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GENERAL SESSIONS

NATIONAL SAFETY COUNCIL
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2. The explosions described, resulting from contact between molten aluminum and copper oxide, and molten aluminum with the oxides of bismuth and lead, confirm the above statement. The attached "Table of Free Energy of Formation" for various metallic oxides should serve as a guide to possible similar reactions between other materials. We do not imply that all of the materials listed in this table will react nor that they are the only ones which can contribute to such a reaction. The table is included here as a guide to possible reactions.

3. Preventive measures to eliminate contacts between materials in this table are practical and easily performed by operating personnel. As listed earlier, these measures consist essentially of preventing any contact between oxides and pure metals which may react with such oxides.

It is hoped that this information will prove to be of value in preventing explosions and resultant injury to personnel and damage to equipment in non-ferrous metal melting operations.

Table of Metallic Oxides Listed in Decreasing Order of Free Energy of Formation

Beryllium Oxide	BeO
Magnesium Oxide	MgO
Aluminum Oxide	Al_2O_3
Zirconium Oxide	ZrO_2
Titanium Dioxide	TiO_2
Silicon Dioxide	SiO_2
Boric Oxide	B_2O_3
Sodium Oxide	Na_2O
Manganese Oxide	MnO
Zinc Oxide	ZnO
Stannic Oxide (Tin)	SnO_2
Stannous Oxide (Tin)	SnO
Ferric Oxide (Iron)	Fe_2O_3
Ferrous Oxide (Iron)	FeO
Water	H_2O (Liquid)
Manganese Dioxide	MnO_2
Lead Oxide	PbO (Red)
Lead Oxide	PbO (Yellow)
Bismuth Oxide	Bi_2O_3
Cuprous Oxide	Cu_2O
Cupric Oxide	CuO
Lead Dioxide	PbO_2
Nickel Oxide	NiO_2

HEALTH HAZARDS IN THE FOUNDRY A BIRD'S-EYE VIEW OF WHAT TO DO

By LYNN D. WILSON, PH. D.
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For many years, foundry operations of all types have been held in low regard by both the foundry worker and the general public as being dark, smoky, smelly, dusty sources of ill health. In the not-too-distant past this impression was without question well-founded, but under the enlightenment of expanding research such impressions need no longer be entertained.

The purpose of this discussion then will be to consider the various types of health hazards and their effects and then to examine and select the most promising of remedial measures. The time and space alloted for this discussion will not allow exhaustive treatment but it is hoped that comment herein will be sufficiently thought-provoking that new and perhaps more simple remedial measures may be devised.

The human organism is daily exposed to any number of stimuli which vary both in exposure intensity and the severity of their effects. Quite broadly these may be grouped into physical and systemic stimuli. Among the physical stimuli are glare, heat, noise, and skin irritation while the systemic stimuli include the whole gamut of the chemicals of industry together with their decomposition products. This classification is admittedly not acutely restrictive but has been chosen to facilitate discussion despite some overlapping of concepts.

Considering the several physical stimuli in turn, attention is first invited to the incidence of excessive glare or light in the foundry. These are so obvious as to require only their mention—namely, welding, cutting, air-arcing and furnace melting operations.

Incandescent metals radiate ultra-violet light, results in conjunctivitis, corneal ulcers or iritis.

Protective requirements are (1) to the operator in direct exposure, and (2) to the passerby in flash exposure. To the operator, goggles and face shields are mandatory with the density of the optical protection dependent on the operation. Shaded lenses with shade gradients from 1 to 14 are standard and are readily selected from manufacturers' recommendations. Full face protection in the form of an opaque mask is virtually mandatory as protection against sparks and so-called "sun-burn."

Of equal importance, but often insufficiently stressed is the exposure received by workers in surrounding areas. Only too frequently the protection afforded by curtains or walls is inadequate, either by original deficiency in planning or through tears, rips, rents and other damage incurred in use. Often because of faulty design, welding booths are poorly ventilated, resulting in protective curtains being drawn aside to allow increase in air flow with resultant glare exposure to employees in the area. It is evident then that protection against glare is not a subject which can be treated lightly.

Location of operations involving glare must be chosen with care and supplementary protection well-planned. Restrictions against entry in glare areas by unprotected persons must be prominently posted and area foremen must be provided with authority to enforce such restrictions.

The question of excessive heat associated with open hearth furnace, annealing oven and core oven operation and the floor-cooling of stripped castings is one that has existed since founding operations were devised. Beyond random and haphazard provision of added local air movements, little really constructive work has been done to alleviate the nuisance and discomfort of excessive heat and reduce accompanying decreases in worker production capacity.

The most serious aspect of excessive heat is the increase in accident proneness, though heat prostration through loss of water and salt is not to be minimized. The hazard of heat prostration is readily controlled through the use of salt tablets preferably of the *enteric-coated* type.

Decreasing the nuisance to the individual and increasing his comfort involves, as a minimum, the movement of sufficient air volume to provide cooling but it must be remembered that unless the supplied air is humidified, air movements in excess of 500 feet per minute will be required to reduce average foundry temperatures more than a degree or so. Air velocities of this magnitude present added safety and hygiene hazards in that blowing dust endangers the eyes and maintains fine particles in suspension for continuous inhalation.

Actually, significant reduction of excessive heat levels involves isolation and shielding of the heat sources, but this is largely possible only in new construction. The glass industry has made marvelous strides in this direction and while the problems there are not directly comparable to those in the foundry the principles can be applied in new or revised installations.

In recent years serious attention has been focused on hearing losses engendered in industrial operations. There are a number of factors concerned in this problem, namely, what constitutes a hearing loss?, how may an industrially caused hearing impairment be differentiated from that resulting from normal physiological deterioration?, what noise levels can be regarded as excessive?, what sound frequency ranges are concerned?, what are the legal liabilities?, etc.

Only a few answers are now available for all these and many other questions associated with hearing loss. As a first requirement, instrumentation is now available for measuring noise levels of both the continuous and impact types; hence arguments as to noise intensity and range distribution need no longer occur.

With reference to maximum allowable noise levels, the value of 95 decibels has been quite firmly established as the upper limit above which hearing acuity is likely to be affected. Some clarification of legal aspects is now emerging as evident in the fact that several states now require a waiting period of six months before suits for hearing loss compensation may be filed before industrial commissions.

Finally, knowledge of physical techniques leading to reduction in noise generation is rapidly increasing.

In view of the potentially very serious financial losses which might be expected in hearing loss litigation, management is advised to examine noise sources and consider

means of reduction of current noise levels. Since most methods of noise reduction still require experimental approaches, it is possible that considerable expense may be involved, but this would be only a drop in the bucket if a rage of compensation suits should be filed.

Skin irritation, or dermatitis, and back injuries are the two most costly industrial disabilities so far as compensation payments are concerned. The causes of skin irritations may be almost as numerous as the very items with which a person comes in daily contact and hence a sure preventative is not known, nor can it be devised. The problem is further complicated by the phenomenon of sensitization wherein dermal irritation does not result from a single exposure but does erupt on a second exposure.

Long observation of industrial dermatitis has revealed, however that there are two factors in the causation of irritation which can be controlled. These are (1) personal cleanliness, and (2) improper use of industrial solvents. There are unbelievably large numbers of people whose personal cleanliness leaves much to be desired, with the result that just plain dirt serves as the focus of irritation and infection and, accordingly, a true industrial dermatitis is not present.

Records of the foundry medical department and close observation by the nurse and foreman frequently serve to spot such offenders, after which the solution to the difficulty becomes one of company policy as to education in and enforcement of personal sanitation.

The availability of industrial solvents used as degreasing agents has resulted in a readily identifiable cause of dermatitis. These degreasing agents such as carbon tetrachloride, trichloroethylene, methyl chloroform, etc., are all too frequently used for the removal of dirt and grease from the hands, forearms, and even the necks and faces of workers. Natural oils in the skin are thus removed leaving the skin dry, cracked and scaly and allowing easy secondary infection.

It is evident, therefore, that strict prohibition against such improper use of solvents must be posted and enforced. To aid in such enforcement management should provide barrier creams which protect against inadvertent penetration of solvents. These creams and protective gloves should also be provided for other known sources of dermatitis. Details of issuing such protection and enforcing their use are the problems of each foundry, but frequently are best handled through the safety and medical departments.

The systemic stimuli are those which actually enter the human organism and result in acute or chronic disabilities. It is important to realize that an acute disability may appear to be transitory, but that delayed chronic effects are possible, and similarly that chronic exposures may have no obvious manifestations until incurable disability appears, sometimes after many years.

Toxis stimuli enter the human organism by inhalation, ingestion or skin absorption. To a lesser degree entry may occur through cuts and abrasions in the skin but this is not common and can usually be precluded by protective bandaging or barrier creams. Absorption through the intact skin has not usually been considered as an important mode of entry, except for a few specific chemicals, but there is increasing evidence that the chlorinated solvents do permeate the skin and are then distributed throughout the body by the blood stream.

Entry by ingestion is likewise uncommon but does occur where vapors or gases invade lunch boxes and saturate foodstuffs, or where a drinking glass has been incorrectly used as a dipper for some material other than water, or in the case of fingernail chewers.

This latter instance of inadvertant ingestion is more common than would normally be suspected, especially in the case of women.

In the light of this brief review then, it is evident that inhalation remains as the prime port of entry of toxic materials.

Because of continuous changes in manufacturing processes, there can be no invariant list of toxic substances present in foundry practice. There are a number of standard practices however which are productive of toxic materials. Among them is carbon monoxide, which is a common product of incomplete combustion. The gas is highly toxic, being fatal in concentrations above 0.4 per cent for exposures of less than one hour. Its maximum acceptable concentration for the 8-hour working day is 0.01 per cent.

As far as is known there are no chronic effects from acute sub-lethal exposures or from chronic low exposures. In cases of acute exposure, removal to fresh air and administration of oxygen or oxygen containing 5 per cent to 7 per cent carbon dioxide is standard first-aid practice.

Carbon monoxide has been found being released from improperly ventilated core ovens through decomposition of core binders and very infrequently at improperly adjusted gas burners at annealing furnaces. More commonly it has been found inside large castings which are being heated with smoky gas flames to prevent overcooling.

One instance is quite remarkable in that its origin was quite obscure. The shot-blast operator working inside a total enclosure complained of headache, nausea, dullness, etc., but obvious investigation failed to reveal the cause.

Finally, a sample of air from the compressor furnishing air to his supplied-air hood was checked for carbon monoxide, a level of some 160 ppm being found. It immediately appeared that compressor oil was somehow being subjected to excessive heat and partial decomposition through friction so the unit was subjected to complete overhaul. On replacement of worn parts the generation of CO was stopped.

In general, prevention of carbon monoxide exposure involves the realization that any condition of incomplete combustion is a sure source of CO. Where complete combustion is not possible, exhaust ventilation or at least copious air movements for dilution must be supplied.

Carbon dioxide is not normally a hazard in the foundry, except perhaps in the interiors of ovens. Its role as a toxic agent is that of a contributor of oxygen deficiency, but except for instances where oxygen has been to reduced to below 16.5 per cent from its normal value of 21 per cent in air, fears of its lethal aspects need not be lield. The remedy in all cases is introduction of fresh air.

Exposure to industrial solvents in foundry areas proper is not frequent except for machine shop and maintenance areas. Here the chlorinated solvents such as carbon tetrachloride, trichloroethylene and methyl chloroform are met on occasion, but exposures are usually well-controlled in industrial degreasing. When open pan or spraying degreasing is practiced, such as in the cleaning of electric motors, operations should be conducted within a ventilated hood or booth. Within the foundry, at grinding operations, chlorinated solvents are occasionally used in wiping off dye markings from grinding areas or cracks. Only closed containers of solvent should be used and wiping cloths should be located downwind between wipings.

In the past few years certain buyers have required that finished castings be sprayed with special plastic paints to prevent corrosion in transit. Some of these paints contain ketone solvents such as methyl ethyl ketone which are slightly toxic but, more importantly, are fire and explosion hazards. Spraying with these types of coatings should be conducted in standard explosion-proof well-exhausted hoods. In all cases the paint manufacturer should be requested to supply toxicity and safety data before routine use is established.

Of more importance is the subject of the toxic by-products generated in welding and cutting operations. It has been shown that oxides of nitrogen and free ozone are produced, and in special cases, zinc and cadmium fume are released from the base metals, together with fluorides from coated electrodes.

The oxides of nitrogen present bronchial hazards and may dispose toward pneumonia. Ozone, a highly reactive form of oxygen, is a serious pulmonary irritant and in excessive concentration accelerates the pulse, produces stupefaction and creates continuous general body pain. The maximum acceptable concentrations are 5 ppm and 0.1 ppm respectively.

Zinc fume produces the familiar metal fume fever which is largely transitory, but cadmium poisoning is more permanent and severe, involving both abdominal and pulmonary effects, together with some deposition in the skeleton, from which it may be released and offer continuation of symptoms. The relative severity of the two exposures is indicated by their maximum acceptable concentrations of 15mg/cu. meter and 0.1 ppm respectively.

The use of fluoride-coated electrodes has offered controversial findings, but certain respiratory irritations ensue and some mottling of the teeth occurs. Inhibition of cer-

tain digestive ferments has also been reported.

Finally, while not a true toxic hazard, the matter of evolution of iron oxide fume must be considered. The fume itself is benign, but its inhalation produces an x-ray lung pattern virtually indistinguishable from that of silicosis, and it is evident therefore that unwarranted compensation suits for silicosis might be experienced.

With reference to protection against welding and cutting by-products it seems safe to say that in wide open foundry areas allowing 10,000 cu. ft. of air per welder, dilution and general ventilation should be adequate to prevent inhalation of these toxic materials. However, in confined areas where it would be possible for these fumes to enter the breathing zone under the welding hood, local exhaust must be provided.

The most serious toxic hazard encountered in the foundry is free silica from the sand used in core and molding operations. Inhalation of free silica dusts results in the disease known as silicosis. It occurs only after long-continued exposure (5-20 years) and is characterized by an x-ray lung pattern revealing uniform bilateral fibrotic nodulation, the nodules ranging from 3 to 5 mm in diameter, the size being proportional to the extent of the disease.

Symptoms include shortness of breath on exertion, decreased chest expansion, a dry-non-productive cough, chest pain and, as the disease progresses, increased inability to perform normal work functions.

There are four factors which are concerned with its contraction and progression. These are

1. Particle size of the dust being inhaled.
2. Concentration of the dust being inhaled.
3. Amount of free silica in the dust.
4. Duration of exposure.

The concentration of the dust being inhaled and the amount of free silica in that dust are inter-related. A long-established bench mark based on extended research stated that if the product of the free silica content of the dust and the number of particles in cu. ft. less than 10 microns in size exceeded the figure 5 million, the exposure could be regarded as conducive to the contraction of silicosis. This restriction has been somewhat relaxed in recent years such that maximum acceptable levels now fall in silica concentration ranges as follows:

Maximum Allowable Concentrations of Free Silica

Percent	*mppcf*
High—above 50%	5
Medium—5%—50%	20
Low—below 5%	50

On the basis of broad studies in various foundries, it has been found that the free silica content of settled dusts in general foundry areas is of the order of 30 to 50 per cent; hence the maximum allowable concentration of respirable dust should be 20,000,000 particles per cubic foot (mppcf).

Most foundry areas are quite liberally covered with sand dust, but certain of them are more productive of conditions conducive to concentration of silicosis than others. In general, core rooms show a relatively low dust count, since core sand is usually moistened with binders. However, spilled sand which is allowed to dry on the floor is constantly being dispersed into breathing zones and represents a serious hazard.

Similarly, dispersals from roll-over machines, jolting machines and core blowers present appreciable hazard because of accelerated drying. The same considerations apply to molding operations.

In molding however a more serious operation is current in many operations, namely, the use of silica washes where finely divided aqueous silica suspensions are sprayed over mold surfaces. Even though the particles are moist, they are so finely divided that evaporation of moisture is very rapid leaving the dry dust air-borne.

The greatest source of surge loading of the working atmosphere is, of course, the shake-out where dust counts as high 70—100 million have been found. In all fairness it can be said on the basis of studies covering "before—during—after" measurements that within 10 to 30 minutes after completion of shake-out of a series of flasks, dust counts subside to reasonably satisfactory levels, but where shake-out operations are relatively continuous, no such reduction can be obtained.

At least as serious a source of dust as the shake-out is the sand-handling system, especially that portion in the pit below a shake-out and the belt system conveying hot sand to the recovery system.

Finally, the third great source of dust dispersal lies in the gross dust accumulated over general floor areas, in that it can be constantly dispersed into the atmosphere by traffic in the form of men, trucks, chains, dragging flasks, etc.

A minor but still real source of air-borne dust arises through the use of compressed air to blow off molds, cores, core plates, dies and floor areas.

In alleviation of both gross and specific dusts there are certain measures which can be adopted. First and foremost is the matter of promoting superior housekeeping. This embodies constant policing of floor areas for removal of dust piles, wetting of floor areas such as flogging floors, stripping floors, knock-out areas and sand-handling areas where large spillages occur. Large piles of used sand awaiting reclaim should not receive floor storage but rather should be located in surge boxes or tanks connected to sand systems by conveyors.

Included in the concept of good housekeeping should be prohibitions against the indiscriminate use of compressed air in blowing of dusty surfaces. Such action does nothing more than promote dust dispersal and cause fine particles of respirable size to remain air-borne almost continuously. Another prohibition concerns the un-intelligent use of man-coolers which, while of apparent comforting effect on specific employees, actually present a continuing health hazard to all in the environment.

By way of individual protection against dust excesses, it would at first appear that the basic remedial measure would involve the use of respirators. By adopting a respirator policy, tacit admission of the existence of unhealthful dust conditions is automatically elicited. Furthermore, enforcement of the wearing of respirators is practically impossible, since they are cumbersome, irritating, and inconvenient. Actually, respirators should be worn only where other more satisfactory means of elimination of hazard are not feasible.

Acknowledging that respirator protection, both in general and particular, is but a feeble attempt at fostering employee welfare, it appears that general reduction of exposures is in order. Such reduction is normally accomplished by so-called "dilution" ventilation, whereby gross contamination is brought below toxic limits by dilution of excessive levels of contaminant by general natural ventilation or through forced drafts from roof ventilators.

This technique is admirably suited to reduction of toxic exposures in the cases of gaseous or vaporous contaminants, such as may arise in paint spraying or degreasing. The procedure is not generally applicable in the case of particulate matter, such as foundry dusts, for the reason that vast masses of source contaminants are usually available for dispersal—floor dusts, sand piles, shake-out residues are examples. Furthermore any deposited dusts, especially fines, are readily re-dispersed by such dilution ventilation.

Realizing then that neither respirator protection nor dilution ventilation are the sine qua non of foundry hygiene, it would seem that removal of contaminant at the source should be the most logical procedure.

That this is true in general is acknowledged but not without the benefit of further thought. Local exhaust of either fixed or flexible character certainly would serve to remove localized sources of contamination, but at an economic disadvantage since, for each unit of contaminant removed, many times that mass or volume would be conducted into the working area from adjacent areas.

However, if the local source were to be segregated and especially supplied with its own "make-up" air, the problem of removal would be restricted to the locale without disturbance of adjacent general areas.

The combination then of local exhaust under segregated conditions with adequate supply of make-up replacement air is very definitely the best answer to the total problem.

Objections that materials handling considerations would offer interferences are of little significance since ready solutions to such problems are available. Thus for instance, crane handling of castings could be proposed as a major deterrent to segregation, but if it is realized that segregation could be accomplished in individual bays with stock being introduced therein from short transfer tracks or roller conveyors from the main aisle where cranes usually operate, no real problem exists.

In like manner, the suggestion that welders work up-wind can be facilitated by posi-

tioning work pieces on turntables backed by wall ventilators with operator thus constantly on the up-wind side.

In summary it is felt that real reduction in employee exposures can be made by adoption of the principles of segregation combined with local exhaust and adequate make-up air to prevent cascading of contaminants into breathing zones. It would be possible to consider other specific means of alleviation such as the use of wet water in particular instances but such techniques border on ultra-refinements which are not generally applicable.

A LOOK AT THE FUTURE

By HOWARD M. WINTERSON
Vice President—Industrial Relations, Blaw-Knox Company, Pittsburgh, Pa.

My assignment here is to pilot us on a journey to safety's tomorrow. But I feel it will be more useful if first we pause for a look at safety's past and check our preparations for that trip to the future.

Among the first things to be noted in this look at the past is that a good million lives have been saved by the national safety movement during the 45 years it has been an organized force in this country. Think of it—1,000,000 people saved from premature, so-called accidental, death.

(Actually the National Safety Council claims the saving of only 750,000* people. This is based on reductions from the 1900-1913 accident rates. This makes no allowance for improvements in categories for which there was no basis of comparison in the early years of the century. A reasonable estimate is at least 1,000,000—and the figure could approach 1,500,000.)

So, visualize with me for a moment this most rewarding aspect of the past accomplishments of the safety movement. Picture a vanguard of at least 1,000,000 people fulfilling their natural destiny, given additional life and opportunity through the prevention of accidents. Many in this vanguard are alive today. They don't know they were saved, but they were. Perhaps some of those saved are in this room, or among our families.

That's a gratifying picture of U. S. safety performance. That vast deed of life-saving was, in part, your deed—the results of the efforts of all who contributed to, invested in, and supported the safety movement.

There are many other evidences of progress in the safety movement. But there is no point in my detailing this progress, for you know it better than I. It is sufficient to say that many people live who would have died, that millions have escaped injury, and that accident frequency has been reduced generally throughout industry, sometimes by as much as 90 per cent, because of the achievements in your profession.

And yet, the same data shows the tremendous challenge which still faces us: in the 44 years from 1914 through 1957, a total of 4,048,044 people actually died in the United States because of safety failures.

That's one highlight from the story of safety's past: 1 million saved, 4 million killed—for every life-saving success, four tragic failures!

Another highlight from the story of safety is that on the basis of 1957 accident records, we were performing at the lifetime rate of . . .

1 person out of every 26 in our population being killed; 1 person out of every 7 being permanently disabled; and all the individuals in the U. S. being temporarily disabled by accidental causes an average of four times.

Will this slaughter and crippling of human beings continue? What is the future of safety?

It would be easy to try some forecasting. It would be easy to extend some trend lines and tell ourselves that we have a projective mirror of safety's tomorrow. It would also be in style, for this is an age of crystal ball gazing, a time when the tendency in human

*Accident Facts, 1958 Edition.

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