surrounding a pool of molten metal at the bottom of the vessel. An electric induction furnace operates in batch mode, an operating cycle consisting of charging, melting the charge, adding an additional charge (backcharging) in some cases and melting that charge, and tapping the molten metal.

Scrap feed for an electric induction furnace is commonly preheated, usually by direct exposure to a gas flame, prior to charging to the furnace. Preheating is done primarily to eliminate volatile substances such as water and residual oil and grease that may vaporize suddenly and cause an explosion if added to a molten charge or heel in the furnace. When preheating is done, the scrap is commonly heated to 800§ F or higher because the cost of initial heating with gas is less costly than heating with electricity. A scrap preheater, where used, is considered to be an integral part of the electric induction furnace melting operation.

Electric arc furnaces. An electric arc furnace is a vessel in which forms of iron and steel, such as scrap and foundry returns, are melted through resistance heating by an electric current that flows through the arcs formed between electrodes and the surface of the metal and also through the metal between the arc paths. Typically, the electric arc furnace is equipped with a removable cover and charged from the top. Molten metal is tapped from the electric arc furnace by removing the cover and tilting the furnace. An electric arc furnace operates in batch mode as does an electric induction furnace, an operating cycle consisting of charging, melting, backcharging in some cases and melting that charge, and tapping.

Pouring, Cooling, and Shakeout Lines

A pouring, cooling, and shakeout line includes three major operations: pouring molten metal into molds, allowing the metal to cool and solidify, and removing the castings from the molds. The most common type of pouring, cooling, and shakeout line is the conveyor or pallet line, in which the pouring ladle is stationary and molds are moved to the ladle by conveyor or rail. After pouring is complete, the molds move along the conveyor or rail through a cooling area, which is often an enclosed tunnel. A less common type of pouring, cooling, and shakeout line is floor or pit pouring, which is used by small to medium sized foundries that do not have sufficient capital to finance mechanization and also by foundries that produce castings too large to be transported by conveyor. In this type of line, molds are placed on an open floor or in a pit, and the pouring ladle is transported to the molds, generally by overhead pulley. After pouring, the casting is cooled in place.

After castings have solidified, they are removed from the sand molds in a process called shakeout. At most foundries, shakeout is a mechanized process where molds are placed on vibrating grids or conveyors to shake the sand loose from the casting. In some foundries, the castings and molds are separated manually.

Mold and Core Making Lines

Most iron and steel foundries pour metal into molds that are made primarily of sand. Molds may also be made of tempered metal (iron or steel) that are filled by gravity (permanent molds) or by centrifugal force (centrifugal casting). Some systems use polystyrene or other low density plastic (foam) patterns and pack sand around the patterns. This type of casting operation is referred to as expendable pattern casting, or the lost foam process since the plastic pattern is volatilized (and/or pyrolyzed) by the molten metal as the castings are poured.

The outer shape of a casting is determined by the shape of the molds. Molds are typically made in two halves that are subsequently joined together. The inner shapes of the casting that cannot be directly configured into the mold halves are created by inserting separately made components called cores, which are almost universally made of sand. Sand cores are often required in sand molds as well as in many permanent mold and centrifugal casting operations.

Most sand molds are made from green sand, which is a mixture of approximately 85 to 95 percent sand, 4 to 10 percent bentonite clay, 2 to 5 percent water, and 2 to 10 percent carbonaceous materials such as powdered coal (commonly called sea coal), petroleum products, cereals, and starches. The composition of green sand is chosen so that the sand will form a stable shape when compacted under pressure, maintain that shape when heated by the molten metal poured, and separate easily from the solidified metal casting. The clay and water bind the sand together. The carbonaceous materials partially volatilize when molten metal is poured into the mold, creating a reducing atmosphere that prevents the surface of the casting from oxidizing while it solidifies.

Some sand molds and most sand cores are bound into shape by plastic- or resin-like chemical substances. Chemical binder systems are used when the shape of the mold or core cannot be made from green sand or when strength and dimensional stability requirements are too stringent for green sand to provide. Chemically bonded molds and cores are made by first blending the sand and chemicals (mixing), then forming the sand into the desired shape and hardening (curing) the chemical binder to fix the shape. Chemical binder systems are of three types depending on the curing process required:

- Chemicals that cure upon heating (thermosetting),
- Combinations of chemicals that cure by reacting with each other at ambient temperature (self-setting or nobake), and
- Chemicals that react by catalysis upon exposure to a gas at ambient temperature (gas-cured or cold box).

Several systems of each type are available, with the choice of system depending on such features as strength of the mold or core, speed of curing, and shelf life.

Mold and Core Coating Lines

Molds and cores are often coated with a finely ground refractory material to provide a smoother surface finish on the casting. We refer to these processes as "coating" operations. The refractory material is applied as a slurry. After coating, the liquid component of the slurry is either allowed to evaporate or, if it is a flammable substance such as alcohol, eliminated by ignition (the light-off process).

[redacted]

Metal Melting Furnace Emissions

Almost all emissions from a cupola are contained in the flow of air exiting the stack of the furnace, which contains particulate matter (PM) and organic compounds in addition to CO. The HAP in PM emissions from cupolas are primarily lead and manganese, with other HAP such as cadmium, chromium, and nickel present in lesser amounts. These HAP originate as impurities or trace elements in the scrap metal fed to the furnace. Organic HAP arise as by-products from combustion of coke and also from incomplete combustion of residual oil and grease on the scrap. Cupola exhaust gases contain acetophenone, polychlorinated dibenzo-p-dioxins, polychlorinated dibenzofurans, and pyrene. Most cupolas control PM emissions by dedicated baghouses or wet scrubbers. Also, most cupolas employ afterburners, which effectively destroy organic HAP. Another potential source of emissions is the charging door of a cupola in which the gas takeoff is above the charge. However, the cupola is generally operated with enough vacuum in the shaft to prevent gases from exiting the door during normal operations.

Emissions of PM from electric induction furnaces contain HAP metals such as manganese and lead, but may also contain significant amounts of chromium or nickel if stainless steel or nickel alloy castings are produced. Emissions from scrap preheaters contain PM and organic species that have not been characterized. Emissions from electric induction furnaces and scrap preheaters are controlled by baghouses, cyclones, and wet scrubbers, with emissions from both types of units often controlled by the same device. Organic emissions from scrap preheaters are typically controlled by direct flame heating of the scrap and, at one source, by afterburning the preheater emissions.

Emissions of PM from electric arc furnaces contain HAP metals such as lead and manganese, but may also contain significant amounts of chromium or nickel if stainless steel or nickel alloy castings are produced. Emissions may also include trace levels of organic substances that have not been characterized. Emissions of PM are typically controlled by baghouses. Organic emissions are controlled by natural incineration within the furnace.

Pouring, Cooling, and Shakeout Line Emissions

The majority of HAP emissions from pouring, cooling, and shakeout lines are organic HAP created by incomplete combustion of organic material in the mold and core sand. When molten metal comes into contact with organic materials in the sand such as binder chemicals and sea coal, these materials are partially volatilized and incinerated. Due to the limited availability of oxygen in the poured molds, combustion is incomplete, and the mold offgas can contain a wide variety of organic substances. The primary HAP emitted are benzene, formaldehyde, and toluene. The offgases from most molds ignite spontaneously. For floor and pit pouring, the offgas does not always spontaneously flare but is ignited by applying a flame to the mold's vent locations. Aside from lighting-off mold vents, three foundries use add-on controls to further reduce organic emissions from pouring, cooling, and shakeout lines. In addition to organic emissions, pouring lines are a source of metal HAP emissions. Metal HAP contained in the molten metal is emitted as metal fumes when the metal is poured into the molds. Baghouses and scrubbers are used to control metal HAP emissions at several pouring lines.

Mold and Core Making and Mold and Core Coating Line Emissions

Mold making using green sand produces virtually no emissions. The use of chemical binder systems, by contrast, can produce significant HAP emissions. In the process of mixing, forming, and curing, volatile constituents of these chemicals evaporate to some extent. Many binder system components contain HAP as polymerization reactants, solvents, or catalysts. Although some information on the composition of binder system components is proprietary, much is known about their HAP content. The HAP used in these chemicals and emitted in the mold and core making process include cumene, formaldehyde, methanol, naphthalene, phenol, and xylene. Also, triethylamine is commonly used as a catalyst gas in the cold box process. Most foundries capture and control triethylamine emissions with wet scrubbers that use acid solution as the collection medium. No other organic emissions from mold and core making lines are controlled. Emissions of HAP can also arise in the process of coating the molds and cores. The liquid component of the slurry may contain a HAP such as methanol. Coating emissions are controlled only where the light-off process is used to eliminate flammable constituents.

E. What are the Health Effects Associated With Emissions From Iron and Steel Foundries?

The metal HAP emitted from melting furnaces includes cadmium, chromium, lead, manganese, and nickel. Aromatic organic HAP produced by mold and core making lines; melting furnaces; and pouring, cooling, and shakeout lines contain acetophenone, benzene, cumene, dibenzofurans, dioxins, naphthalene, phenol, pyrene, toluene, and xylene. The non-aromatic organic HAP emitted are formaldehyde, methanol, and triethylamine. The known health effects of these substances are described in the "EPA Health Effects Notebook for Hazardous Air Pollutants-Draft," EPA–452/D–95–00, PB95–503579 (December 1994), which is available on-line at: *http://www.epa.gov/ttn/uatw/hapindex.html.*

Although numerous HAP may be emitted from iron and steel foundries, only a few account for essentially all of the mass of HAP emissions from these foundries. These HAP are: formaldehyde, methanol, napthalene, triethylamine, manganese, and lead.

Of the HAP listed above, benzene is a known human carcinogen of moderate carcinogenic hazard. Cadmium, 2,3,7,8–TCDD (dioxin), formaldehyde, lead, and nickel are classified as probable carcinogens. Chromium can exist in two valence states. Chromium VI is a known human carcinogen of high carcinogenic hazard by inhalation. (*Note:* Chromium III and Chromium VI by oral pathways are classified as Group D "not classifiable as to carcinogenicity in humans.") Acute effects of some of the HAP listed above include irritation to the eyes, nose, and throat, nausea, vomiting, drowsiness, dizziness, central nervous system depression, and unconsciousness. Chronic effects include respiratory effects (such as coughing, asthma, chronic bronchitis, chest wheezing, respiratory distress, altered pulmonary function, and pulmonary lesions), gastrointestinal irritation, liver injury, and muscular effects. Reproductive effects include menstrual disorders, reduced incidence of pregnancy, decreased fertility, impotence, sterility, reduced fetal body weights, growth retardation, slowed postnatal neurobehavioral development, and spontaneous abortions.

The proposed rule would reduce emissions of many of these HAP and would also reduce PM emissions, which are regulated under national ambient air quality standards. Emissions of PM have been associated with aggravation of existing respiratory and cardiovascular disease and increased risk of premature death.

We have no data to assess to what extent iron and steel foundries emissions are causing health effects. We recognize that the degree of adverse effects to health experienced by exposed individuals can range from mild to severe. The extent and degree to which the health effects may be experienced depends on:

• Pollutant-specific characteristics (*e.g.*, toxicity, half-life in the environment, bioaccumulation, and persistence);

• The ambient concentrations observed in the area (*e.g.*, as influenced by emissions rates, meteorological conditions, and terrain);

• The frequency and duration of exposures; and

• Characteristics of exposed individuals (*e.g.*, genetics, age, pre-existing health conditions, and lifestyle), which vary significantly with the population.

II. Summary of the Proposed Rule

A. What Are the Affected Sources?

The affected sources are each new or existing metal casting department, and each new or existing mold and core making department, at an iron and steel