Lecture #29

ERDM

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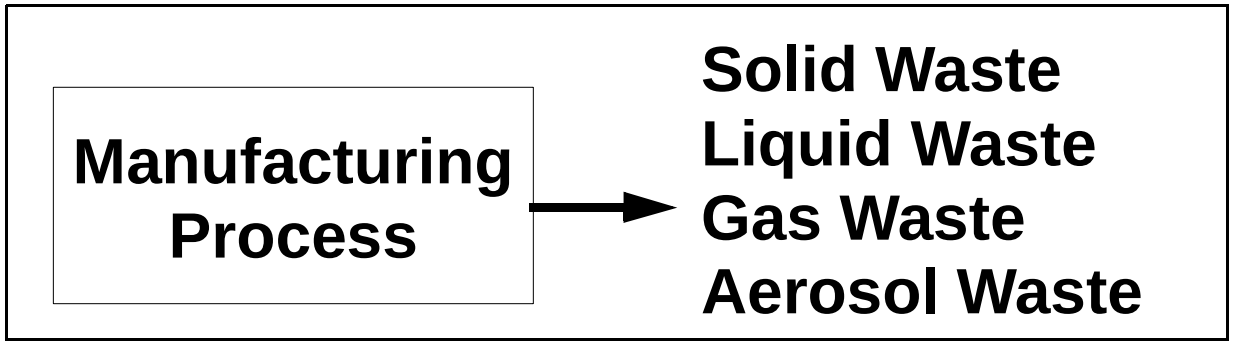
Waste Stream Types



For a given process, we need to have models that can predict both the mass flow rate and character of the waste stream.

Character: Size of solid waste stream elements, components mixed with the liquid waste, particle sizes with the aerosol.

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Aerosols

- **We have spent time talking about specific chemicals and compounds for which there is an environmental concern: Gaseous, Liquid, & Solid waste.**

- **We need to spend a little time talking about aerosols.**

- **The basis for many of the regulations governing workplace air quality is the NAAQS (Natl. Ambient Air Quality Standard) -- this is for outside air but some of the ideas are used in OSHA rules**

  http://www.epa.gov/airs/criteria.html

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What is an Aerosol?

Aerosols: solid or liquid particles suspended in a gas (Particulate Matter in a gaseous medium)

- **Dust: Solid particle aerosol formed by disintegration of parent material**
- **Mist: Liquid particle aerosol formed by condensation or atomization, (generally particles < 20 μm)**
- **Fumes: Solid particle aerosol produced by condensation of gaseous combustion products (generally particles < 1 μm)**
- **Smoke: Visible aerosol resulting from incomplete combustion (particles < 1 μm)**

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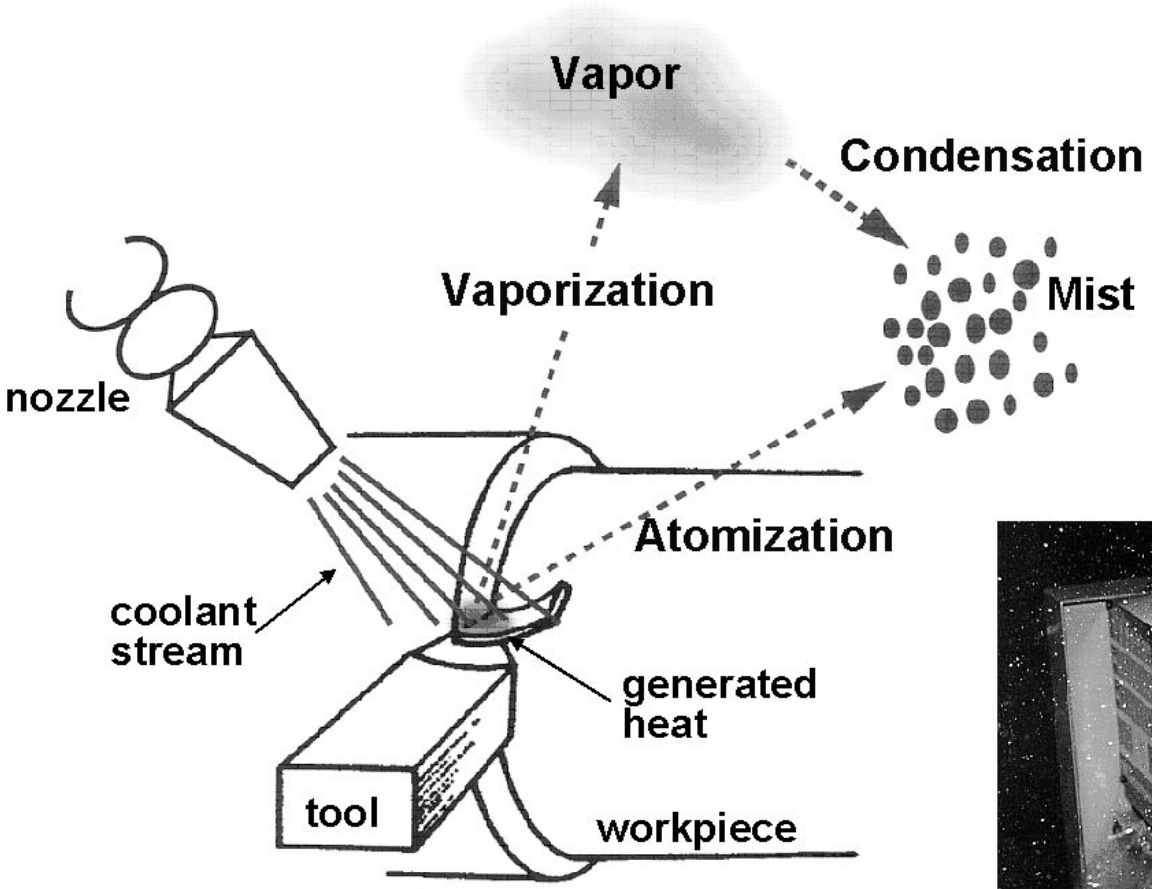
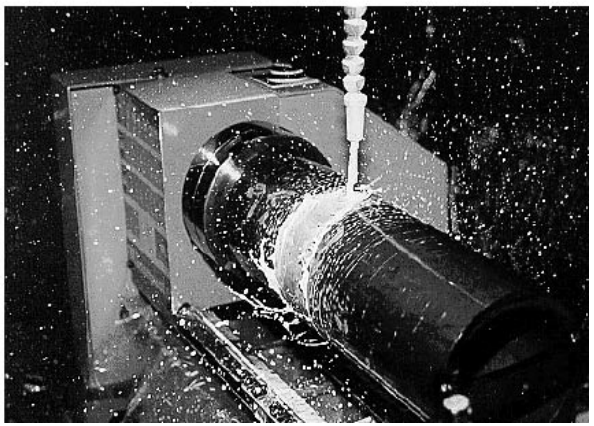
Airborne Particulate in Machining



No fluid being used?

What about dust?



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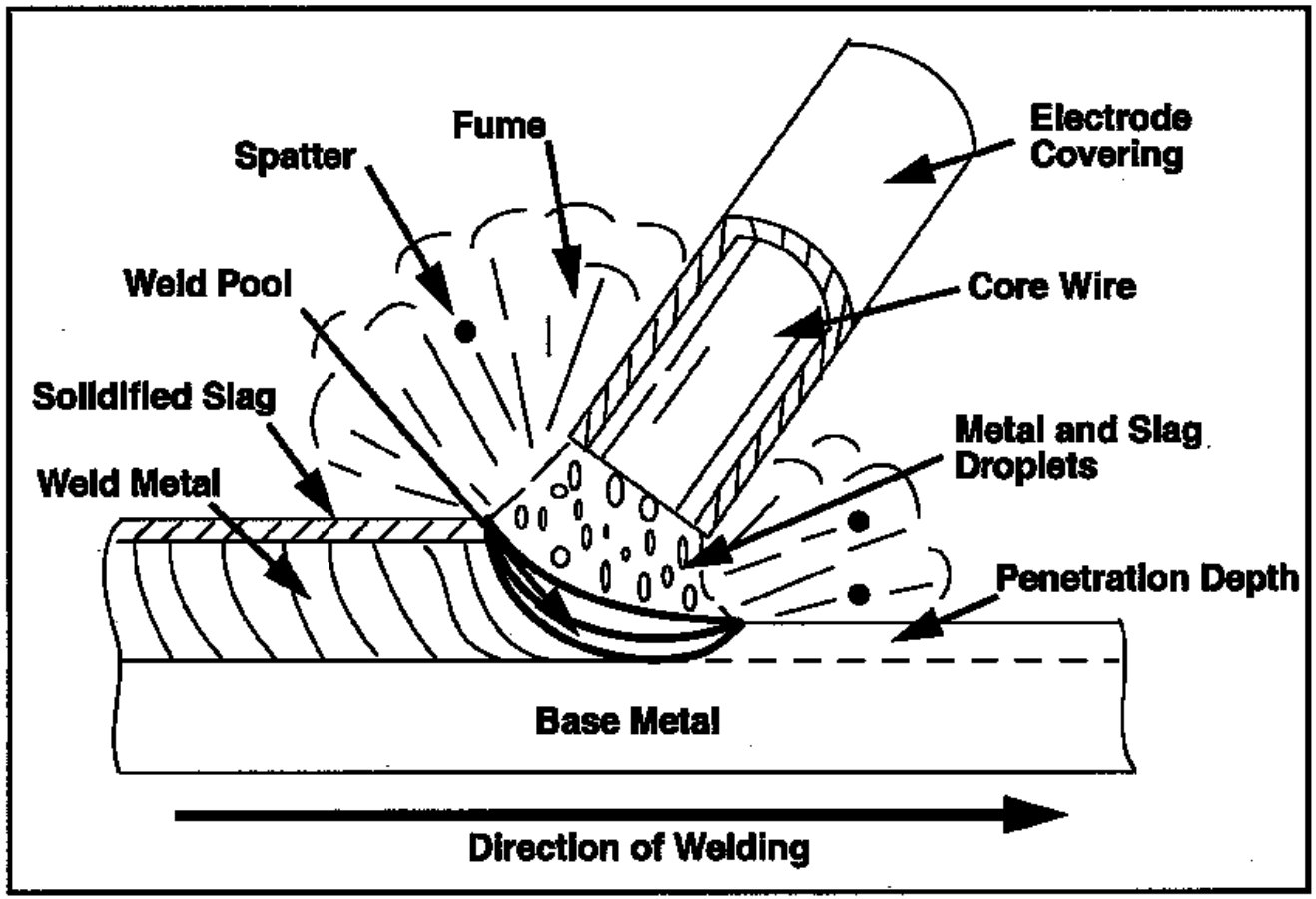
Airborne Particulate in Welding



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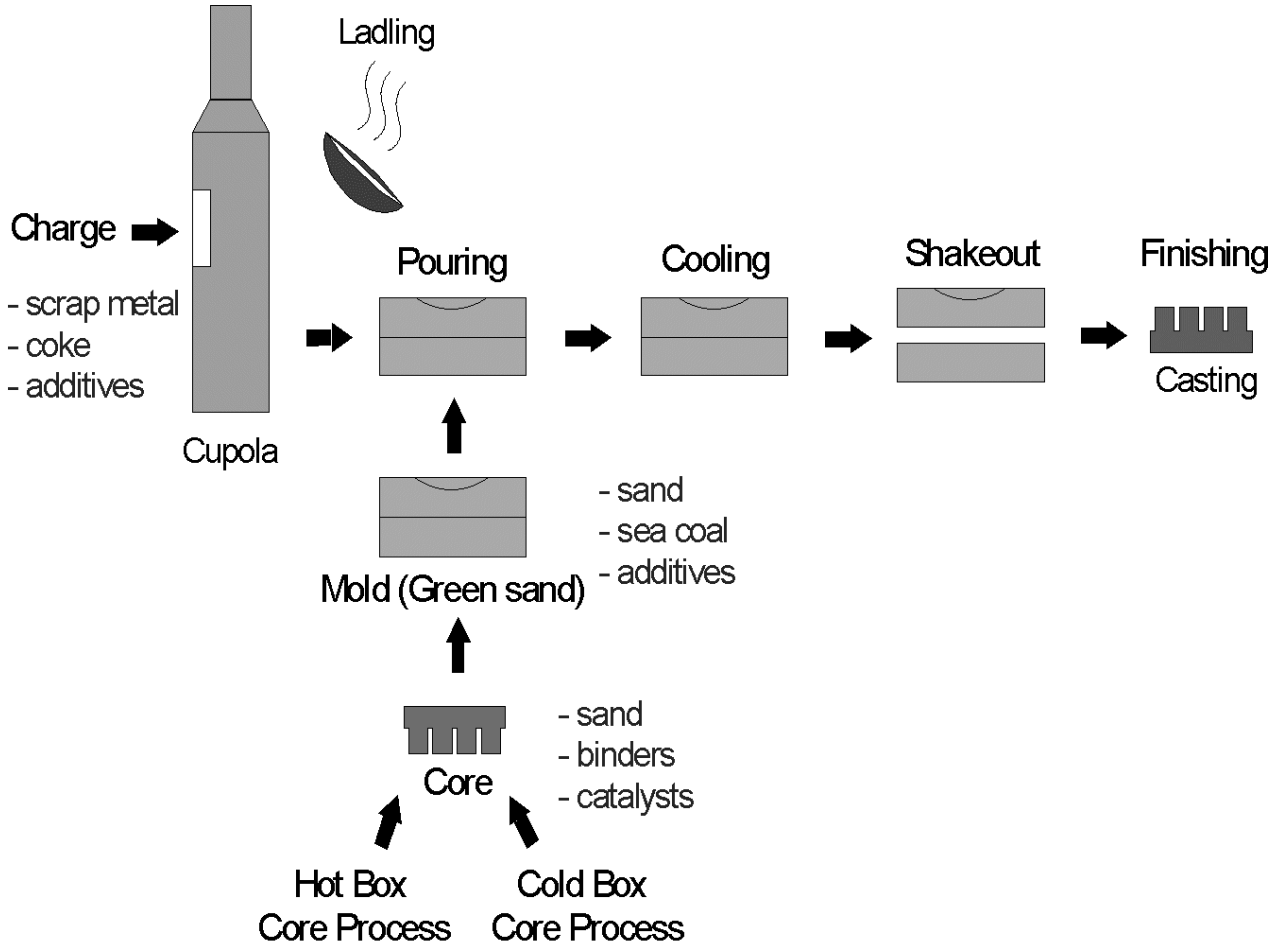
Airborne Particulate in Casting



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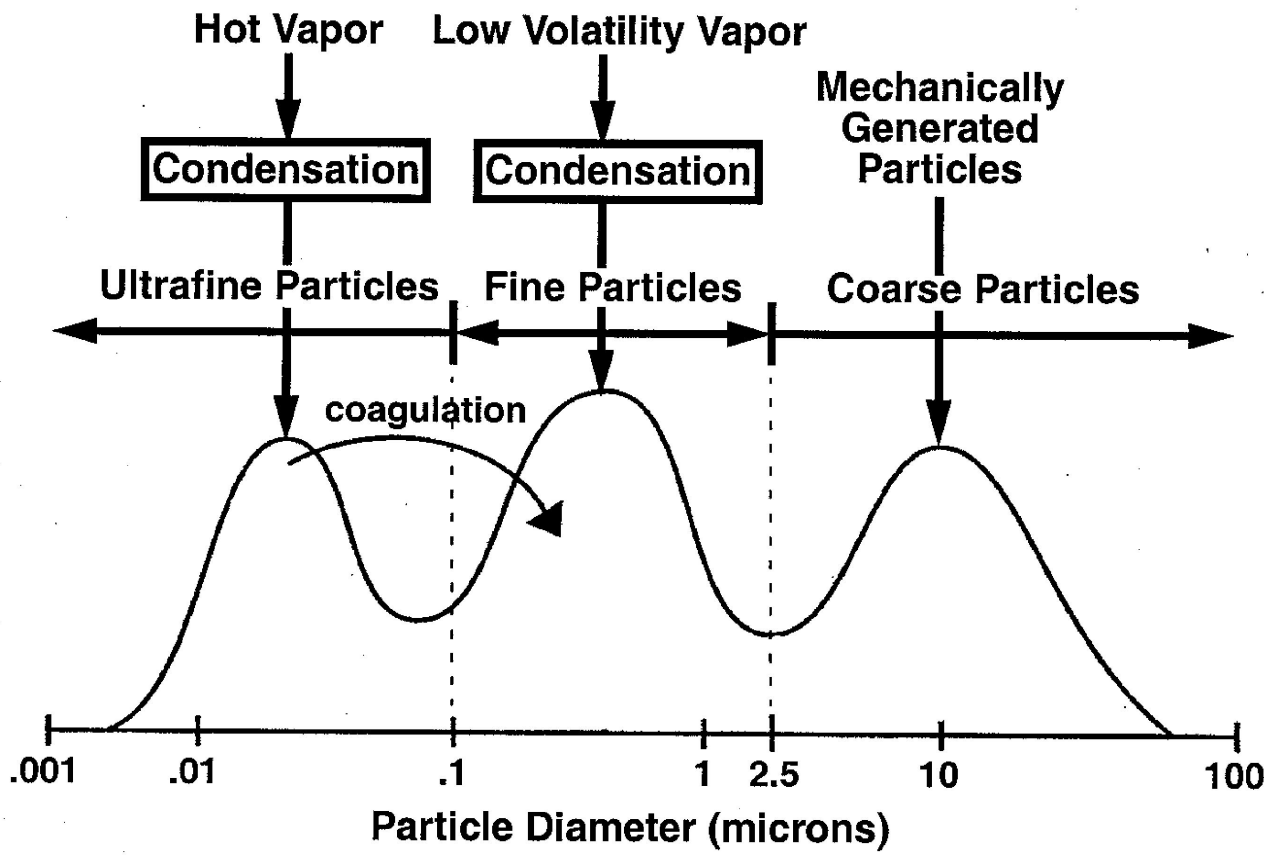
Size of the Particulate



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Aerodynamic Diameter

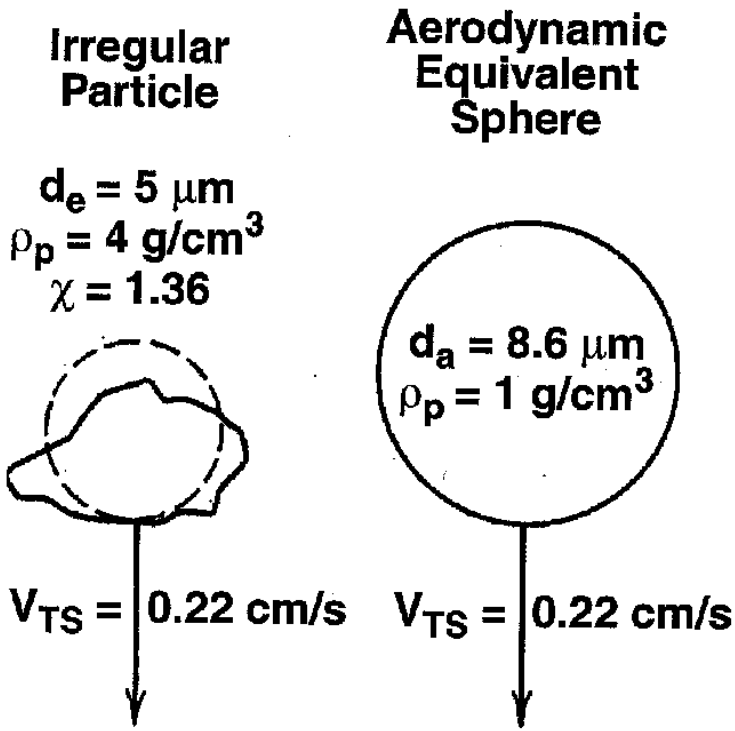
$$d_a = d_e \sqrt{\frac{\rho_p}{\rho_0 \chi}}$$

d_e = equivalent volume dia.

χ = Dynamic shape factor

ρ_p = density of particle

ρ_0 = unit density



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Measuring Aerosols

- **Chemical analysis, e.g., gas chromatograph/mass spectrometer and X-ray diffraction**
- **Time-of-flight sizing -- particle size distribution**
- **Electrical mobility technique -- particle size distribution**
- **Gravimetric Analysis -- mass concentration**
- **Light Scattering Intensity -- mass concentration**

Health Concerns

- **Respiratory Problems (e.g., bronchitis, pneumonia, asthma, decreased lung function)**
- **Cancer (esophageal, pancreatic, colon, stomach, larynx, rectum, etc.)**

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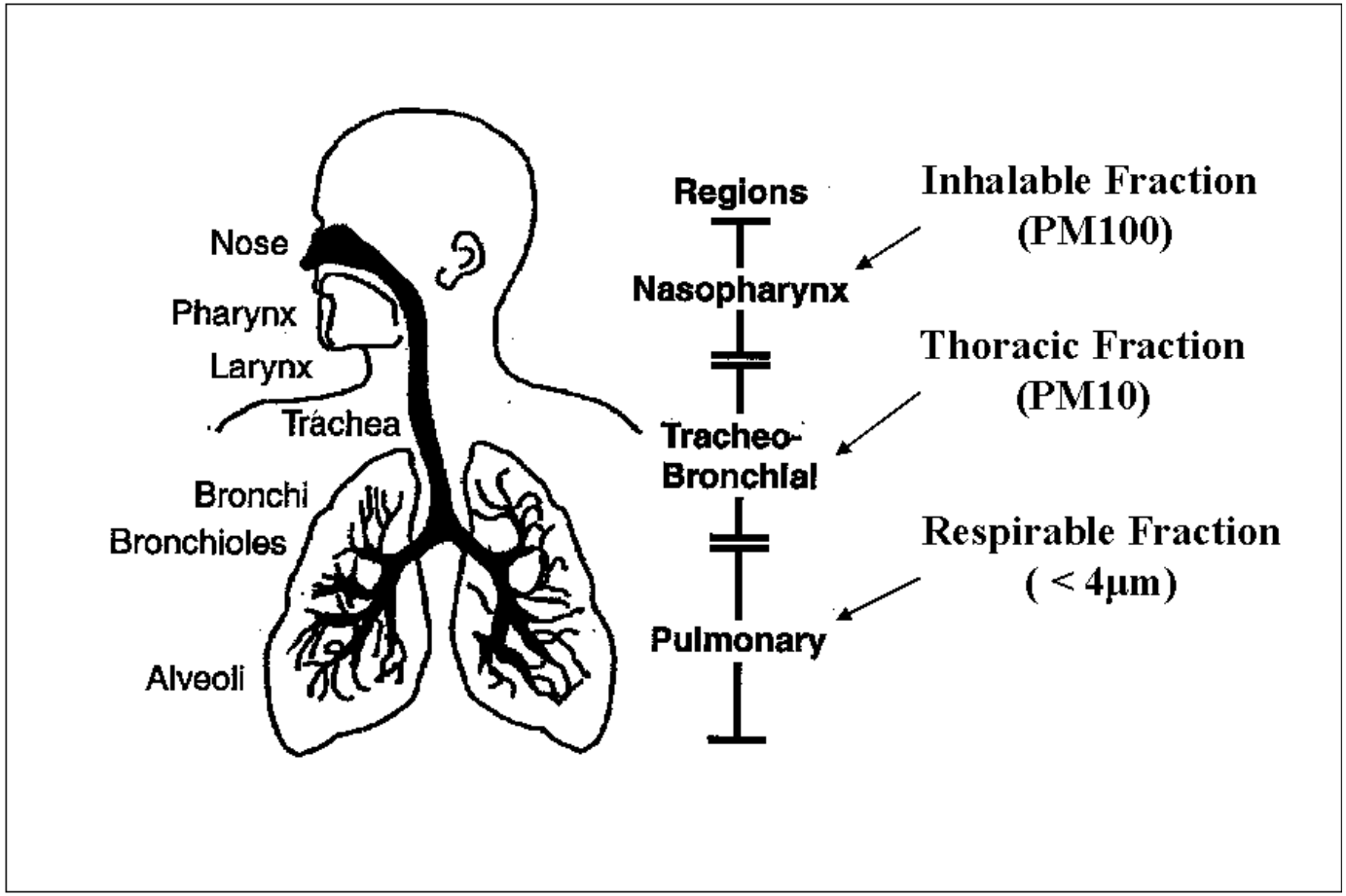
Respiratory Tract Deposition



What is the Law?

- **Based on mass concentration (mg/m^3) & particle size**

- **OSHA Regulations**
- **PEL = 5 mg/m^3 as an 8 hr TWA for mineral oil mists**
- **PEL = 15 mg/m^3 for total particulates not otherwise regulated (5 mg/m^3 for the respirable fraction)**

- **NIOSH recommendation: all MWF types = 0.5 mg/m^3**
- **UAW recommendation: 0.5 mg/m^3 for cutting fluid mists (they want an even further reduction - 0.25 mg/m^3)**

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Exposure Effects to Dust

Aluminum – Excessive exposure to aluminum fume and dust has been associated with lung disease, but this effect is probably due to simultaneous silica exposure.

Arsenic – Arsenic compounds can be absorbed into the body from industrial exposures, especially by inhalation and ingestion. Signs of toxicity are dermal lesions, conjunctivitis, upper respiratory tract irritation, nausea, vomiting, peripheral neurilis and occasionally anemia. Arsenic in combination with promoters such as sulfur dioxide, metal oxide fumes and smoking has caused respiratory cancer. Arsenic has been identified as a carcinogen by NTP and IARC.

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Beryllium – Inhalation of beryllium dust/fume may result in the production of an acute or chronic systemic disease depending upon the level of exposure and the beryllium compound involved. Granulomatous lesions of the skin, liver, kidneys, spleen and lymph nodes have been reported. Damage to the lungs may be in both the acute and chronic forms, both of which have similar signs and symptoms. These include a relatively non- productive cough, progressive difficulty in breathing, loss of appetite, and loss of weight. The major difference between the two is the suddenness of onset and the rate of progression. In the acute form, the symptoms appear in several hours to several weeks after exposure and there is usually rapid progression of signs including dyspnea, anorexia, and extreme weight loss. Complete recovery is possible and fatal cases usually result from acute heart disease. In chronic beryllium disease, the symptoms or signs are generally delayed in their onset and are persistent in nature. They may be triggered or aggravated by stresses such as pregnancy, respiratory infection and thyrotaxicosis. In the progression of the disease, symptoms of heart disease may occur. Beryllium is also a suspected human carcinogen and has caused cancer in laboratory animals.

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Cadmium – Inhalation of cadmium fumes may cause respiratory irritation with a dry, sore throat and a metallic taste followed by a cough, chest pain and difficulty in breathing. Bronchitis, pneumonitis and pulmonary edema have also been reported as a result of the irritation of the fumes. Headaches, dizziness, loss of appetite and weight loss have also been reported and the liver, kidneys and bone marrow may be injured by the presence of metal. Continued exposure to lower levels of cadmium has resulted in chronic poisoning characterized by irreversible lung damage and kidney damage. A single, high level exposure to cadmium can cause severe lung irritation which may be fatal. Cadmium is also a suspected human carcinogen.

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Chromium – In some workers, chromium compounds act as allergens and may cause dermatitis and may also produce pulmonary sensitization. Chronic acid and chromates have a direct corrosive effect on the skin and the mucous membranes of the upper respiratory tract. Although rare, there may be the possibility of skin and pulmonary sensitization. IARC has determined that there is sufficient evidence of increased lung cancer among workers in the chromate-producing industry and possibly among chromium alloy workers. This determination is supported by sufficient evidence for carcinogenicity to animals and possible mutagenicity testing CR 6 compounds.

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Cobalt – Cobalt has been reported as causing hypersensitization-type dermatitis in individuals who are susceptible. Animal studies have shown that particulate cobalt is an acutely irritating substance and industrial exposures, possibly combined with small amounts of silica, are reported capable of producing serious pneumoconiosis which is initially of an insidious nature.

Columbium – Also known as Niobium, there is almost no information on the toxicity of this metal or its fumes. Russian medical literature has described impact on welders and chemical workers handling niobium and tantalum, but no specific data. It is expected that the metal dust and fumes could cause irritation to the skin, eyes and respiratory tract upon acute exposure.

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Copper – Melting, grinding, or cutting of copper may produce fumes or dust. Exposure to, or inhalation of these fumes or dust may present potentially significant health hazards. Fumes of copper may cause metal fume fever (flu-like symptoms), and hair/ skin discoloration. While industrial dermatitis has not been reported, keratinization of the hands and the soles of the feet have been reported. Copper dust/ fume can cause irritation of the upper respiratory tract, metallic taste in the mouth, & nausea.

Iron – The inhalation of iron oxide fumes or dust may cause an apparent benign pneumoconiosis which is called siderosis. This disease is reported to be disabling, but makes x-ray diagnosis of other lung conditions difficult or impossible.

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Lead – Short-term exposure: Lead is an accumulative poison. Effects of inhalation of fumes or dust of inorganic lead may not develop quickly. Symptoms may include decreased physical fitness, fatigue, sleep disturbance, headache, aching bones, constipation, abdominal pains, and decreasing appetite. Effects are reversible & complete recovery is possible. Inhalation of large amounts of lead may lead to seizures, coma, & even death.

Lead – Long-term exposure can result in a build-up of lead in the body and more severe symptoms. These include anemia, pale skin, a blue line at the gum margin, decreased hand-grip strength, abdominal pain, severe constipation, nausea, vomiting, and paralysis of the wrist joint. Prolonged exposure may also result in kidney damage. If the nervous system is affected, usually due to very high exposures, the resulting effects include severe headache, convulsions, coma, delirium, and death. Alcohol ingestion and physical exertion may bring on symptoms. Continued exposure can lead to decreased fertility and/or increased chance of miscarriage or birth defects.

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Magnesium – Exposure to magnesium may cause metal fume fever with flu-like symptoms. Particles imbedded in the skin may cause severe lesions.

Manganese – Chronic manganese poisoning may result from inhalation of dust or fumes. The central nervous system is the chief site of injury, but there may also be adverse blood and kidney effects. Chronic manganese poisoning is not a fatal disease although it is extremely disabling. Some individuals may be hyper-susceptible to manganese. Freshly formed manganese fumes has caused fever and chills similar to metal fume fever.

Molybdenum – This metal can be toxic via interperitoneal and subcutaneous routes. Care should be taken to avoid inhalation of large amounts of dust or fumes. Molybdenum is generally considered to exhibit a low order of toxicity.

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Nickel – The most common ailment arising from nickel or its compounds is an allergic dermatitis known as nickel-itch, which usually occurs when the skin is moist. Generally, nickel and most salts of nickel do not cause systemic poisoning, but nickel has been identified as a suspected carcinogen. There can also be adverse effects to the lungs and nasal cavities.

Phosphorous – The dusts and fumes can act as minor irritants to the eyes, throat and respiratory tract. Long-term excessive inhalation of phosphorous compounds may lead to cough, bronchitis and pneumonia.

Silicon – Accumulation of silicon in the lungs may be responsible for benign pneumoconiosis, but is not considered to be responsible for pulmonary functional impairment or respiratory symptoms.

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Silver – Chronic occupational exposure to silver results in argyria, a permanent pigmentation (gray to purple) of the skin and eyes. Inhalation of silver may localize the argyria in the respiratory tract with chronic bronchitis as the only symptom.

Sulfur – The fumes may irritate: skin, eyes, lungs, and gastrointestinal tract.

Tantalum – There are no reports of adverse health effects in industrially exposed workers. Massive doses of tantalum given by intratracheal route to rats have produced respiratory tract lesions. In contact with tissue, metallic tantalum is inert. Tantalum pentoxide has an LD sq. of >8 g/kg, orally in rats.

Tellurium – Inhalation of tellurium fume in quantities results in a metallic taste and garlic breath, gastrointestinal disease, dry-mouth, and somnolence.

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Tin – The inhalation of inorganic tin fume or dust may cause an apparent benign pneumoconiosis called stannosis, which is reported to be not disabling.

Titanium – Titanium is considered a physiologically inert dust. However, high concentration of oxides can cause mechanical irritation of eyes, nose and throat. Inhalation of titanium could cause mild irritation to the respiratory tract. Inhalation of titanium dioxide dust or fume could produce lung fibrosis and chronic bronchitis.

Tungsten – Inhalation of tungsten dust may cause irritation to the respiratory tract. Skin or eye contact could cause abrasion or irritation of the respective surfaces. No hazards have been identified for tungsten fume except that it may aggravate an existing chronic respiratory disease.

Yttrium Oxide – Short-term inhalation in large amounts could cause discomfort, coughing and nasal discharge similar to the symptoms of a bad cold. Drying of the mucous membranes may be experienced. After intratracheal administration in rats, emphysema and diffused modular fibrosis in the lungs have been reported. The oral toxicity of this material is low as it is poorly absorbed from the gastrointestinal tract. Skin and eye contact should produce mechanical irritation.

Zinc (as Oxide) – Zinc is very low in toxicity, but inhalation of fumes may cause metal fume fever. Onset of symptoms may be delayed 4-12 hours and include irritation of the nose, mouth, and throat, coughing, stomach pain, headache, nausea, vomiting, metallic taste, chills, fever, pains in the muscles and joints, thirst, bronchitis or pneumonia and a bluish tint to the skin. These symptoms go away in 24-48 hours and leave no effect.

Note: Antimony trioxide, beryllium, cadmium, chromium, cobalt-chromium alloy, lead and nickel have been identified as potential human carcinogens.

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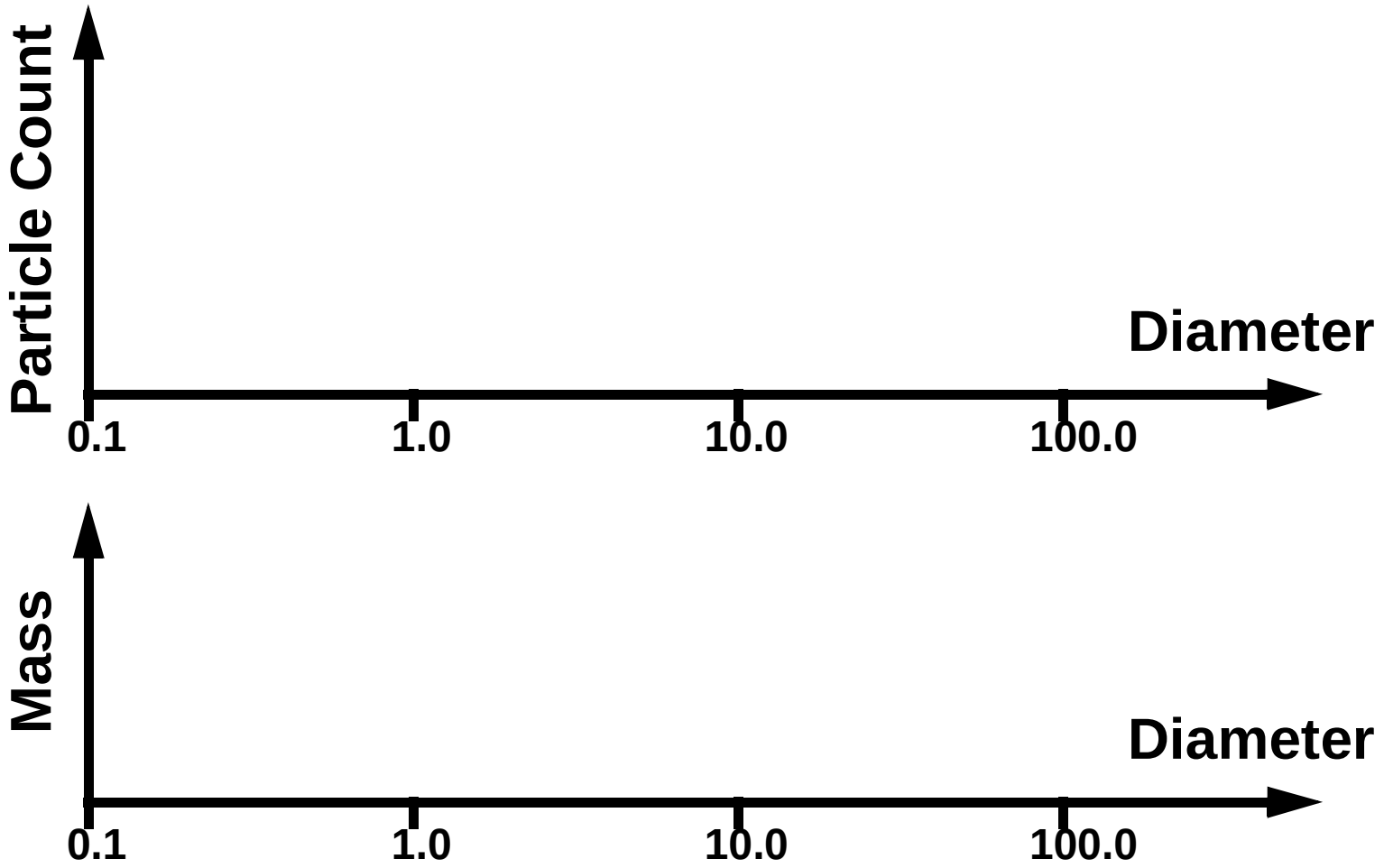
Particle Distribution



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Controlling Exposure

- **Mist Collectors**
- **Air Cleaners/Filters**
- **Enclosures**
- **Respirators**

Better yet....

- **Eliminate the process**
- **Change the process to reduce emissions**

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