturing from preparation of the metal and sand to finished castings ready for shipment. The company procedural manual includes the different job categories for workers responsible for each step in production, but virtually nothing about chemical exposures or safety information. This manual may be provided to the WSIB for use in determining work histories of Neelon employees which is why we have documented each Departmental work process identified in the manual and who was responsible for completion of the tasks.

It is interesting to compare the information contained in the company manual with the information workers provide about the same processes – the latter from a workers' health and safety perspective rather than product/machine-focused. In the company manual there is virtually no mention of any chemicals or materials used in a process or PPE required with their use (the single exception being 1. risks and PPE related to use of the Pedestal Grinder machine and 2. naming of the specific rust proofing chemical used prior to storage/shipping). In the company manual, gloves and aprons are occasionally included in descriptions of different processes under the heading "equipment," but masks and other safety interventions are rarely, if at all mentioned. There is discrepancy between job titles the workers use and those identified by the company, which may have historical roots and could hinder workers in their claims.

Importantly, the tasks and job classifications presented in the official procedure manual does not reflect the reality; while workers were assigned to specific tasks and given a job designation—they were required to do numerous other tasks that would overlap with regular duties but not be reflected in their job classification/s. Examples of this include pattern workers utilized as maintenance helpers or working in Refractory making wooden frames for furnace rebuilds during shut-downs. In fact, workers from all departments were routinely called on to help in other departments on a daily basis; they were a flexible, multi-skilled work force.

The table below may be helpful to workers, families, and their advocates in filing WSIB claims by breaking down various departmental processes into their unique tasks and identifying personnel responsible for them. In some cases, it may be useful to review the complete departmental document for a specific process, which is available from the Sudbury Local of the United Steel Workers Union (phone number). The Neelon Production Manual specifically included the following Departments: Melt, Mould, Core, Finishing, Pattern, Sand Lab, Metal Lab, and Maintenance, as well as Administration, Human Resources and Quality Control (which are not included in the table because their work involved limited direct exposure risks although they could be at higher risk if their offices were directly affected by dust, fumes, noise and vibration from near-by departments. Maintenance trades' (e.g., electricians, mechanics, computer technicians, supervisory personnel) work tasks were trade specific and other than the general process title of "preventive maintenance" were not identified in the product manual.

TASKS	PERSONNEL
MELT DEPARTMENT	
Arc Operation	Arc Operator
Arc Charging	Furnace Operator/Supervisor
Arc Slagging	Arc Operator
Arc Sampling	Arc Operator
Arc Bull Ladle Transfer	Channel Furnace Operator
Ajax Temperature	Channel Furnace Operator/Melt Supervisor
Ajax Slagging	Channel Furnace Operator/Melt Supervisor
Ajax Sampling	Melt Supervisor/Melt Operator
Ajax Spout Repairs	Melt/Mould Supervisors/Ladle Operator /Refractory Maintenance
Coreless Operation	Coreless Operator
Coreless Cold Start	Supervisor/Coreless/Channel Operator
Coreless Charging	Coreless/Channel Operator
Coreless Slagging	Coreless Operator
Coreless Slug Re-melt	Supervisor/Coreless/Channel Operator
Coreless Sampling	Coreless Operator
Coreless Bull Ladle Transfer	Supervisor/Coreless/Channel Operator
Coreless Furnace Reline	Melt Supervisor/Refractory Maintenance
Temperature Verification	Supervisor
Housekeeping	All Melt Employees
Arc/Coreless Charge Make-Up	Melt Dept. Process Leader
Transfer Ladle Repairs	Refractory Maintenance
Ladle Inoculation/Alloying	Channel/Ladle Operator
Pour Box Charge Inserts	Refractory Maintenance
Auto pour #3 Draining Procedure	Melt Supervisor/Refractory Maintenance
Auto pour #2 Power Setting	Melt Supervisor/Refractory Maintenance
Auto pour #1 Power Setting	Melt Deck Channel Operator/Supervisor/Channel Furnace Operator
Melt Deck Arc and Coreless Temperature	Arc/Coreless Furnace Operators
Melt #1 Preheater	Melt Deck Supervisor/Melt Operators
Melt #2 Preheater	Melt Deck Supervisor/Melt Operators
Melt Deck Chemistry Adjustment	All Melt Dept.
Melt Deck Metal Testing	Melt Dept.
Metal Transfer #1 and #2 Iron Transfer	Melt Supervisor
Metal Transfer Ajax to Ajax	Melt Transfer/Channel Furnace

TASKS	PERSONNEL
MOULD DEPARTMENT	
Pouring Temperature	Metal Transfer/Auto pour Operators/Maintenance/Lab
Core Inspection Trays	Mould Trainee
Core Placement (Tray and Mask)	Mould Trainee/Disa Operators
Mould Hardness Test	Mould Supervisor
Auto pour Sample Requirement/Pouring	Auto pour/Ladle Operators
Weekly Shutdown Lines #1 and #2	Auto pour/Ladle Operators/Utility/Lead /Production Trainees
Weekly Start Up	Auto pour/ladle Operators/Utility/Lead/Production Trainees
Wedge Control Procedure	Melt Department
Core Setting Adjustment Disa #1	Lead Hand
AMC Inspection	Supervisor
Auto pour Set-Up Procedure	Auto pour/Ladle Operators/Utility
Blowing of Autopour Lines and Filters	Shift Leader/Ladle Transfer Operator
CORE DEPARTMENT	
Water Meter Verification	Core Labourers
Luber Flow Meter Settings	Supervisor
Disa Box Change	Core Operator
Load Care Procedures	All Core Employees
Tagging Procedures	All Core Employees
Downshift Cleanup	All Core Employees
Data Code in Core Box	Core Operator
Core Machine Operation	Core Operator
Defin Cores	Core Operator
Assembly Cores	Core Packer
Fill Binder Day Tasks	Core Labourer
Ring Force Gauge Test	Core Labourer
Samples for Sand Lab	Supervisor
GM-8989 Vent Quality	Supervisor
Core Assembly Gauge	Core Packer
Core Hardness Test	Core Operator
Core Breakage Test	Core Operator
Inspect Cores	All Personnel
Sand Temperature (thermometer)	Core Labourer
Dewpoint Test Procedure/Verification	Core Labourer
Baume Test (FH-100)	Core Labourer/Operator/Supervisor
OMCO Mixer Binder Calibration	Core Labourer

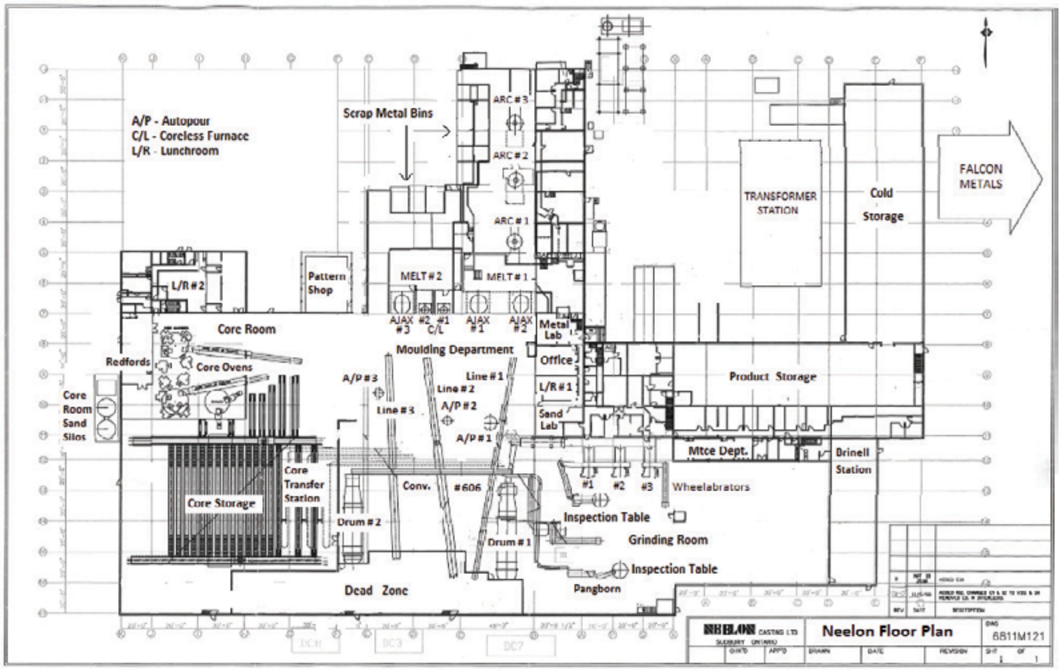
TASKS	PERSONNEL
SAND LABORATORY	
Incoming Clay	Lab Technician
Temperature Determination	Lab Technician
Moulding Sand Test Specification	Process Engineering Manager
Incoming New Sand	Lab Technician
Sand Lab Pattern Change	Lab Technician
Incoming Inoculant Analysis	Lab Technician
Sand Rammer Calibration	Lab Technician/Supervisor
Sand Testing Equipment Verification and Calibration	Lab Technician/Maintenance
Strength Machine Calibration	Lab Technician
Incoming Sea coal	Lab Technician
% Moisture Determination	Lab Technician
% Volatile Combustible Material Deter-mination	Lab Technician
Sand Test Report	Lab Technician
% Compactability Determination	Lab Technician
Green Compression Determination	Lab Technician
Preparation of 2”x2” specimen	Lab Technician
% Loss on Ignition Determination	Lab Technician
Preparations of Solutions Methylene Blue and Sodium Phosphate	Lab Technician
Scrap Date – Computer Entries	Lab Technician
Internal Blast Equipment – Shot Analysis	Lab Technician
Hand Refractometer Test	Lab Technician
Internal Mould Sand Analysis	Lab Technician
Internal Core Room Sand and Core Analysis	Lab Technician
Sieve Analysis and Grain Fineness Number	Lab Technician
METAL LABORATORY	
Test Bars – Metal Lab	Moulding/Quality Control Departments
Tensile Test Results	Lab Technician
Post Inoculation	Mould/Lab/Maintenance Departments
Sample Analysis	Lab Technician
Metal Specification	Process Engineering Manager
Leco-Carbon-Sulfur Determination	Lab Technician/Lab Supervisor/Maintenance
Spectrometer Standarization	Lab Technician

TASKS	PERSONNEL
Spectrometer Verification	Lab Technician
Spectrometer Calibration and Curve Adjustments	Supervisor/Lab Supervisor
Metal Lab Pattern Change	Lab Technician
Customer Certificate	Lab Technician/Supervisor
Daily BHN entries	Lab Technician/Supervisor
Lab Department Housekeeping	Supervisor/Lab Technicians
FINISHING	
Shot Pattern Analysis	Utility
Didion Drum Media Level Check	Supervisor
Wheelabrator Operation	Wheelabrator Operator
Pangborn Operation	Designated Operator
Autogrand Operation	Grinder
Product Identification and Traceability	Supervisor/Grind/Sort/Inspect
Tagging Boxes at Table and Inspection	
Conveyor	Grind/Sort/Inspect
Pedestal Grinder Operation	Grind/Sort/Inspect
Casting Inspection Light	Grind/Sort/Inspect
Plugged Vent Detector Set-up Procedure	Supervisor or designate
Casting Gauging Procedure	Grind/Sort/Inspect
Hand Grinding	Grind/Sort/Inspect
Mixing Rust Proofing Solution	Utility
Rust Proofing	Grind/Sort/Inspect
Visual Inspection of Castings	Supervisor or designate
Bar Code Input System	Supervisor or designate
Tagging Ready to Ship Product	Supervisor or designate
Scale Operation	Supervisor or designate
Production Report	Finishing Supervisor or designate
Finishing Job Specification	Grind/Sort/Inspect
PATTERN SHOP	
Pattern Shop Work Order	Supervisor or designate
2032 Line #1/ 2013 Lines #2 and #3 Patterns and Core Box Storage Racks	Moulding Utility Person/Coreroom Floater/Pattern Shop Repair Personnel
Pattern and Core Mask Preparation	Pattern Shop Repair Personnel
Core Mask Core Locating Buttons	Pattern Shop Repair Personnel
Stamped Date Code Procedure	Pattern Shop Repair Personnel

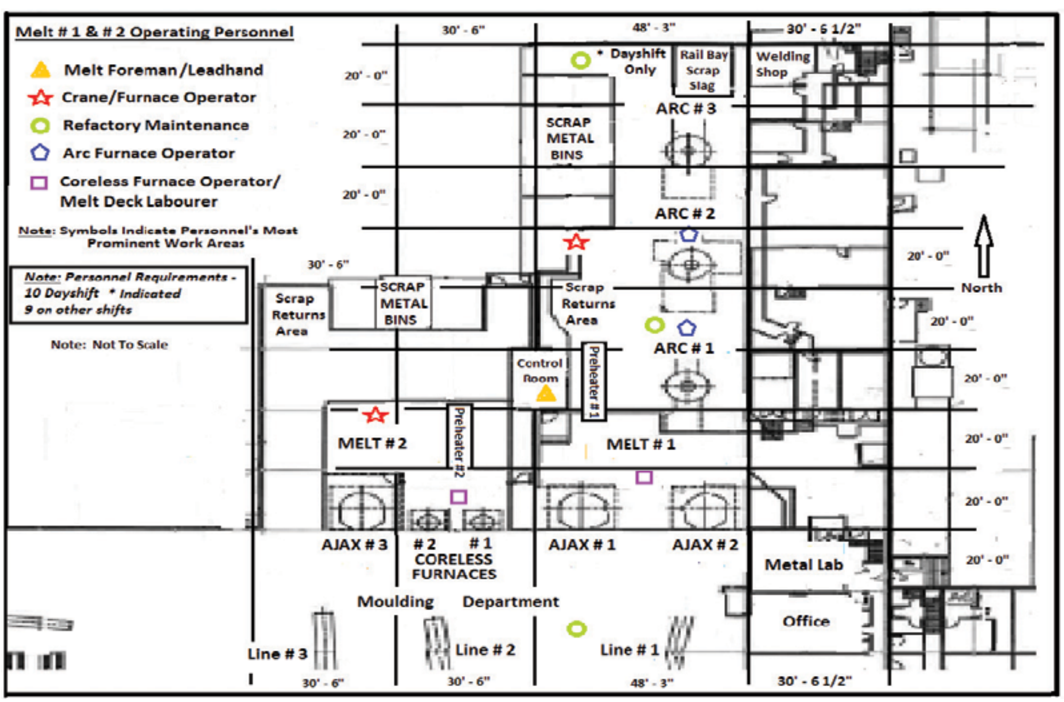
TASKS	PERSONNEL
Disamatic Chamber Height Check	Pattern Shop Repair Personnel
Disa 300 Corebox Rubber Seal Change	Pattern Shop Repair Personnel
2032 Line #1/2013 Line #2 and #3 Disamatic Alignment	Pattern Shop Repair Personnel
Disa 300 Corebox Side Hooks and Lifting Hardware	Pattern Shop Repair Personnel
Magnetic Thermometer Verification	Pattern Shop Repair Personnel
Dial Indicator Verification	Pattern Shop Repair Personnel
Core Room Tooling Checks	Pattern Shop Repair Personnel
Redford Corebox Preparation	Pattern Shop Repair Personnel
Shalco Corebox Preparation	Pattern Shop Repair Personnel
Pattern Shop Housekeeping	Pattern Shop Repair Personnel
MAINTENANCE	
Spare Parts inventory	Stores Coordinator/Purchasing Supervisor/Maintenance
Monitoring Preventive Maintenance	Facilities Manager/Maintenance Supervisor/Maintenance Scheduler
Work Request System	Supervisors/Facilities Manager/Scheduler
Equipment Installation	Facilities Staff
Plant/Equipment Engineering Drawing	Flow Chart Maintenance Manager
Maintenance Work Order	Supervisors

Appendix I: Departmental Hazard Mappings of Neelon Casting (1-5)

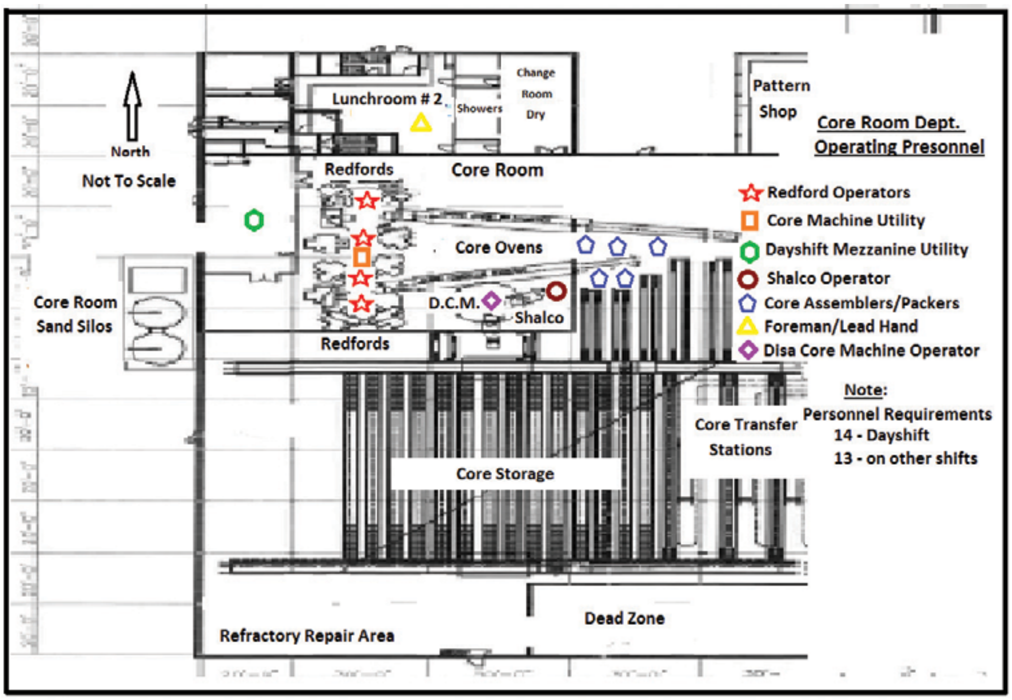
1. NEELON PLANT-WIDE MAP By Daryl Park



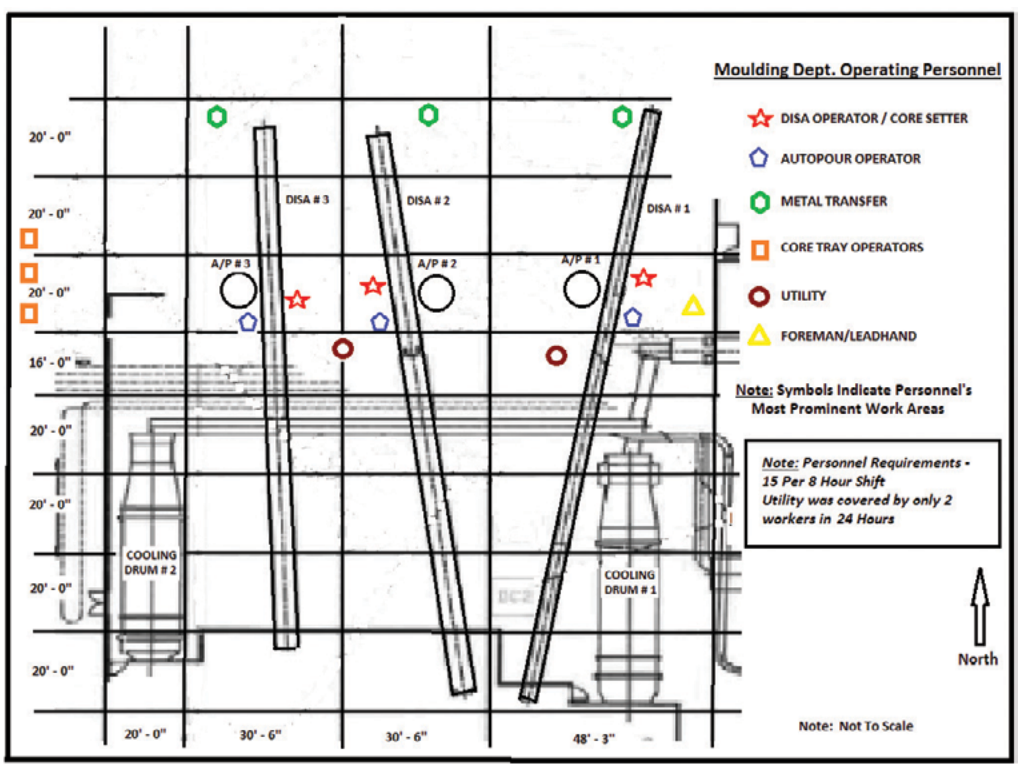
2. MELT DEPARTMENT By Daryl Park



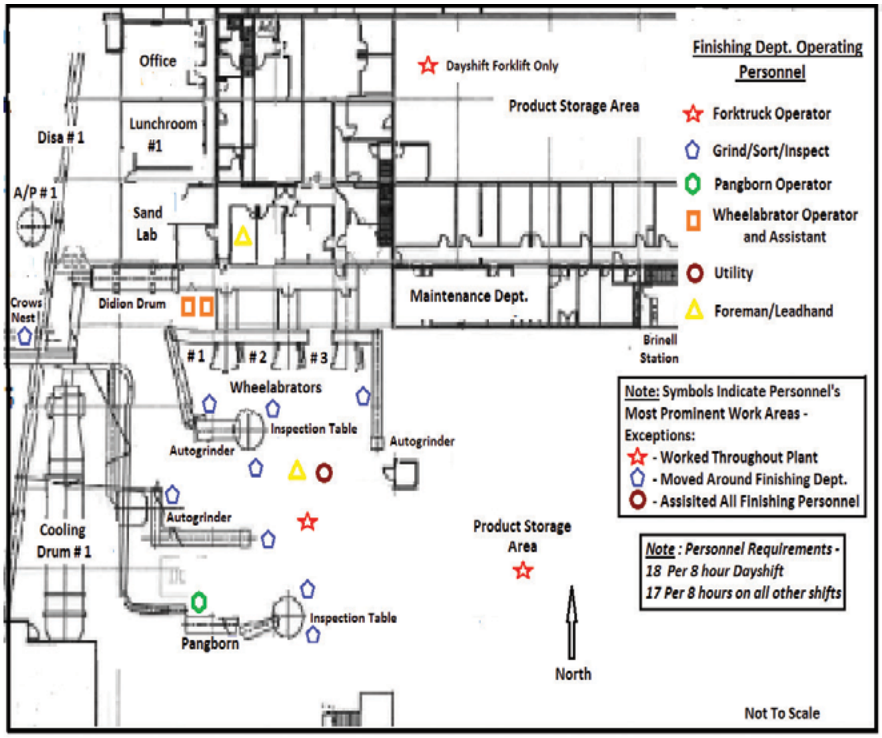
3. CORE ROOM By Daryl Park



4. MOULDING DEPARTMENT By Daryl Park



5. FINISHING DEPARTMENT By Daryl Park



Appendix J: Annotated References Related to Foundry Work

Adzersen KH, Becker N, Steindurf K, Frentzel-Beyme R (2003). Cancer mortality in a cohort of male, German, iron foundry workers. Am Jour Ind Med. 43(3):295-305.

Increase of cancers of upper aero-digestive tract (e.g., esophagus, larynx, lung) noted among German production workers in 17 foundries when compared to German general population. Elevated all-cause mortality was noted: SMR=115.4 95%C, 111.9=119.1; Elevated for total Cancers: SMR=123.8, 95% CI 102.1-152.6; Elevated for Lung SMR*=123.8 95% CI 102.1-152.6; Elevated for Liver SMR*=322.5, 95% CI 149.5-844.8; and Elevated for Respiratory System diseases SMR*147.6, 95% CI 100.4-221.5. As well, there was elevated mortality among workers with early termination.*

Barnes H, Goe NSL, Leong TL Hoy R (2019). Silica-associated lung disease: an old world, exposure in modern industries. Asian Pacific Society of Respirology 23:1165-1175.

Three types of silicosis: chronic > 10 yrs. at low moderate dose; accelerated: within ten years of moderate exposure; acute: within weeks to 5 yrs. of high intensity exposure. New materials and new industries linked to high intensity silica concentrations, oxidative stress from freshly fractured silica and rapid pro-inflammatory and pro-fibrotic response.

Bauer AK, Velmurugan K, Plottner S, Siegrist K J, Romo D, et al, (2018). Environmentally prevalent polycyclic aromatic hydrocarbons can elicit co-carcinogenic properties in an in vitro murine lung epithelial cell model, Archives of Toxicology 92:1311-1322 Genotoxicity and Carcinogenicity, http://doi.org10.1007/s00204-017-2124-5.

This study demonstrates the co-carcinogenic properties of low weight PAHs and their interaction with Benzo-a-Pyrene. The authors provide evidence that LMW PAHs act as co-carcinogens in the presence of Benzo-a-Pyrene. Their study provides evidence that LMW PAHs in the presence of BaP can elicit increased carcinogenic potential. This has great bearing on the founding industry generally and Neelon Casting where this combination of exposures was prevalent.

Blanc P, Annesi-Maesano I, Balmes JR, Cummings KJ, Fishwick D, Miedinger D, Murgia Ni, Naidoo RN, Reynolds CI, Sigsgaard T, Toren K, Vinnikov D, Redlich CA (2019). The occupational burden of non-malignant respiratory disease. Official American Thoracic Society and European Respiratory Society Statement in American Jour of Resp and Critical Care Med 199(11): 1312-1334.

Workplace exposures contribute substantially to the burden of multiple chronic respiratory diseases across a range of non-malignant lung conditions. There is a pressing need to improve clinical recognition and public health awareness of occupational factors as significant contributor. Workplace exposures were identified for the incidence of the following proportion of non-malignant respiratory diseases: 16% for asthma; COPD 14%; chronic bronchitis 13%; hypersensitivity pneumonitis 19%; idiopathic pulmonary fibrosis 26%; other granulomatous disease like sarcoidosis 30%; TB 29%.

Campo L, Hanchi M, Sucato S, Consonnie D, Polledri E, Olgiati L, saidane-Mosbahi D, Fustinoni S (2020). Biological monitoring of occupational exposure to metals in electric steel foundry workers and its contribution to 8-oxo-7, 8-Dihydro-2' – Deoxyguanosine levels. Environ Res and Public Health. doi: 103.390/ijerph17061811.

In comparison with existing occupational limit values and with reference value for the general population shows that the study workers were occupationally exposed to metals, with levels exceeding biological limit values only for Cd.

Cappellietti R, Ceppi M, Claudatus J, Gennaro V (2016). Health status of male steel workers at an electric arc furnace in Trentino, Italy. Jour of Occ Med and Toxicology 11(7): 10.

(Case-control study with 331 workers studied) Findings included: excess mortality (compared to general population) excess tumour mortality, excess lung cancer, excess ischemic heart disease, excess chronic liver disease, and excess injury/poisoning with statistically significant increases identified for diabetes, cardiovascular diseases, and deaths due to lung cancer in exposed workers. ***Metal particulates were identified as a most important pollutant in working area that requires a reliable method for measuring metal PM in tissues, to enable exposure assessment).***

Chen S, Zhang J, Xu K, Xu Qingwei (2020). Thermal decomposition behaviour of foundry sand for cast steel in nitrogen and air atmospheres. Mathematical Problems in Engineering 2020: Article ID: 8121276, 12 pages.

The mass loss rate of foundry sand from 250°C to 600°C was much larger in the air atmosphere than in the nitrogen atmosphere, but beyond this range, the rates were almost the same. The mass loss rate of foundry sand was the highest at approximately 450°C, and the thermal decomposition was the most severe at this time. The sand-binding agent used in this study was furan resin. Methylene or methane bridges connecting furan resin chains begin to break at temperatures exceeding 250°C]. Furan resin undergoes significant ring-opening reactions between 300°C and 350°C. Benzene may also be formed from the fragments derived from said ring-opening reactions; in our experiment, the amount of benzene significantly increased starting at 400°C. From 460°C to 650°C, benzene formed from the furan resin-derived intermediates. Pyrolic decomposition of mould sand was higher in air than nitrogen environment and temperature is an independent variable for amount of release.

Chenjing F, Graff P, Vihborg P, Byngelsson IL, Anderson L (2018). Silica exposure increases the risk of stroke but not myocardial infarction: a retrospective cohort study. Plos https://doi.org/10.1371/journal.pone.0192840.

Mortality from cardiovascular disease (SMR 1.3; 95% CI 1.2–1.4) and stroke (SMR 1.6, 95% CI 1.2–2.1) was significantly elevated among the studied population. The cohort also exhibited significantly elevated morbidity from stroke (SIR 1.34; 95% CI 1.2–1.5) but not myocardial infarction. The mean age at the time of first morbidity from stroke was 64 years, with 36% of the cases occurring before the age of 60. Swedish foundry workers exposed to respirable silica exhibit elevated morbidity and mortality from stroke, but not from myocardial infarction. Our results also suggest a relationship between silica exposure and morbidity from stroke at a younger age than the general population.

Cooke J, Simpson A, Yates T, Llewellyn V (2017). Exposure to substances hazardous to health in foundries. Health and Safety Executive, UK; Report No. RR1115.

A review of the major hazards of the foundry industry and measures to control and mitigate exposures.

Crocker J (2011). Biomonitoring for isocyanates. Annals Occup Hyg; 55: 2 (127-131).

Biomonitoring of MDI correlation of body burden and air concentrations identified, but confounded by presence of monomers and oligomers creating uncertainty.

Demers PA and Del Bianco (2013). Trends in compensation for death from occupational cancer in Canada: a descriptive study. CMAJ: doi:10.9778/cmajo.2013-2014.

Recent patterns of compensation paid to Canadian workers' families due to occupationally related cancer.

deVocht F, Sobala W, Wilcynska U, Kromhout H, Szeszenia-Dabrowska N (2009). Cancer mortality and occupational exposure to aromatic amines and inhalable aerosols in rubber tire manufacturing in Poland. Cancer Epi 33(2):94-102.

Cumulative exposure was assigned to cohort based on estimates from a company specific JEM. Exposure levels were higher for women than for men. Aromatic amine exposure significantly associated with increased urinary bladder cancer risk (RR=7.32-8.27) depending on exposure level, and prostate cancer at low levels only (RR=5.86).

Dodson RF, Levin JL (2001). An unusual case of mixed-dust exposures involving a "non-commercial" asbestos. Environmental Health Perspectives, 109(2) 199-203.

Foundry worker presenting with evidence of pneumoconiosis, and later asbestosis confirmed but linked to non-commercially used asbestos type fibers (i.e., anthophylite and tremolite) compared to amphibole or commercial type asbestos. ***The instructive nature of this case highlights growing concern with how many similar exposures may occur in which asbestos is not considered a contributor to disease or risk of future disease. Historical links of exposure to asbestos-containing products in the workplace or environment are not immediately evident…(but) may have significant implications for clinical prognostic reasons as well as medical and legal concerns (since non-commercial types of asbestos are likely to be encountered as" natural contaminants" of other minerals—rather than linked specificallly to asbestos).***

Dungan RS, Reeves III JB (2007). Pyrolysis of carbonaceous foundry sand additives, Sea coal and gilsonite. Thermochimica Acta, 460:60-66.

The tentative identification of organics during the pyrolysis of sea coal and gilsonite in foundry sands revealed that a number of compounds of environmental concern were generated, including substituted benzenes and phenolics, and PAHs. While not accurately mimicking the conditions during metal casting, the results suggest that it is important to determine risk of mould sand in the environment. Authors acknowledge the need to also determine quantitatively the organics in sands from aluminum and iron associated with foundries.

Enferm GR, Alegre P (2020). Lung cancer related to occupational exposure: an integrative review. SciELO Analytics, http://dx.doi.org/10,1590/1983-1447.2020.20190379.

Analytic study of Integrative Literature Review (national and international databases) from 2009-2018 concerning 32 studies referencing association between carcinogenic substances to which worker is exposed and lung cancer. The most exposed workers were from industry (50%) and construction (6.2%), mostly male. Asbestos and silica were identified among the carcinogenic substances most associated with lung cancer risk, accounting for 37.9% and 28.1%. Other substances named in order of frequency were diesel exhaust, mustard gas, quartz, coal, nickel, chromium, carbon, silicon carbide, talc, and spray paint (All of these with high, medium, and low risk, depending on exposure conditions).

Freire BM, Lange CN, Pedron T, Monteiro LR, Sanches LR, Pedreira-Filho, W, Batista BL (2020). Occupational exposure of foundry workers assessed by the urinary concentrations of18 element and arsenic species. Journal of Trace Elements in Med & Biology. https://doi.org/10.1016/j.jtemb.2020126593.

Higher toxic chemicals (18 chemicals tested) were found in the urine of production workers compared to administrative workers in a Brazilian foundry including elevated levels of arsenic, iron, cadmium copper, caesium, and iodine, of special concern was evidence of inorganic and organic arsenic which was 7 times greater than admin staff. The statistical approach indicated the presence of iron, manganese, zinc, arsenic, copper, lead, cobalt, tin, and caesium likely associated with occupational exposure.

Ghahramani G (2010). Silica nephropathy. Intl J Occup Environ Med 1 (3) 108-115.

This article reviews the association between exposure to silica and various forms of kidney disease. The kidneys are particularly susceptible to toxic effect of heavy metals, organic solvents and silica. Silica is associated with excess mortality from acute renal disease. Silica exposure is linked to several multisystem autoimmune diseases: rheumatoid arthritis, progressive systemic sclerosis, polyarteritis nodosa, small vessel vasculitis, con-

nective tissue disease. Mechanisms include the triggering of a maladaptive immunological response to a silica containing nodules.

Ghormley S, Williams R, Dvorak B (2020). Foundry sand source reduction options: life cycle assessment evaluation. Environments 7,66; doi: 10.3390/environments7090066.

Processes for sand reclamation include: mechanical (vibration, shocking, air scrubbing); heat (high temp in fluidized bed); thermal (use of microwaves to reclaim sand).

Gunnarsson Linus (2015). Exposure to respirable dust and cardiovascular disease mortality among Swedish iron foundry workers (Version 2). Orebro University.

A cohort study of 3,048 foundry workers selected from 10 Swedish foundries with comparisons with the general populations and respirable dust concentrations. Overall mortality was higher among foundry workers (SMR 1.19) and SMR for cardiovascular disease was 1.26 but varied among different job titles. Stroke was diagnosed as CVD and had the most statically significant excess mortality. But there was no dose response with respirable dust exposure. Workers with higher exposures showed less mortality. The highest SMR was for "melters" although they had a lower mean dust concentration.

Hadrup N, Zhernovkov V (2020). Acute phase response as a biological mechanism of action of (nano) particle induced cardiovascular disease. https://doi.org/10.1002/smll.201907476.

Inhaled nanoparticles constitute a potential health hazard due to their size dependent lung deposition and large surface to mass ratio. Exposure to high levels contributes to the risk of developing respiratory and cardiovascular diseases, as well as of lung cancer. Particle induced acute phase response may be an important mechanism of action of particle induced cardiovascular disease. Here, the authors review new important scientific evidence showing causal relationships between inhalation of particle and nano-materials, induction of acute phase response, and risk of cardiovascular disease. Particle induced acute phase response provides a means for risk assessment of particle induced cardiovascular disease and underscores cardiovascular disease as an occupational disease.

Hamzah NA, Tamrin SBM, Ismail NH (2015) Metal dust exposure and respiratory symptoms among steel workers: a dose-response relationship. Intl Jour Collab Res in Int Med & Pub Health 7(3): 24-39.

Exposure to metal dust and fumes are leading cause of respiratory problems by increased likelihood of reversible narrowing of the airways and greater prevalence of chronic respiratory symptoms among steel workers. A cross sectional study was conducted to assess metal dust exposure to cobalt, chromium and nickel and its relationship to respiratory symptoms among 184 workers. British Medical Research Council Questionnaire was used to identify respiratory symptoms. Exposure to cobalt and chromium were 1 to 3 times higher than permissible exposure limit, while nickel did not exceed PEL. Findings: Cumulative of chromium was the predictor to all of the respiratory symptoms which cumulative of cobalt was the predictor of chronic cough. Smoking was contributor to shortness of breath (1.06, 95% CI102-110) while past respiratory illnesses were found to be the predicting factor in tightness of the chest (2.15, 95% CI1.28-159 and shortness of breath (1.93, 95% CI 1.37-10.15). Only few worker (34.6%)s were found to wear their masks at all times during work. In conclusion, there is a dose-response relationship of cumulative metal dust exposure with elevation of respiratory symptoms prevalence. Improvements of control measures are needed to reduce the metal dust exposures and workers should be encouraged to use respiratory protection during work hours.

Holtzer M, Danko R, Kmita A (2016). Influence of a reclaimed sand addition to moulding sand with furan resin on its impact on the environment. Water Air Soil Pollut 227:16 2702-2709.

Reclaimed sand additions to moulding sand have significant negative influence on the environment and working conditions. Increase in reclaim sand leads to greater emissions of metal, BTEX and PHAs. This concerns *mainly carbon substances which amounts increase along with reclaimed sand increase. Special attention paid to significant increase in the emission of substances from BTEX and PAHs (especially benzo(a) pyrene) and less for metals.*

Holtzer M, Danko R, Kmita A, Drozynski, Kubecki M, Skrzynski M, Roczniak A (2020). Environmental impact of the reclaimed sand addition to molding sand with furan and phenol-formaldehyde resin – A comparison. Materials 13:4395-4407.

An addition of reclaimed sands to matrices of two types of mould sand caused a significant increase in volume of emitted gasses up to three-fold. The mechanical reclamation process of spent moulding sand does not fully remove the hardened binder from sand grains. By adding reclaimed sand to sand matrices, additional amounts of inactive binder are introduced into moulding sands, increasing the volume of emitted gases and constituting a higher risk to the (work) environment with BTEX emission values proportional to the fraction of reclaimed sand.

Humfrey CDN, Levy LS, Faux SP (1996). Potential carcinogenicity of foundry fumes: a comparative in vivo-in vitro study. Food and Chemical Toxicology 34(11-12):1103-1111.

The rodent bioassay failed to demonstrate a carcinogenic response, although an increase in pre-neoplastic lesions was seen in all fume-treated groups relative to controls. When tested in vitro, the fumes were positive in many assays and activity correlated with the polycyclic aromatic hydrocarbon content of the fumes.

Hye, JB, Mi RN, Sang ML Jung YJ, Byung HS, Young GP, Jong HJ (2015). Exposure assessments of chemical risk factors to airborne contaminants in foundry process. Jour Environ Sci Intl 24(5): 699-708.

Study identified exposure characteristics of toxic substances in 4 casting sites (methanol, silica, formaldehyde and phenol were analyzed). Highest concentrations of methanol found in casting and moulding the highest concentration of silica found in core. The most oxidized steel dusts and highest concentrations of fume were found in shakeout and finishing. Workers found to be constantly exposed to various forms of hazardous chemicals.

IARC review of occupational exposures during iron and steel founding (updated to 2014).

IARC's review of occupational exposures in the foundry industry and the classification of foundry work as a Group 1 carcinogen with special emphasis on lung cancer. In that review of hygiene exposure studies and epidemiological studies, IARC concluded that all workers are exposed to silica and respirable dusts, carbon monoxide; binder compounds used in cores and molds, including phenol formaldehyde, furan, urea formaldehyde, urethane resins. Curing reactions and thermal decompositions give rise to additional compounds; components of these include: aliphatic components including methane, ethane, ethylene, acetylene, benzene, toluene, xylene, naphthalene, a variety of PAHs as well as Nitrogen containing urea, ammonium, cyanide and amines. The review also noted the extent to which pyrolysis processes, resulted in PAHs bonding to soot, fume and sand particles and distributed all over the plant. IARC's review also encompassed reviews of bio-monitoring studies indicating a high body burden of metals in blood and urine, in addition to high fiber counts. A review of 13 cohort studies on foundry workers found that foundry workers worldwide had significantly increased risk of lung cancer in both the entire cohort and in high exposed subgroups (IARC 2014 Updated from 1987 review).

Ibarluzea J M, et al (2004) Breast cancer risk and combined effects of environmental estrogens. Cancer Causes and Controls 15:591-600.

Detection of elevated risk of breast cancer when total burden of several combined EDCs (estrogenic compounds) analyzed, but not when single EDCs are considered, indicating an additive and/or synergistic effect working in this biological interaction. This study has implications for analyzing the biological effects for simul-

taneous and/or sequential complex mixtures of chemical exposures.

Jafari MJ, Pirposhteh EA, Dehghan SF, Khodakarim S, Jafari M (2020). Relationship between heat stress exposure and some immunological parameters among foundry workers. Intl J Biometeorology 64:853-861.

Occupational exposure to heat stress may lead to changes in blood cell count. The objective of this retrospective descriptive-analytical field study is to investigate the relationship between heat stress exposure and some immunological parameters among foundry workers. This study was carried out on 55 subjects of which, 35 were working in a foundry unit (exposed group) and 20 were working in a computer numerical control (CNC) machining unit (control group). The measurement method consisted of taking 10 cc of the subjects' blood between 10 am and 2 pm and then performing the automated blood cell counting and enzyme-linked immunosorbent assay (ELISA) on the sample. Environmental parameters such as noise levels, lighting, and the wet-bulb globe temperature (WBGT) index were measured at the subjects' workstations. The laboratory test results show a significant decrease in white blood cell count and lymphocyte levels and a significant increase in neutrophil levels and neutrophil to lymphocyte ratio in exposed group compared with control ones ($P < 0.05$). IgM levels decrease under heat stress, but we do not observe significant differences between IgG and IgA levels between two groups. A significant negative correlation was observed between white blood cell count, lymphocyte levels, and IgM concentration with WBGT index and significant positive correlation was observed between neutrophil and neutrophil to lymphocyte ratio with WBGT index. In conclusion, under heat stress conditions, leukocytes levels and immunoglobulin concentration may reduce and it may weaken and suppress the human immune system.

Kelleher P, Pacheco K, Newman LS (2000). Inorganic Dust Pneumonias: The metal-related parenchymal [lung] disorders. Environ Health Perspectives 108(supplement 4):685-696.

In addition to Pneumoconiosis produced by asbestos, silica and coal, inhalation of metal dusts and fumes induces a wide range of lung pathology including airways disorders, cancer, and parenchymal diseases caused by inhalation of metals. This study explores immunologic and inflammatory bases of metal induced parenchymal disease through review of knowledge related to the following metals: aluminum, cadmium, cobalt, copper, iron, mercury, nickel. Finding: Aluminum associated with pneumoconiosis, fibrosis and granulomatous lung disease – mechanism remains poorly defined. Cadmium: linked to emphysema, obstructive lung disease, pulmonary fibrosis and lung cancer. Increased mortality from bronchitis reported in cadmium workers in several studies – oxidant-induced cytotoxicity suspected as mechanism. Cobalt (industrial hygiene surveys suggest cobalt levels are frequently underestimated and are higher than TLVs). Cobalt alloys are desirable in auto industry because of their great strength and resistance to oxidation. Cobalt is major component of "hard metal" matrix that consists mainly of cobalt and tungsten carbide with other metal alloys added in small amounts. Hard metal disease (HMD) linked to the hard metal matrix includes a variety of respiratory or parenchymal, diseases including giant cell interstitial pneumonitis, bronchiolitis obliterans, hypersensitivity pneumonitis and interstitial fibrosis. The mechanism is unclear, but an immunologic mechanism is suggested. Copper: Respiratory illness associated with copper is infrequent although it may result in upper respiratory tract irritation and ulceration of perforation of nasal septum. Iron: Pulmonary disease including fibrosis and siderosis are linked to iron dust exposure with more recent animal studies on siderosis in animals showing high concentrations of low toxicity dusts including carbonyl iron was linked to sustained pulmonary inflammation, impairment of particle clearance and deficits in particle clearance. Reactive oxygen species may play a role in iron-induced pulmonary toxicity as iron is suspected to be an important mediator in catalyzing asbestos induced production of reactive oxygen species in the lung. Thus oxidant- induced cytotoxicity may be a mechanism for respiratory disease linked to iron dust. Nickel: this is a highly sensitizing metal associated with IgE mediated sinusitis, dermatitis, and asthma but also causes chemical pneumonitis, pulmonary edema and pulmonary fibrosis in high dose exposures. Mechanism is thought to be cytokinetic in response to inflammation.

Kmita A, Benko A, Roczniak A, Holtzer M (2019). Evaluation of pyrolysis and combustion products from foundry binders: potential hazards in metal casting. Journal of Thermal Analysis and Calorimetry 140: 2347-2356.

Both the type and amount of decomposition gasses released in mould casting is dependent on temperature, heating rate, and atmosphere. The highest versatility of harmful volatiles produced during heating in the inert atmosphere takes place in closest proximity of the liquid metal. Workers engaged in metal extraction of castings are at greatest risk and this work should be done under a hood and with proper PPE equipment.

Kmita A, Benko A, Roczniak A, Fraczek-Szczypta A, Holtzer M (2018). Pyrolysis of organic ester cured alkaline phenolic resin: Identification of products. Journal of Analytical and Applied Pyrolysis 129:6-12.

This study identified degradation products formed through pyrolysis during metal castings, looking at both "slow" and "flash" mechanisms. During "flash" pyrolysis at 500, 700, 900 and 1100 C mainly phenol and its methyl and ethyl derivatives, as well as benzene were released. It was determined that the pyrolysis products and their ratio depended on the temperature during the degradation process.

Koskela K, Ritta S, Panu O, Jukka U, Eeva M, Lauri L (2021). High alveolar nitric oxide is associated with steeper lung function decline in foundry workers. Jour of Breath Research 15(3):036002.

Occupational dust exposure induces inflammatory responses that often precede the onset of clinical disease. Inflammation in the peripheral part of the lung can be demonstrated by measuring the alveolar NO concentration (CaNO) in exhaled breath. The aim of this case control study was to assess whether cumulative dust exposure effects the change in CaNO during follow-up and whether baseline CaNO can predict impairment in lung function during follow-up in foundry workers. Baseline testing was followed up 7 years later. An increase in CaNO during the follow-up period was positively associated with cumulative dust exposure in foundry work (p=0.035). Furthermore, a higher baseline CaNO was associated with an accelerated decline in the forced vital capacity (FVC) during the follow-up period (absolute decrease in FVC p=0.021, relative decrease in FVC p=0,017). Higher cumulative dust exposure in foundry work is associated with a greater increase in CaNO during follow-up, suggesting ongoing pulmonary inflammation in these subjects. Importantly, a high baseline CaNO is associated with an accelerated decline in lung function, suggesting that CaNO measurements might serve as a screening tool for high-risk workers.

Koskela RS, Mutanen P, Sorsa JA, Klockars M. (2005). Respiratory disease and cardiovascular morbidity. Occ Env Med (62): 650-655.

Work related dust exposure is a risk factor for acute and chronic respiratory irritation and inflammation. Exposure to dust and cigarette smoke predisposes to exogenous viral and bacterial infections of the respiratory tract. Respiratory infection can also act as a risk factor in the development of atherosclerotic and coronary artery disease. Aims: To investigate the association of dust exposure and respiratory diseases with ischaemic heart disease (IHD) and other cardiovascular diseases (CVDs). Methods: The study comprised dust exposed (granite, foundry, cotton mill, iron foundry, metal product, and electrical) workers hired in 1940–76 and followed until the end of 1992. National mortality and morbidity registers and questionnaires were used. The statistical methods were person-year analysis and Cox regression. Results: Co-morbidity from cardiovascular and respiratory diseases ranged from 17% to 35%. In at least 60% of the co-morbidity cases a respiratory disease preceded a cardiovascular disease. Chronic bronchitis, pneumonia, and upper respiratory track infections predicted IHD in granite workers (rate ratio (RR) = 1.9; 95% CI 1.38 to 2.72), foundry workers (2.1; 1.48 to 2.93), and iron foundry workers (1.7; 1.16 to 2.35). Dust exposure was not a significant predictor of IHD or other CVD in any group. Dust exposure was related to respiratory morbidity. Thus, some respiratory diseases appeared to act as intermediate variables in the association of dust exposure with IHD. ***Conclusion: Dust exposure had only a small direct effect on IHD and other CVD. IHD morbidity was associated with preceding respiratory morbidity. A chronic infectious respiratory tract disease appeared to play an independent role in the development of IHD.***

Koskela RS, Mutanen P, Sorssa JA, Klockars M (2000). Factors predictive of ischemic heart disease mortality in foundry workers exposed to carbon monoxide. Am. Jour of Epi 152(7): 628-632.

The potential predictors of ischemic heart disease mortality were studied for 931 male foundry workers in Finland who participated in a health examination in 1973. These workers were followed up to 1993 through registers and by using a questionnaire. In 1973, the systolic and diastolic blood pressures of workers exposed to carbon monoxide (CO) were slightly higher than those of unexposed workers. The prevalence of angina pectoris showed a clear dose-response relation to CO exposure. Electrocardiogram (ECG) findings indicating past myocardial infarction or suggesting coronary artery disease as a function of smoking and/or CO exposure were not evident. In the 1987 follow-up, the rate ratio for ischemic heart disease mortality was estimated as 4.4 for CO-exposed smokers compared with unexposed non-smokers. Ischemic heart disease mortality in 1973–1993 was analyzed by using the Cox proportional hazards model. The statistically significant predictors were age, pathologic ECG findings in 1973, regular CO exposure, and abundant alcohol drinking. Of the ECG findings, changes in Q or QS and ST-J or ST waves and in ventricular systoles were statistically significant. The risk of mortality from ischemic heart disease was increased by working in iron foundries, by hypertension, and by smoking.

Kraim-Leleu M, Lesage, FX, Drame M, Lebargy F, Deschamps F (2016). Occupational risk factors for COPD: A case-control study. PLOS ONE 11(8) e0158719.

Smelter or foundry workers only group of 11 occupations studied with increased COPD. Machine maintenance (65.2%), moulding (49.6%), finishing (41.1%), and casting (41.0%) were the most common activities. Nearly all (95.1%) of the foundry workers cleaned floors and machines with a brush or compressed air.

Kuo JW, Chang CL, Liang WM, Chung BC. (1999). Respiratory abnormalities among male foundry workers in central Taiwan. Occupational Medicine 49(8):499-505.

Furnace workers were found to have the highest prevalence of chronic phlegm, thoracic disorders and chronic bronchitis. In general, smokers had a higher prevalence of respiratory symptoms as compared with non-smokers. Pulmonary function abnormalities and pneumoconiosis were closely linked to smoking and work duration. After adjusting for age, height and smoking there was a significant decrease based on work duration in FVC and FEV1 for furnace and moulding workers compared with after-processing and administrative workers. The overall prevalence of pneumoconiosis was 8.8%, highest among furnace workers (16.3%) and after-processing workers (11.4%) and lowest among administrative workers (2.5%). Using multiple logistic regression, the risk of developing pneumoconiosis (as compared with the administrative workers) for furnace workers was highest (8.98 times greater risk), followed by after-processing workers (6.77 times greater risk) and moulding workers (5.41 times greater risk). Prolonged exposure to free silica, and smoking habits, can result in respiratory abnormalities among foundry workers.

Lee FY, Chen WK, Cheng L, Kao CH (2015). Carbon monoxide poisoning and subsequent cardiovascular disease risk: A National-wide population-based cohort study. Medicine 94(10): PMC 4602477.

The overall incidences of arrhythmia, CAD, and CHF were higher in the patients with CO poisoning than in the controls (2.57 vs. 1.25/1000 person-years, 3.28 vs. 2.25/1000 person-years, and 1.32 vs. 1.05/1000 person-years, respectively). After adjusting for age, sex, and comorbidities, the patients with CO poisoning were associated with a 1.83-fold higher risk of arrhythmia compared with the comparison cohort, and non-significantly associated with risk of CAD and CHF. CO-poisoned patients with coexisting comorbidity or in high severity were associated with significantly and substantially increased risk of all 3 CVDs.CO poisoning is associated with increased risk of subsequent development of arrhythmia. Future studies are required to explore the long-term effects of CO poisoning on the cardiovascular system.

McDonald JC, McDonald A, Hughes J, Fando R, Weill H (2005). Mortality from lung and kidney disease in a cohort of north American industrial sand workers, Annals of Occupational hygiene, 49 (5):367-373.

This was a nested case control study based on data generated in large Swedish cohort study that found elevat-

ed excess mortality among Swedish foundry workers as well as non-malignant renal disease. While the McDonald et al 2005 found elevated risk ratios they could not find a statistically significant elevated risk of renal disease.

McDonald JC, Rando R et al (2001) Cohort mortality study of North American industrial sand workers. I. Mortalitiy from lung cancer, silicosis and other causes. Ann Occup Hyg; 45 (3):193-199.

Supports a causal relation between lung cancer and quartz exposure in absence of other known carcinogens. Unexpectedly a strong indication in this cohort of excess mortality from chronic non-malignant renal disease that was worthy of further investigation.

The follow up study by McDonald JC et al with very small numbers and lacking statistical power for renal issues found an excess that was not statistically significant. (9 cases vs 18 controls). However, the excess risk of lung cancer and silica exposures remained statistically significant.

McKenzie J F, Sonia E Z, Carey R N (2020). Prevalence of exposure to multiple carcinogens among exposed workers in Australia. School of Public Health, Curtin University, Western Australia, Australia.

Analysis of data from the Australian Work Exposure Study to examine the extent of exposure to multiple carcinogens at work. 81% of exposed workers are exposed to more than one carcinogen; 26% reported exposures to 5 or more. Multiple exposures were more likely for younger workers, while older workers were less likely to be exposed to multiple carcinogens.

Mehra R & Juneja M (2004). Elements in scalp hair and nails indicating metal body burden in polluted environments. Journal of Scientific & Industrial Research 64:119-124.

Metal content higher in Nail than hair samples, nails more accurate, copper and magnesium higher in foundry workers irrespective of regions of study.

Mehri F, Jenabi E, Bashirian S, Shahna FG, Khazaei S (2020). The association between occupational exposure to silica and risk of developing rheumatoid arthritis: A Meta-Analysis. Safe Health Work 11(2):136-142.

Pooled studies link occupational silica exposure (foundry work) to higher rates of rheumatoid arthritis.

Merlo F, Costantini M, Reggiardo G, Ceppi M, Puntoni R (1991). Lung cancer risk among refractory brick workers exposed to crystalline silica: a retrospective cohort study. Epidemiology 2(4): 299-305.

A retrospective cohort study among 1022 brick workers exposed to crystalline silica. Mortality from lung cancer (SMR=1.77), respiratory diseases (SMR=3.15), was elevated in workers first employed before 1958 and likely highest exposures to silica. Workers with 19 or more cumulative years of employment experienced particularly increased risks for lung cancer (SMR=2.01) and respiratory diseases (SMR=389). Relative mortality increased with age since employment. Indirect adjustment for smoking due to lack of excess mortality from cardiovascular diseases and emphysema indicated little effect of smoking on the increased risks for lung cancer and respiratory disease.

Mgonja CT (2017). A review of effects of hazards in foundries to workers and environment. Intl Jour Innovative Sci, Engineering & Technology. 4(6): 2348-7968.

This is a comprehensive review of Hazardous chemicals common to foundries including: amines, benzene, hexschloroethane, ammonia, epoxy resins, formaldehyde, fufuryl alcohol, isocyanates, mould release paints, protective coatings, phenol, and silica. Health effects include: headaches, nausea, fatigue, irritant or allergic dermatitis, asthma, bronchitis, chemical burns, irritation of the nose, eyes and respiratory tract, adverse effects on the central nervous system and other systems including lungs, kidneys and liver. Airborne contaminants in the form of fume, mist, gas, vapour or dust and includes microorganisms which involve all *facets of foundry operations including: pattern making, core making, furnace, fettling and sand plant sections with furnace tenders, melters, casters, ladlemen, pourers and crane operators exposed to smoke and fumes during melting. Contaminants released by or generated from: handling of scrap, receiving, unloading, storage and conveying; scrap preparation using heat and solvent degreasers - carbon monoxide; the melting process – carbon monoxide, sulphur dioxide, nitrogen oxides, chloride and fluoride compounds; the treatment and inoculation of molten metal before pouring; core and mould making processes during sand reclamation, sand preparation and sand mixing; mould and core forming processes including core baking and mould drying from additives, binders and catalysts; cooling of casts causing decomposition of organic binders; casting knockout and shake-out and fettling. Health effects include respiratory irritation, coughing, asthma, acidic taste, and eye irritation. Inhalation of wood dusts causes slowing of dust clearance and alteration to structure of mucous membrane lining of nasal cavity (including risk of nasal/sinus cavity cancers). Respirable silica dusts one of greatest risks produced by rubbing, abrading or mechanical action on the quartz, which is composed of crystalline silica. Foundry operations associated with silica exposures include core and mould making shakeout, cleaning of castings, furnace and ladle repair, sand reclamation and sand preparation. (Class A1 carcinogen).*

Michaud D, Baril M, Perrault G (1993). Characterization of airborne dust from cast iron foundries by physio-chemical methods and multivariate statistical analyses. Air and Waste 43:729-735.

Three foundries sampled with electron microscopy. A clear pattern of composition as a function of size emerges—in particular, trace metals accumulate in fine particles and volatile species on the surface of these. Chemical composition changes are also related to daily schedules, where applicable, with trace metals appearing during pouring operations, silicon generated during mould making and unmoulding. High zinc levels were noted when cleaning of furnaces. The authors noted the "sophistication" of airborne dust. Both type and size (penetration) important in linking dust exposure to illnesses.

Mohamed RS, Helmy NM, Self-Eldin A (2020). Epigenetic changes and cardiovascular risks among workers occupationally exposed to iron and zinc. Egyptian Jour of Occ Med. 44(3):809-824.

Introduction: Several metals such as Iron and Zinc were found at high concentration in foundry particulate matter and demonstrated to have pro-coagulant effects, these effects may occur through epigenetic changes of pro-inflammatory genes. So, Iron and Steel workers are at a high risk for cardiovascular diseases. Aim of work: Evaluation of the risk of thrombosis and cardiovascular diseases among individuals occupationally exposed to Iron and Zinc. Results: the current study showed highly statistically significant increase of serum Iron, Zinc levels and percentage of ETP among exposed group when compared to the control with Mean ± SD 125.6±22.9, 110.9±19.2,168±0.5 vs. 63.6±15.3, 42.5±7.2, and 102.22±12.36 respectively. There was also a significant decrease of methylated DNA of EDN1and NOS3 genes among exposed group with Mean ± SD 0.71±0.3, 0.75±0.3 versus 1.51±1.01,4.09±0.68 respectively among the control group. Serum levels of Iron and Zinc and percentage of ETP were negatively correlated with methylated DNA of NOS3 and EDN1 genes r= -0.304, r=-0.450, r=-0.259, r= -0.787, r= -0.866 and r= -0.618 respectively (p value <0.005), while positive correlation were detected between Iron and Zinc levels with ETP (r= 0.692 and r=0.625). It was found that Iron, Zinc and NOS3 are determinants for END1 while the latter is the only predictor for NOS3. ***Conclusion: The risk of thrombosis and cardiovascular diseases were related to occupational exposure to high levels of Iron and Zinc. So, regular wearing of good quality's personal protective equipment, especially masks and gloves, is highly recommended to decrease exposure to these metals.***

Moroni B, Viti C, Cappelletti D (2014). Exposure vs toxicity levels of airborne quartz, metal and carbon particles in cast iron foundries. Jour Exposure Sci & Envir Epi 24: 42-50.

Health risk assessments tend to ignore possible lung injury by concomitant exposure to carbonaceous and metal particulate and accompanied oxidative stress and inflammation. Overall, the results indicate substantial changes in quartz crystal structure and texture when passing from the raw material to the airborne dust, which *include lattice defects, non-bridging oxygen hole centres and contamination of quartz grains by metal and or graphite particles. All these points towards the relevance of sand grain surface properties on reactivity." Relevant particle properties to determine include: Particle properties vs. toxicity; Quartz grain; metal particles; carbonaceous particle; possibly synergistic effects. Health risk assessment in cast iron foundries generally tends to ignore possible lung injury by concomitant exposure to carbonaceous and metal particles.*

Mossman B, Borm PJ, Castranova V, Costa DL, Donaldson K, Kleeberger SR (2007). Mechanisms of action of inhaled fibers, particles and nanoparticles in lung and cardiovascular diseases. Particle and Fibre Toxicology 4, Article number 4:43 pgs.

Occupational exposures to inhaled pathogenic particles and fibers such as silica and asbestos have been associated with the development of lung inflammation and disease. The development of lung fibrosis and cancer by these naturally occurring minerals is dose and time-related with relatively long durations of exposure. In the last decade, epidemiology and animal models have revealed acute morbidity and mortality, including exacerbation of asthma and toxic effects extending to the cardiovascular system, from episodic exposures to PM. Dissecting the adverse components of PM and mechanistic events occurring in the lung, its initial site of deposition, and systemically is daunting because of the complexity and seasonable variability of PM. However, ultrafine particles and components such as metals (iron, vanadium, zinc, etc.), sulphates, and adsorbed hydrocarbons may act uniquely or synergistically and/or render the lung more sensitive to secondary insults. The majority of experimental data suggests that size and pro-oxidation state of PM determine its overall distribution and durability in lung and distal organs, cell/tissue transport mechanisms and toxic potential. This information may be vital to the design and use of "safe" synthetic nanoparticles and nano-fibers, a burgeoning technology.

Pro-inflammatory and acute effects of PM are directly related to oxidative stress and induction of multiple oxidant or xenobiotic-induced signalling cascades and transcription factors (NF-κB, AP-1, Nrf2), a paradigm consistent with models of asbestos and silica-associated lung diseases. An important consequence of initial oxidant injury is the antioxidant response that when overwhelmed or compromised in subjects with weakened defences, i.e., individuals with single nucleotide polymorphisms or changes in expression of antioxidant enzymes, the GSTM1 gene, etc., predisposes to cardiopulmonary morbidity or mortality. Information on other host susceptibility factors and genes predisposing to the development of acute and chronic diseases by inhaled particles may be obtained by genotype and phenotype analyses.

Knowledge of the events leading to systemic transport and pathogenicity of PM, including impairment of vascular and fibrinolytic function, is also vital to preventive approaches in the public health domain. The presentations summarized above suggest a number of potential mechanisms whereby PM may adversely affect the cardiovascular system by altering autonomic function, vascular reactivity, and thrombosis. However, how these effects contribute to and whether they are related causally to the pathogenesis of atherosclerosis is unclear. Another important question that needs to be addressed is whether the physical presence of PM is required for distal organ effects or whether these effects are mediated by lung chemokines, cytokines, or inflammatory cells, after inhalation of PMs. Moreover, the many physical and chemical properties of PM and other inhaled particulates that are central to their pathogenicity need to be elucidated.

National Institute of Occupational Safety and Health (1985). Foundries, U.S. Department of Health and Human Services, Center for Disease Control, #85-116

This is a comprehensive review of the types of foundry production: Production processes, emissions, known health and safety hazards, review of epidemiological studies on diseases associated with foundry exposures, health effects of selected chemicals and physical agents. The review also includes detailed engineering controls, best practices in the industry, PPE, exposure limits, and sampling strategies and analytical methods to assess exposures.

Neslihan D, Nuren S (2010). Effects of work place carbon monoxide exposure on blood viscosity. Archives of

Envir & Occ Health. 65(1):49-53.

Both blood viscosity and carbon monoxide (CO) has been associated with cardiovascular diseases (CVDs). In order to investigate the effects of chronic low-level CO exposure on the determinants of blood viscosity (hematocrit, plasma viscosity, erythrocyte deformability, and erythrocyte aggregation), 10 men exposed to CO at work for at least 6 months and 10 healthy controls were included in the study. Plasma viscosity was determined by a cone-plate viscometer, erythrocyte deformability and erythrocyte aggregation by laser-assisted optical rotational cell analyzer. Mean plasma viscosity of the group exposed to CO (1.4 ± 0.1 mPa·sn) was significantly higher than that of the controls (1.2 ± 0.06 mPa·sn) ($p < .05$). Plasma fibrinogen level of the CO group (275 ± 11 mg/dL) was slightly higher than that of the controls (263 ± 14 mg/dL). The rise in plasma viscosity by chronic low-level CO exposure may be the mechanism of CO-induced increase in the risk for CVDs.

OHCOW studies (Occupational Health Clinics for Ontario Workers)

Gauvin A, Albinger M, (1999) Neelon Casting sampling data for respirable crystalline silica and respirable dust, Occupational Health Clinics for Ontario Workers. In conjunction with:

Wakely, Lorraine (1999) Industrial Hygiene Assessment: Silica Exposures at Neelon Casting, Sudbury, Ontario. Occupational Health Clinics for Ontario Workers, April 28, 1999.

Gauvin A, Albinger (1999). Neelon Casting sampling data for triethylamine (TEA), Occupational Health Clinics for Ontario Workers. In conjunction with:

Keller N (1999). Air sampling: Triethylamine at Neelon Casting, Occupational Health Clinics for Ontario Workers, September 16 and 17, 1999.

Gauvin A, Albinger M (1999). Neelon casting sampling data for lead, Occupational Health Clinics for Ontario Workers. In conjunction with:

Wakely L (1999). Industrial hygiene assessment: lead exposures (at Neelon Casting), Occupatinal Health Clinics for Ontario Workers, March 29, 1999.

Oliver, Christine, Zarnke Andrew (2021). Sarcoidosis: an occupational disease? CHEST, https://doi.org/10.1016/j.chest.2-21.06.003.

This paper is a literature review of research and evidence on Sarcoidosis as an occupationally caused granulomatous lung disease, moving beyond its current classification as an idiopathic disease, a classification which is undergoing change as a result of case reports, biological studies and epidemiological studies providing stronger evidence of a causal association. Agents identified include silica and certain metals. Evidence from in vitro study employing lymphocyte proliferation tests (LPT) provide evidence of immune system mediated reactivity to silica, silicates and metals from occupational exposures. This is of particular relevance to exposures in the foundry industry, and the incidence of at least three Sarcoidosis cases identified and the intense retrospective exposures to silica and metals, characterized in our exposure risk assessment at the Neelon Casting plant in Sudbury, Ontario—with particular reference to multiple exposure to silica coated with metal (Oolitic sand) as well as phenol/formaldehyde binding compounds.

Oudyk J, (1995). Review of an extensive ferrous foundry silica sampling program. Applied Occ. Environ Hyg, 10:(331-340).

This is an extensive review of sampling data collected as part of the regulatory process. Attempts are made to classify exposures by groupings of jobs in what appears to be a "banding" approach. Useful insights into sampling practices and strategies with respect to what sampling technicians choose to sample and the choice of what jobs to repeat in the sampling process based on level of exposure detected. Technician may over-test on low-level findings and therefore dilute the entire TWA. Author also notes the importance of separating

certain jobs from a job grouping for separate sampling and measurement. In this case the high-level outliers in refractory maintenance would raise the TWA for the whole grouping.

Oudyk, John (1983). The role of metals in foundry occupational health and safety. (Unpublished graduate paper on occupational health and safety in the foundry industry)

The author notes "….it is evident that the biological interactions of the metals present in the foundry atmosphere have been overlooked in research in favour of the better studied effects of PAHs. Although the levels of metals in foundry environment do, in general, not exceed prescribed limits, in combination it appears they may cause significant effects related to their synergistic action and their direct interaction with cell DNA."

Oudiz J, Brown JW, Ayer HE et al (1983). Report on silica exposure levels in U.S. foundries, Amer Ind Hyg. Assoc J, 44:(374-376).

This article cites extreme silica exposures in the foundry industry in the US with levels between 10mg/m^3 and 100mg/m^3.

Peng S, Hong M, Shuhua X (2019). Urinary metal/metalloid levels in relation to hypertension among occupationally exposed workers. Chemosphere 234:64-647.

Occupational exposure to metals can have an adverse effect on the cardiovascular system. However, epidemiological studies of the associations of metals expose with hypertension among occupationally exposed workers were limited. The aim of this study was to investigate the potential association between urinary metal levels and the risk of hypertension among molybdenum miners and iron and steel foundry workers. The cross-sectional study had 395 participants. Urinary metal levels were determined by inductively coupled plasma mass spectrometry. Log-binomial regression model and two-piece-wise regression model were applied to assess the dose-response relationship between metal exposure and hypertension. We observed that increased prevalence ratios for hypertension among the quartile of urinary concentrations of molybdenum, arsenic and lead were positive (all P for trend <0.05). Compared with the lowest quartiles, participants in the highest quartiles of molybdenum, arsenic and lead had a 2.58-fold, 4.30-fold and 4.85-fold increased probability of having hypertension, respectively. In the threshold effect analyses, we found the relationship was nonlinear between urinary molybdenum, cobalt, cadmium, arsenic and lead concentrations and the prevalence of hypertension. In addition, Pb, Mo, As and Co may have joint effect, and a strong positive correlation with the prevalence of hypertension. Conversely, the association between the joint effect of Cd, Pb and Mo versus the prevalence of hypertension is not significant. We provide reference levels of molybdenum, cobalt, cadmium, arsenic and lead that can be used to assess the effects of occupational metal exposure on hypertension.

Poinen-Rughoopth S, Shumsher Rughoputh M, Guo Y, Rong Y, Chen W (2016). Occupational exposures to silica dust and risk of lung cancer: an updated meta-analysis of epidemiological studies. BMC Public Health 16:1137.

The risk of lung cancer found to be elevated in both silicotics and non-silicotics. The pooled SMR was 2.32 with 95% confidence interval of 1.91-2.81. A positive exposure response relation was found between cumulative silica exposure and risk of lung cancer.

Poreba R, Gad P, Poreba M, Antonowicz-Juchniewicz J, Andrzejak R (2011). Relation between occupational exposure to lead, cadmium, arsenic and concentration of cystatin C. Toxicology 283(2-3):88-95.

Lead, cadmium and arsenic represent well-recognized toxic agents, which in a specific manner disturb function of cardiovascular system. Cystatin C has been accepted to be a significant prognostic factor for cardiovascular diseases. The study aimed at defining relationship between occupational exposure to lead, cadmium and arsenic on one hand and concentration of cystatin C on the other. The studies were performed on 282 men occupationally exposed to lead, cadmium and arsenic. Among the tested individuals several groups of persons were distinguished: exposed exclusively to lead (Pb group), cadmium (Cd group), arsenic (As group), to lead *and cadmium (Pb/Cd group), to lead and arsenic (Pb/As group) or to cadmium and arsenic (Cd/As group). In all individuals' serum concentration of cystatin C was estimated. Concentration of cystatin C was found to be significantly higher in Pb group than in Cd and As groups, also in Pb/Cd group higher than in Cd group and in Pb/As group than in As group. Positive linear correlations were established between Pb concentration in blood (Pb-B) and serum concentration of cystatin C (r = 0.59; p < 0.05) as well as between urinary concentration of As (As-U) and serum concentration of cystatin C (r = 0.41; p < 0.05). Regression analysis demonstrated that higher blood level of lead, higher urinary level of arsenic, more advanced age and higher body mass index represented independent risk factors of an increased serum concentration of cystatin C in the group of persons exposed to lead, cadmium and arsenic. Conclusions: Higher blood level of lead and higher urinary level of arsenic represented independent risk factors of an increased serum concentration of cystatin C in the group of persons occupationally exposed to lead, cadmium and arsenic. Concentration of lead in blood was significantly influencing serum concentration of cystatin C. The highest mean serum concentration of cystatin C was detected in the group of foundry workers exposed simultaneously to lead and arsenic.*

Riaz MA, Tabinda A, Amtul B, Riaz A, Mujtaba G, Muhammad A, Beenish I (2017). Heavy metals identification and exposure at workplace environment its extent of accumulation in blood of iron and steel recycling foundry workers in Lahore, Pakistan. Pakistani Jour Pharmaceutical Science 30(4):1233-1238.

The determination of heavy metals in blood is an important occupational environmental toxicology screening procedure. The aim of study was to determine the concentrations of Pb, Cd, Cr and Ni in blood samples of iron and steel foundry workplace exposed workers under routine clinical laboratory conditions. The method was employed for the quantitative determination of lead, cadmium, chromium and nickel in workplace environment particulate matter blood samples from iron and steel foundry workers and in unexposed controls. The results indicate that lead, chromium and nickel levels of the exposed workers are significantly higher those of the controls. Nickel Concentration (µg/L) in high P value=0.0306 and Chromium Concentration (µg/L) in P value=0.0295in worker population as compared to controls. Lead showed highest Absorption concentration in serum from particulate matter to Serum 47.3(µg/L). Absorption concentration of nickel in serum 16.5(µg/L) was lower than lead observed in worker's population. Absorption concentration of cadmium and chromium in serum from particulate matter -152(µg/L) observed very low. The results also show the need for immediate improvements in workplace ventilation and industrial hygiene practices.

Rodriguez V, Taldon A, Kogeninas M, Prieto CS (2001) Lung cancer risk in iron and steel foundry workers: a nested case control study in Asturias, spain. Am Jour of Indus Med 38:644-650.

Workers ever employed in the blast furnace had an elevated cancer risk (OR 2.55, 95% CI 1.25-5.21) compared to the referent group of workers not employed in metal producing departments. A two-fold risk was found for workers in the main foundry. High risk found for subgroups employed in high silica, PAH and carcinogenic exposure departments.

Scott WD, James Rh, Bates CE (1976). Foundry air contaminants from green sand moulds. Am Ind Hyg Assoc J. 37(6):335-344.

Principal gases evolved during pouring and shakeout of castings include: hydrogen, carbon monoxide, carbon dioxide, methane and other low molecular weight hydrocarbons with smaller amounts of ammonia, hydrogen cyanide, and sulphur dioxide.

Sen S, Narayana J, Ravichandran B, Dhananjayan V (2019). Polyaromatic hydrocarbons deposition and their carcinogenic risk assessment in the foundry workers. Aerosol Science and Engineering 2:173-181.

Inhalation exposures to PAHs in foundry workers was explored, related to different workplace exposures including molding, melting, shaking, blasting, and finishing. Air samples were taken re: amount and type of PAHs inhaled. 16% of samples exceeded NIOSH standards with the highest found in moulding, followed by *finishing, blasting, shaking and melting with 95% of the risk due to benzo(a)pyrene and dibenzo. Researchers concluded that inhalation risk is not negligible and should be addressed for protection of workers to address quantitative aspects related to lung cancer in foundries. PAHs with lower molecular weight contributed to (55.02%) while those with higher molecular weights contributed 44.98%). The highest levels of PAHs was found in moulding (82.64 ug/m^3); followed by finishing (67.86 ug/m^3; blasting (34.74 ug/m^3; shaking (25.04 ug/3); and melting (23.48 ug/3). 95% of risk is contributed by benzo(a)pyrene and dibenzo (a)anthracene. Conclusion: PAHs inhalation risk is not negligible and presents a lung cancer risk to PAH compounds in foundries.*

Sherson D, sabro P, Sigsgaard T, Johansen F, Autrule A (1990). Biomonitoring of foundry workers exposures to PAHs. Brit J Ind. Med 47(7):448-453.

Additive effects: higher exposures associated with slightly higher concentrations in blood than with lower exposures. Possible additive effects with mixed quartz and B(a)P exposure connected to higher risk of lung cancer with mixed exposure.

Sherson D, Svane O, Lynge E (1990). Cancer incidence among foundry workers in Denmark. Archives of Envir Health: An International Journal https://doi.org/10.1080/00039896.1991.9937432.

Cancer incidence was studied among 6,144 male foundry workers who were invited to participate in either of two Danish national silicosis surveys conducted during 1967–1969 and 1972–1974. Cancer incidence was followed through to the end of 1985 by computerized linkage to the Danish Cancer Registry, and Standardized Morbidity Ratios (SMRs) were calculated based on incidence rates for the Danish population. For the entire cohort, significantly elevated SMRs were seen for all cancers (SMR, 1.09; 95% CI, 1.01–1.18) and lung cancer (SMR, 1.30; 95% CI, 1.12–1.51), and SMRs were at the borderline of statistical significance for bladder cancer (SMR, 1.24; 95% CI, 0.97–1.59). Excess lung and bladder cancer risk were confined to workers who had worked in foundries for at least 20 y. There was a positive correlation between silicosis prevalence in employees at the foundries at the time of the x-ray examinations and lung cancer incidence during the follow-up period. Squamous cell carcinomas, anaplastic carcinomas, and other lung cancers accounted for the excess lung cancer risk, whereas there was not excess risk among the foundry workers for adenocarcinomas of the lung.

Steenland K (2005). One agent, many diseases: exposure-response data and comparative risks of different outcomes following silica exposure. Am Jour of Indus Med 48(1):16-23.

Recent evidence indicates that silica causes lung cancer, silicosis, and probably renal disease. There is also growing evidence it can cause arthritis and other auto-immune diseases and therefore joins a handful of other toxic exposures such as tobacco smoke, dioxin and asbestos which cause multiple serious diseases. In a study of excess risk of the three diseases identified above the excess risks were: 1.7 for lung (0.2-3.6%), 1.9 for silicosis (0.8-2.9%) and 1.8 for renal disease (0.8-9.7%) with kidney disease emerging as perhaps a higher risk of mortality than either silicosis or lung cancer, although the data are based on fewer studies.

Tong R, Cheng M, Ma X, Yang Y, Liu Y, Li J (2019). Quantitative health risk assessment of inhalation exposure to automobile foundry dust. Environ Geochem Health https://doi.org/10.1007/s10653-019-00277-8.

With a growing awareness of environmental protection, the dust pollution caused by automobile foundry work has become a serious and urgent problem. This study aimed to explore contamination levels and health effects of automobile foundry dust. A total of 276 dust samples from six types of work in an automobile foundry factory were collected and analysed using the filter membrane method. Probabilistic risk assessment model was developed for evaluating the health risk of foundry dust on workers. The health risk, and its influencing factors among workers, was then assessed by applying the Monte Carlo method to identify the most significant parameters. Health damage assessment was conducted to translate health risk into disability-ad-

justed life year (DALY). The results revealed that the mean concentration of dust on six types of work ranged from 1.67 to 5.40 mg/m^3. The highest health risks to be come from melting, cast shakeout and finishing, followed by pouring, sand preparation, moulding and core-making. The probability of the risk exceeding 10−6 was approximately 85%, 90%, 90%, 75%, 70% and 45%, respectively. The sensitivity analysis indicated that average time, exposure duration, inhalation rate and dust concentration (C) made great contribution to dust health risk. Workers exposed to cast shakeout and finishing had the largest DALY of 48.64a. These results can further help managers to fully understand the dust risks on various types of work in the automobile foundry factories and provide scientific basis for the management and decision-making related to health damage assessment.

Tossavainen A (1976). Metal fumes in foundries. Scand J Work Environ Health 2(1):42-49.

Temporal variation of metal fume contaminant concentration was noted affected by characteristics of the melt process and the contaminant as well as time length of sample but also precision of dust sampling devices and metal analysis. Lead, copper and zinc identified as significant hazard to worker health during melting and casting operations. In 1976 recommendation to prevent worker exposures included, furnace enclosures, efficient local exhaust to remove fumes during pouring and casting, and attending to general ventilation of melt and casting areas.

Valavanidis A, Vlachogianni T, Fiotakis K, Loridas S (2013). Pulmonary oxidative stress, inflammation and cancer: respirable particulate matter, fibrous dusts and ozone as major causes of lug carcinogenesis through reactive oxygen species mechanisms. Int J Environ Res Public Health 10: 3886-3907.

Dusts and respirable particulate is linked to cancer via oxidative stress which is confirmed in T 9/11 studies of NY residents and first responders.

Westberg H, Hedbrant A, Person A et al (2019). Inflammatory and coagulatory markers and exposure to different size fractions of particle mass, number and surface area air concentrations in Swedish iron foundries, in particular respirable quartz, Intl Arch Occup Environ Health, 92:(1087-1098).

This study of 85 subjects from three Swedish foundries explored the relationship between exposures to air borne particulate and quartz and markers of inflammation and increased coagulation as indicators of an increased risk of cardiovascular disease. Markers included: interleukin, C-reactive protein, and serum amyloid ASAA as measured in plasma together with markers of coagulation including: fibrinogen, factor FVIII, von Willebrand and D-dimer.

Wong JYY, Bassig, BA, Seow WJ, et al (2017) Lung cancer risk in welders and foundry workers with history of heavy smoking in USA: National Lung screening trial, Occupational and Environmental Medicine; 74:(6)440-448.

Findings indicate further evidence that exposure to welding/metal fumes is associated with elevated lung cancer risk with smoking. Also found an elevated risk with either welding and foundry work, but did not reach significance. A joint effect found among those who were ever employed in both occupations. A higher risk was found even when they were mutually exclusive of each other.

Yeon SA, Jong UW, Park RM (2010) Cancer morbidity of foundry workers in Korea. J Korean Med Sci 23:1733-1741.

Increased lung cancer most plausibly explained as result of exposures to known carcinogens in foundry environment, primarily freshly cleaved crystalline silica from fettling (finishing) operations, carcinogenic metals from melting and fettling, and PAHs from pyrolysis products from hot moulds. Production workers at 10 or more years exhibited significant excess of stomach cancer, with exposures to asbestos, metal fluids and other oil mists. When compared to general (Korean) population Lung cancer was significantly higher for foundry

workers [SIR]=1.58, 95%C 1.11-1.87; stomach cancer in finishing [SRR]=2.10, 95%C 1.10-4.01; lung cancer in moulding [SRR]=3.06, 95%C 1.22-7.64; and lung cancer in finishing [SRR]=2.63, 95%C, 1.01=6.84.

Zarei F, Azari MR, Salehpour S, Khodakarim S, Omidi L, Tavakol E (2017). Respiratory effects of simultaneous exposure to respirable crystalline silica dust, formaldehyde, and triethylamine of a group of foundry workers. J Res Health Sci. (March 4) 17(1): e00371.

This case control study's purpose was to examine the effects of simultaneous exposure to complex mixtures of silica dust, formaldehyde and triethylamine on lung function parameters. Workers were monitored for personal exposure to crystalline silica respirable dust using NIOSH method No.7602. The mean concentrations of personal exposure to silica dust, formaldehyde and triethylamine in core making workers were 0.23 mg/m^3, 2.85 ppm, and 5.55 pm and respective exposures of control subjects were less than the LOD (limit of detection). There were significant associations between exposure to silica dust and decreases in FVC (forced vital capacity) values ($p<0.05$. The findings showed a statistically significant synergistic effect of silica dust and triethylamine on FVC vales ($p<0.05$). In conclusion, the mean exposure of all studies substances was higher than occupational exposure limits. Synergistic effects of exposure to silica dust and triethylamine on some lung function parameters were observed. Simultaneous exposure of foundry workers to silica dust and triethylamine can impair lung function.

Zhang Min et al (2000). Mortality analysis of foundry workers (Center for Diseases Control, Dongfeng Motor Col, Shiyan 442000 China). Https://en.cnki.com.cn/article_en/GJFDTotal-GYWZ200003010.htm.

A retrospective cohort study and PYLL analysis were conducted to evaluate the death cause of foundry workers. The results showed that the highest relative risk occurred in shakeout and finishing workers, RR=2 50(P0 01). The RRs of pouring, moulding and sand preparation were also statistically significant, RRs=2 21(P0 01), 213(P0 01) and 185(P0 05), respectively. The mortality rate of foundry workers was significantly higher than controls and increased with the increase of working age. When all death causes were analysed, there was significant increase of death risk from heart disease including hypertension and cerebrovascular diseases, the RRs of working-age 20 years, ranged from 15 to 20 was 5 96(P0 01) respectively. PYLL analysis results showed that the first early death cause among foundry workers was malignant tumour (729 5) followed by accidents (654 5), heart disease (271), and injuries (172).

Zhang, Z, Zhou M, He J, Shi T, Zhang S, Tang, N, Chen W (2020). Polychlorlnated dibenzo-dioxin and polychlorinated dibenzo-furans exposure and altered lung junction; the mediating role of oxidative stress, Environmental International `37: 105521.

The authors explore the mediating role of oxidative stress in exposures to PCDD/Fs and their impact on lung function utilizing a case control study of 201 foundry workers and 222 controls. Lung function was measured and levels of PCDD/Fe were determined, and serum levels were measured for a sub-group to reflect body burdens. Results showed that lung function FVC and FEV declined significantly with increased levels of PCDD/Fe among foundry workers mediated through a mechanism partly involving oxidatively generated damage to the DNA. This also has a bearing on the role of oxidative stress in the production of disease in the foundry.

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