SMOKING AND TLVS®

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ABSTRACT

Today, many employers prohibit smoking in the workplace. However, smokers can step outside the workplace for a quick cigarette. The question is whether or not this is a problem, particularly for workplaces that use many different chemicals. This question is different from the usual concerns regarding the direct adverse effects of smoking. The chemicals in cigarette smoke can combine with workplace chemicals to create unexpected results such as the following:

- Additive effects
- Synergistic effects
- Transportation of workplace chemicals into the body
- Transformation of workplace chemicals to more toxic materials
- Transformation of workplace chemicals to more easily absorbed materials
- Decreased mucociliary clearance of other toxic materials
- Tumour promotion
- Increased epithelial permeability

Each of these can increase the effective toxicity of workplace chemicals, or create new unexpected toxic metabolites. Even when smoking is prohibited in the workplace, some of these effects can still occur. It would appear that even living with a smoker (sidestream or secondhand smoke) can alter the effective toxicity of some workplace chemicals. The simple prohibition of smoking in the workplace may not prevent adverse health effects from cigarettes. The lesson learned from this is that the profession of industrial hygiene is more than the clerical function of comparing sample data to TLVs. It is essential to understand the basis of the individual TLV, the workplace, and the workers to draw correct conclusions in order to protect workers.

1.0 BACKGROUND

In the Threshold Limit Values® booklet the Introduction to the Chemical Substances states that "the TLVs are guidelines to be used by professional industrial hygienists".[(1)] The emphasis should be placed on "guidelines", these are not absolute lines between acceptable and unacceptable exposure levels. The TLVs are based on a normal healthy workforce working in normal workplace conditions during a standard shift. Any variation from this must be taken into account when evaluating the risk that a unique workplace presents to an individual worker.

One of the factors that must be taken into account is the behavior of individual workers including whether or not they smoke. Ignoring these factors and only comparing sampling data with the TLVs in a simple clerical fashion could result in unexplained illnesses in the workplace. It is the job of the occupational hygienist to recognize when these standard conditions are not met, and to interpret the exposure limits in light of the current reality. In this case, the current reality is the introduction of the many chemicals and risks associated with cigarette smoke.

Smoking is the inhalation of tobacco smoke. In its own right, smoking is the source of many major health hazards such as:[2, 3]

- Lung cancer
- Lung disease
- Heart attack
- Heart disease
- Hypertension
- Stroke
- Oral cancer
- Bladder cancer
- Pancreatic cancer
- Cervical cancer
- Pregnancy complications
- Low birth weight babies
- Early menopause
- Lower estrogen level for women
- Facial wrinkles

In this case we will look at the potential interaction of smoking and workplace chemical exposures. Smoking is still a concern in the workplace although in 13 out of 34 OECD (Organization for Economic Co-operation and Development) countries less than 20% of adults smoked in 2009.

1.1 What is in Cigarette Smoke?

Cigarette smoke contains many chemicals. It has been estimated that there are over 4000 chemical compounds in cigarette smoke. Many of the materials are toxic, and some are known carcinogens. The following table is a list of some of the classes of chemicals found in cigarette smoke.

It should be noted that the chemical composition of tobacco smoke is influenced by the specific manner in which individuals smoke but is mainly determined by the type of tobacco. The chemical composition is also influenced by the design of the smoking device or product and by the presence or absence of filters on cigarettes; and by other factors including ventilation, paper porosity and types of additives mixed in with the tobacco. In addition to this variability, the dose will also vary with the amount that an individual smokes.

TABLE 1: A list of different classes of chemicals in cigarette smoke.

Classes of chemicals in cigarette smoke
Aldehydes
Nitrosamines
PAHs
Dioxins
Gases
Furans
Metals

An additional factor is that cigarette smoke is divided into two types, mainstream smoke (MS) (smoke drawn through the tobacco into the smoker's mouth) and sidestream smoke (SS) (smoke generated by smouldering tobacco between puffs). The peak temperature in the burning cone of a cigarette can reach 800–900^{o}C when generating mainstream smoke, and decreases to 600^{o}C when producing sidestream smoke. This difference in temperature results in a change in combustion conditions and thus different mixtures of combustion products.[1, 3, 4] Table 2 shows the ratio of the concentrations of materials in sidestream smoke to mainstream smoke. This gives some indication of the range of chemical concentrations found in cigarette smoke.

These factors introduce a significant uncertainty into an individual's chemical dose, and professional judgement is needed to interpret cigarette dose and its interaction with workplace chemical exposures. These factors must be taken into account where exposure assessments alone cannot account for reported concerns or illnesses in the workplace.

In this paper we are primarily addressing mainstream smoke as this is more predictable and in most cases has the highest potential dose. However sidestream smoke and second hand smoke is still a problem, and other sources such as a spouse[3, 5] must be kept in mind.

As with many of the external influences on workplace exposures, there is not a lot of data on the combined effects of smoking and workplace exposures. To estimate the effects of smoking on workplace exposures, we must go back to principles.

TABLE 2: Relative chemical concentrations and variability of sidestream smoke and mainstream smoke.

Compound	Ratio of SS/MS
2-Naphthylamine	39
3-Vinylpyridine	24 - 34
4-Aminobiphenyl	31
Benz(a)anthracene	41001
Benzene	8 - 10
Benzo(a)pyrene	2.5 - 20
Cadmium	7.2
Carbon monoxide	2.5 - 14.9
Carbonyl sulfide	0.03 - 0.13
Catechol	0.67 - 12.8
Formaldehyde	50
Hydrazine	3
Hydrogen cyanide	0.06 - 0.4
N'-nitrosonornicotine	0.5 - 5.0
Nickel	13 - 30
Nicotine	1.3 - 21
Nitrogen oxides	3.7 - 12.8
N-nitrosodiethanolamine	1.2
N-nitrosodimethylamine	20 - 130
N-nitrosopyrrolidine	6 - 120
o-Toluidine	18.7
Phenol	1.3 - 3.0
Polonium-210	1.06 - 3.7
Quinoline	8 - 11
Tar	1.1 - 15.7

2.0 THE INTERACTIONS BETWEEN CIGARETTE SMOKE AND WORKPLACE CHEMICALS

As with many of the external influences on workplace exposures, there isn't a lot of data on the combined effects of smoking and workplace exposures. To estimate the effects of smoking on workplace exposures, we must go back to principles. The starting place is the TLV Documentation®. TLVs which are based on animal studies are not likely to include exposure to smoke as part of the test. However, TLVs based on industrial exposures are more likely to have included smokers. If the exposure data was taken from a typical workplace, smokers would likely be included in the sample population. Table 3 is a list of chemicals with TLVs based on industrial exposures. In each case the Documentation should be reviewed to determine if the exposed population is comparable with your workplace conditions.

TABLE 3: Chemicals with TLVs based on industrial exposures.

Materials With TLVs Based on Industrial Experience		
Acetic Acid	Furfural	Phosphorus
Allyl Glycidyl Ether	Grain Dust	Portland Cement
Allyl Propyl Disulfide	Graphite	Quinone
Ammonium Chloride Fume	Hydrogen Sulfide	Resorcinol
Antimony Trioxide Production	Hydroquinone	Rosin Core Solder Pyrolysis Products
Arsine	Iron Oxide	Rouge
Asbestos	Isophorone	Silica, Amorphous - Diatomaceous Earth
Asphalt Fumes	Isophorone Diisocyanate	Silica, Amorphous - Fume
Barium & Soluble Compounds	Kaolin	Silica, Crystalline - Cristobalite
Barium Sulfate	Magnesite	Silica, Crystalline - Quartz
Benzene	Manganese, Elemental & Inorganic Compounds	Silicon Carbide
Benzoyl Peroxide	Mercury (Alkyl Compounds)	Soapstone
Beryllium & compounds	Mercury (Aryl Compounds)	Sodium Hydroxide
Borates, Tetra, Sodium Salts	Methane	Sodium Metabisulfite
n-Butanol	Methylacrylonitrile	Starch
tert-Butyl Chromate	Methyl Bromide	Subtilisins
n-Butyl Lactate	Methyl 2-Cyanoacrylate	Sucrose
Calcium Hydroxide	Methyl Isobutyl Ketone	Synthetic Vitreous Fibers
Calcium Oxide	Methyl Methacrylate	Talc (no asbestos)
Calcium Sulfate	Methyl Silicate	Tellurium and Compounds
Camphor	Mica	Tetramethyl Succinonitrile
Caprolactam (dust)	Mineral or Rock Wool	Tetryl
Captafol	Molybdenum and Compounds	Tin
Carbon Black	*B*-Naphthylamine	Toluene-2,4-Diisocyanate
Carbon Disulfide	Neon	Trimethyl Benzene Isomers
Chlorine	Nickel (elemental metals)	Trimethyl Phosphite
Chromite Ore Processing	Nickel (soluble compounds)	2,4,6-Trinitrotoluene

Materials With TLVs Based on Industrial Experience		
Chromium Metal	Nickel (insoluble compounds)	Triphenyl Phosphate
Chromium III	Nickel Carbonyl	Uranium
Water Soluble Chromium VI	Nickel Sulfide Roasting	Vinyl Acetate
Water Insoluble Chromium VI	Oil Mist, Mineral	Vinyl Chloride
Coal Dust	Osmium Tetroxide	Vinylidene Chloride
Copper	Oxalic Acid	Wood Dust (Soft Wood)
Cotton Dust (Raw)	Parathion	Wood Dust (Hard Wood)
Dibutyl Phosphate	Perlite	Zinc Chromates
Diisopropylamine	Phenothiazine	Zinc Oxide (fume)
Fluorides	Phosphine	Zinc Oxide (dust)
Fluorine	Phosphoric Acid	

2.1 Additive Effects

As seen in Table 1, there are many chemicals found in cigarette smoke that are also found in the workplace. In addition to the similar chemicals, there are also similar health effects such as respiratory irritation. This means that in addition to the health effects of similar workplace chemicals adding their effects, any workplace chemical such as an organic solvent that is a respiratory irritant will also add their effects to those of cigarette smoke. Other examples of cigarette smoke and additive effects mentioned in the literature include chlorine, cotton dust, coal dust, and beta radiation. Other chemicals that have additive effects include exposures to occupational bladder carcinogens such as 2-naphthylamine, 4-aminobiphenyl, and ortho-toluidine.[3, 5]

There is also a concern that there is an additive effect between cigarette smoke and workplace factors that affect the cardiovascular system such as chronic job strain, lead, carbon monoxide, and carbon disulfide. Chronic job strain has been shown to increase ambulatory blood pressure and hypertension. These are similar symptoms caused by smoking.

Table 4 shows the concentration of specific chemicals found in cigarette smoke. [2, 6, 7, 8, 9, 10] Beside each concentration, the TLV is given for each chemical. Where the value is preceded by a "C" the value is a ceiling limit. The Dose at TLV represents the concentration in mg/8 hour workday a worker would receive at the TLV or in the case of a ceiling value in a 15 minute period.

In calculating the dose it is assumed that the worker is breathing the standard amount of air per day (10 m^3), with the assumption that 100% of the inhaled material is absorbed. From this data, the number of cigarettes required to achieve the equivalent TLV exposure was calculated. For example, smoking one cigarette will produce the same dose of acrolein as allowed by the TLV-C.

TABLE 4: Amount of selected chemicals found in cigarettes, and the number of cigarettes that must be smoked in a day to deliver the equivalent maximum dose that is recommended by the TLVs

Chemical	Concentration in Mainstream Smoke (µg/cigarette)	TLV (2012)	Dose at TLV (mg/ exposure period)	# Cigarettes needed to reach Dose at TLV
1,3 – Butadiene	35.5	2ppm	44	1239
Acetaldehyde	680	C25 ppm	14	21
Acetone	287	500 ppm	371	1294
Acrolein	68.8	C0.1 ppm	0.1	1
Acrylonitrile	8.9	2 ppm	43	4831
Ammonia	12.2	25 ppm	170	13934
Arsenic	0.7	0.01 mg/m3	0.1	143
Benzene	46.3	0.5 ppm	16	346
Cadmium	0.103	0.002 mg/m3	0.02	194
Carbon monoxide	13609	25 ppm	290	21
Carbon disulfide	2	1 ppm	3.1	15500
Catechol	88.2	5 ppm	230	2608
Chromium (hex)	0.0042	0.05 mg/m3	0.5	119048
Crotonaldehyde	14.2	C0.3 ppm	0.3	19
Ethylbenzene	8	20 ppm	868	108500
Formaldehyde	33	C0.3 ppm	0.1	4
Hydrazine	0.034	0.01 ppm	0.13	3824
Hydrogen cyanide	118.4	C4.7 ppm	1.6	13
Lead	0.0128	0.05 mg/m3	0.5	39063
Mercury	0.0052	0.025 mg/m3	0.25	48077
Methyl ethyl ketone	54.8	200 ppm	5000	91241
Nickel	0.011	0.1 mg/m3	1	90909
Nicotine	1000	0.5 mg/m3	5	5
Nitric Oxide	37.7	25 ppm	310	8223
2-Nitropropane	0.001	10 ppm	360	360000000
Phenol	21.6	5 ppm	190	8796
Pyridine	11.8	1 ppm	32	2712
Resorcinol	1.2	10 ppm	450	375000
Styrene	5.71	20 ppm	850	148862
Toluene	72.8	20 ppm	752	10330
Vinyl chloride	0.0086	1 ppm	26	3023256
Xylenes	18	100 ppm	4340	241111

The number of cigarettes necessary to meet or exceed the TLV is quite variable. In some cases the dose received at the TLV can be exceeded by as little as one cigarette for some materials.

The additive effects of individual chemicals in cigarette smoke with each other and with workplace chemicals may explain why a worker may show symptoms when ambient air sampling indicates there should not be a problem.

2.2 Synergistic Effects

Synergistic health effects are effects that are far greater in magnitude than the effects one would expect from additive effects alone. Smokers can experience far greater health damage than what might be expected from simply adding together the damage caused by cigarette smoke and by workplace chemicals.[3] For example, people who work with asbestos and who smoke more than a pack a day have up to a 90 times greater chance of dying of lung cancer compared with workers who neither smoke nor work with asbestos. Some workplace illnesses such as lung and bladder cancer appear to be synergistic with cigarette smoke. Table 5 is a list of some materials reported to have additive, and/or synergistic effects with cigarette smoke.

TABLE 5: Examples of additive and synergistic effects of cigarette smoke chemicals and workplace chemicals.

Exposure	**Effect**	**Disease**
Alpha radiation (Radon)	Synergistic	Lung cancer
Arsenic	Additive Synergistic	Lung cancer
Asbestos	Additive Synergistic	Lung Cancer Chronic Lung Disease
Cement dust	Additive	Chronic bronchitis Obstructive lung disease
Chlorine	Additive	Chronic obstructive lung disease
Coal dust	Additive	Chronic obstructive lung disease
Cotton, hemp, flax, dust	Synergistic	Acute airway obstruction (byssinosis) Chronic bronchitis
Carcinogens (misc.)	Additive Synergistic	Cancer of various organs and tissues
Carcinogens (bladder) (2-naphthylamine, 4-aminobiphenyl, benzidine, 4-chloro-o-toluidine, o-toluidine, 4,4' methylene bis (2-chloroaniline), methylene dianiline, and benzidine-derived azo dyes)	Additive Synergistic	Bladder cancer

Exposure	Effect	Disease
Grain dust	Additive	Chronic bronchitis Obstructive lung disease
Irritant gases, metal fumes, dusts, (Radon)	Additive	Chronic bronchitis Obstructive lung disease
Polynuclear aromatic hydrocarbons (PAHs)	Additive Synergistic	Bladder Cancer
Silica dust	Additive	Chronic obstructive lung disease
Sulphur dioxide	Additive	Chronic obstructive lung disease

2.3 Transportation Effects

Smoking in the workplace can result in workers being exposed to unexpected toxic materials, or more of the expected workplace materials. Smoking can also result in an increased toxic dose of workplace materials. One of the simplest examples is the ability of the fine particulates in cigarette smoke to adsorb toxic chemicals such as PAHs, and carry them into the lung. The toxic materials could be from the cigarettes themselves, but also materials in the workplace air. This could alter the normal distribution of such gases or vapours by carrying them into the respiratory system and holding them there. This would change the effective dose of the material that the worker receives.

2.3.1 Effects on Mucociliary Clearance

Cigarettes can also change how toxic materials are transported into or transported from place to place once inside the body and thus change the effective dose of the material.

An example of this is the adverse effect of smoking on the body's ability to remove toxic materials from the respiratory system. Mucociliary clearance [3, 13, 14] refers to the mechanism by which the lungs clear themselves of foreign particles. The bronchi have a moist lining with hair shaped structures called cilia. The cilia are surrounded by a viscous layer of mucous. Small particles (≤2.5 µm) that can reach deeper into the lung are deposited on the mucous layer. In a healthy lung, the cilia move to transport the mucous and the trapped particles in it up towards the pharynx where it is swallowed or coughed out.

Cigarette smoke contains materials, such as acrolein or formaldehyde which are harmful to the mucociliary clearance system. When the lung's clearance system is impaired, in combined with the high levels of particulates and other workplace chemicals, the lung's defense system can be overwhelmed. As a result, the lungs of long-term smokers cannot clear particles at a normal rate so they retain a significant number of particles. This increases the capture and retention of toxic workplace particulates. It should be noted that smoking does not have to take place in the workplace to have an adverse effect.

2.3.2 Epithelial Permeability

Epithelial tissues line the interior surfaces of the lung and act as a barrier separating airways in the lung from the lung's blood vessels. Among other things, epithelial tissues act as a selective permeable barrier for materials moving between the airways and the blood vessels. As such the tissue acts as a barrier to potentially noxious agents such as bacteria, viruses, pollutants, and allergens.

Research with animals and man has shown that cigarette smoke causes the epithelium layer to become more permeable.(17) The epithelial layer of both chronic and acute smokers is more permeable than that of non-smokers. The acute smokers' lungs have the ability to absorb airborne workplace contaminants more quickly and more completely. Thus smokers may receive a greater dose of airborne workplace contaminants.

There is an improvement in permeability 24 hours after the last cigarette. This would suggest that in non-smoking workplaces would be only slightly better protected than workplaces with smoking. A cigarette outside during breaks would tend to maintain maximum susceptibility to workplace chemicals.

2.4 Transformation Effects

Burning tobacco can transform workplace chemicals into more hazardous materials.(3) The main concern is chemicals that can decompose, oxidize, or vaporize at temperatures below 900°C. In some cases the materials are transformed to more toxic materials by the heat during burning, or the state of a material is changed from a solid to a vapour or fume. Table 6 gives examples of workplace materials that can be transformed to different toxic chemicals or states during the burning of cigarettes.

With the transformation of airborne workplace materials, a worker could show symptoms of workplace exposures unrelated to any material used in the workplace. It should be noted that for this effect to take place there would need to be smoking in the workplace.

Solid materials left on the hand can be altered to a vapour or fume outside the workplace if a worker handles a cigarette without washing. This can happen in the parking lot or at home after the work shift. Unless hands are washed before smoking, workplace chemicals can be transferred to the cigarette, and then inhaled when the "finger print" is burned and inhaled. As mentioned, smoking does not have to take place in the workplace for these harmful effects to occur. Workers only need to smoke without washing between working and smoking. Quickly slipping outside for a smoke would provide ideal conditions for this type of exposure. Exposure by this route would not be detected by sampling the workplace air.

TABLE 6: Examples of workplace materials which are altered or created during the burning of cigarettes to become more toxic.

Toxic Material or Effect	Condition
Phosgene	Chlorinated solvents, metal cleaners (dichloromethane, carbon tetrachloride, trichloroethylene), and refrigerants are decomposed in the presence of oxygen to phosgene (TLV-TWA 0.1 ppm).
Polymer Fume Fever	Airborne materials containing fluorine can decompose to form hydrogen fluoride, carbonyl fluoride, and perfluoropropane (this is depends on the parent material, and the temperature and humidity during burning). Any types of solid fluoride containing materials such as Teflon can be become a toxic material when it is left on a cigarette by an unwashed finger. Only a very small amount of material is required. Smoking a cigarette contaminated with a small amount of Teflon about the size of the head of a pin (one millimeter) was equivalent to breathing Teflon fumes at high concentrations for a full workday, or 0.4 mg/m^3 of air over an eight hour work shift. This exceeds the exposure levels that caused polymer fume fever.
Lead, mercury	Metals with low melting points can be vaporized by cigarettes. Metals contaminating the paper of a cigarette from an unwashed hand can produce significant amounts of metal fume.

2.5 Tumour Promotion

Cigarette smoke can alter the rate of activation of a procarcinogen into a carcinogenic metabolite. A procarcinogen, in this case a workplace chemical, is a chemical substance that becomes carcinogenic only after it is altered by metabolic processes. Anything that increases the rate or amount of a chemical that is converted to a carcinogen will potentially increase the incidence of cancer caused by workplace exposures.

Foreign materials (xenobiotics) are metabolized by liver enzymes (the cytochrome P450 system). The production of these enzymes is induced by some polycyclic aromatic hydrocarbons (PAHs), some of these are found in cigarette smoke.

Animal experiments have demonstrated that exposure to cigarette smoke results in the production of the cytochrome P450 enzymes and an increase in mutagenic activity[(3, 15, 16)]. It appears that cigarette smoke can increase the incidence of cancers from workplace chemicals by accelerating the proactivation of some workplace materials into carcinogenic chemicals. Exposure to occupational carcinogens such as aromatic amines, butadiene, acrylonitrile, and nitrosamines may result in cancer developing only among workers also exposed to cigarette smoke.

2.6 Aggravation of Pre-Existing Conditions

2.6.1 Chronic Obstructive Pulmonary Disease

Chronic obstructive pulmonary disease (COPD) is a long-term lung illness that includes chronic bronchitis and emphysema. COPD slowly damages the airways, making airways swollen and partly blocked by mucus. This limits airflow to and from the lungs, causing shortness of breath. The main risk factor for COPD is cigarette smoke. Only 15% of all cases appear to be work related. Studies suggest that smoking combined with exposure to workplace dust may have a synergistic effect.[11, 12]

Industries with a demonstrated increased risk include:

Coal mines	Construction
Building services	Leather manufacturing
Pesticides	Plastics
Pulp and Paper	Rubber
Textile manufacturing	Utilities

Workplace materials associated with COPD include:

Aldehydes	Ammonia
Arsenic	Brick Dust
Cadmium	Chlorine
Chloromethyl Methyl Ether	Chromium
Coal Mine Dust	Cobalt
Coke Oven Emissions	Diesel Exhaust
Endotoxins	Grain Dusts
Osmium Tetroxide	Oxides of Nitrogen
Paraquat	Phosgene
Polychlorinated Biphenyls	Pottery Dust
Sodium Hydroxide	Toluene Diisocyanate
Tungsten Carbide	Vanadium
Vinyl Chloride Monomer	Western Red Cedar
Wood Dust	

The synergistic or additive effects of the chemicals in cigarette smoke may explain why a worker may show symptoms when ambient air sampling suggests there should not be a problem.

2.6.2 Asthma

Asthma is a chronic inflammation of the airways, with widespread airflow limitations. The inflammation results in hyper-responsiveness of the airways to a multitude of stimuli including cold air, cigarette smoke, and exercise. Symptoms include wheezing, coughing, shortness of breath, and chest tightness that are often worse at night or in the early morning.

We are concerned with work-related asthma caused by workplace exposure and not by factors outside of the workplace. Two types of workplace asthma have been described:

- *Allergic occupational asthma* is characterized by a latency period between first exposure to a respiratory sensitizer at work and the development of hypersensitivity symptoms, and
- *Irritant-induced occupational asthma* that occurs typically within a few hours of a highly concentrated exposure to an irritant gas, fume or vapor at work.

Although smoke is not considered an allergen, it is an irritant and can worsen illnesses like asthma and allergic reactions. If a worker has allergies or allergic asthma, smoke can trigger an allergic reaction because the smoke is putting an extra strain on the body and immune system.

Among those workers whose asthma was attributed to high molecular weight agents, active smokers developed asthma earlier than nonsmokers However, their prognosis after diagnosis was better than for non-smokers. Consequently, active cigarette smoking affected the interval between the initial workplace exposure and the onset of asthmatic symptoms.(3)

Second hand smoke can be troublesome if a worker has asthma. It can cause a cough and wheeze and a temporary worsening of breathing. Asthma means having air passageways in the lungs which are extra-sensitive to irritants in the air, including second-hand smoke.

There is empirical evidence which suggests that:(18)

1. smoking is more prevalent among individuals with asthma than those without;
2. smoking is a risk factor for developing asthma;
3. smoking is associated with decreased asthma control, an increased risk of mortality, and an increase in asthma attacks and exacerbations; and
4. mainstream and side stream smoke can aggravate asthma.

3.0 SUMMARY

Smoking is still a factor in the workplace. There are many well publicized health risks associated with cigarettes, such as cancer. A less well explored area is the interaction between cigarettes and workplace chemicals. It is important that smoking not be allowed in the workplace, but workers should also understand that smoking off the job, and even second hand smoke can result in increased risk when exposed to workplace materials.

There are three areas to be aware of with respect to health risk of mixing cigarette smoke with the usual hazards of the workplace as described below.

1. There can be an increased health risk to workers when cigarette smoke and workplace materials are both present. They can combine by additive or synergistic methods. Cigarette smoke can promote adverse health effects when the smoke stimulates a reaction between workplace chemicals and the body’s metabolic

processes. The smoke can deliver workplace materials more effectively to target organs or can create and deliver new hazards to target organs. Reducing this increase in health risk caused by the combination of cigarette smoke with workplace materials is a worthwhile goal.

2. Sidestream or secondhand smoke can have an adverse effect on workers when combined with workplace exposures. It can act as a tumor promoter and affect absorption and elimination of workplace chemicals, as well as contribute to additive and synergistic effects.

3. Cigarette smoke can increase the incidence of expected workplace illnesses and can create new unexpected health effects. Failure to take into account the effects of cigarette smoke can result in under estimating true worker exposure, or not recognizing exposures to unexpected materials.

TABLE 7: A summary of the interactions between cigarette smoke and workplace materials. The type of smoke, both mainstream smoke (MS) and sidestream smoke (SS) are contributors in these effects.

Health Effect	**Comments**	**MS**	**SS**
Altering the fraction of inhaled carcinogen deposited or retained in the lung	Carcinogens adhered to the surface of fine particulates are carried into the lungs.	✓	✓
Additive effects	The toxic effects of materials in cigarette smoke are added to the effects of similar materials in the workplace.	✓	✓
Synergistic effects	The toxic effects of materials in cigarette smoke are greater than the additive effects of similar materials in the workplace.	✓	✓
Tumour promotion	The rate of metabolic activation of a procarcinogen into a carcinogenic metabolite.	✓	✓
Material transport	Smoking impairs mucociliary clearance of carcinogenic particles such as asbestos.	✓	✓

Health Effect	Comments	MS	SS
Material transport	The small particles produced by tobacco smoke can also serve as a vehicle for delivery of other carcinogens such as formaldehyde.	✓	✓
Material transfer	Cigarette smoke has been shown to increase epithelial permeability in the tracheobronchial tree; the effect may increase the exposure of the underlying cell to a workplace chemical.	✓	✓
Conversion of workplace materials	Materials are decomposed, oxidized, or vaporized at temperatures below 900°C by the cigarette.	✓	
Respiratory irritant	Smoke can aggravate asthma.	✓	✓

3.1 ACTION PLAN

Since many of the health concerns aggravated by cigarette smoke are chronic, protection programs must be designed to prevent illness instead of waiting for symptoms to warn of problems. Therefore a program designed to prevent illnesses that could be related to cigarette smoke must consist of:

1. **Prohibition of smoking inside the workplace.** This will reduce the potential for additive and synergistic effects. Chemicals in the cigarette smoke even when smoked off the job can still be additive or synergistic with workplace chemicals. The transport of chemicals on smoke particulates and the transformation of workplace materials will be prevented.

2. **Prohibition of smoking on the property.** This will further reduce the some of the effects mentioned in #1.

3. **Washing at all breaks.** Hand washing at all breaks will reduce some of the transformation and transportation effects for those who smoke during breaks.

4. **Warning of the effects of sidestream smoke.** Sidestream smoke, even after working hours can predispose a person to additive, synergistic, and tumour promotion as well as other effects. A smoking spouse can aggravate workplace exposures.

5. **Being aware of interference with biological samples.** If biological sampling is used to monitor exposures, there is a possibility that smoking may have an effect

on the biological samples. There can be significant increases for materials such as cadmium, chromium, and lead.

6. **Encouraging smokers to quit.** Only avoidance of cigarette smoke will be effective. Both MS and SS smoke can interact with workplace materials and can produce an exaggerated and unexpected health effect.

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