

<http://www.epa.gov/apti/bces/module6/dioxins/dioxins.htm>

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BCES: Module 6: Air Pollutants/Control Techniques

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Module 6: Air Pollutants and Control Techniques - Dioxins and Furans - Characteristics

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Objective

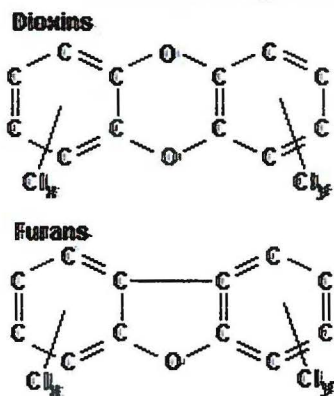
1. Describe the basic characteristics of dioxin and furan compounds.

Lesson Material

Sources of dioxins and furans include waste incinerators, cement production, fossil-fuel-fired combustors, and forest fires.

Dioxins and furans are compounds with the general chemical structure shown in [Figure 1](#). There are a large number of individual dioxin and furan compounds called congeners. There can be as few as one or as many as eight chlorine atoms substituted on the dioxin or furan ring compound.

Figure 1. General Molecular Structure of Dioxin and Furan Compounds



The dioxin and furan compounds having from four to eight chlorine atoms are considered especially toxic. All of the dioxin and furan compounds are considered potentially toxic.

Dioxin and furan compound emissions are calculated and regulated in two different ways:

1. As the total dioxin and furan compound concentrations
2. As the **Toxic Equivalency Quotient (TEQ)** concentration

The TEQ value for dioxin and furan emission is calculated according to a toxicity weighting scale. The compound 2,3,7,8 tetrachlorinated dibenzo-p-dioxin is usually considered the most toxic compound and is assigned a weighting factor of 1.0. Sixteen other dioxin-furan compounds are assigned weighting factors ranging from 0.5 down to 0.001. The observed concentrations of these seventeen dioxin-furan congeners are multiplied by these weighting factors to determine the total concentration of dioxin-furan compounds that have a toxic equivalent to 2,3,7,8 tetrachlorinated dibenzo-p-dioxin. This concentration is usually expressed as dioxin-furan compounds in TEQ nanograms per cubic meter.

The TEQ value is often used in regulatory limits because it is most closely related to the adverse health effects believed to be associated with dioxin and furan compounds.

Procedures for calculating the TEQ values are discussed in the lesson on Concentration in Module 2.

Practice Problems

Dioxins and Furans - Characteristics

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1. Describe the basic formation mechanism for dioxin and furan compounds.
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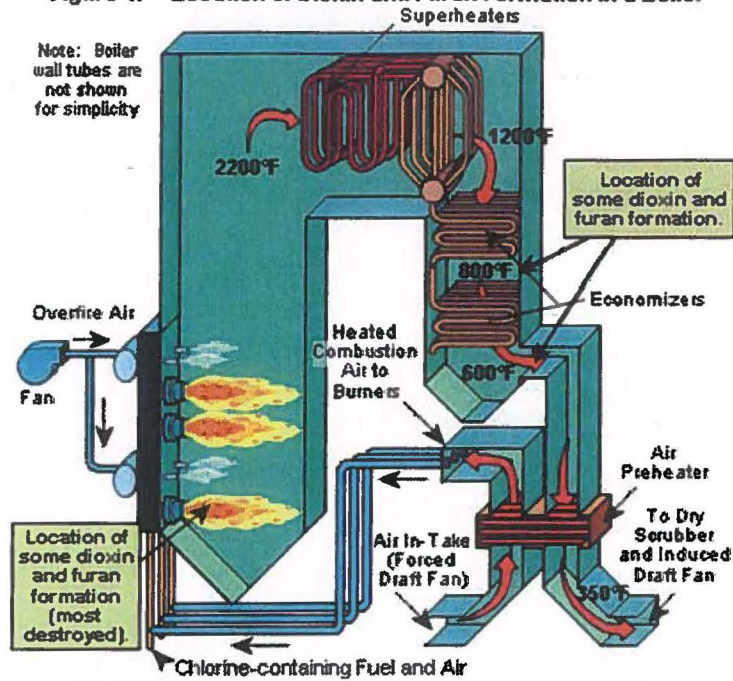
Lesson Material

The formation mechanisms for dioxin-furan compounds have not been fully identified. It is believed that there are at least three different types of formation mechanisms that are possible. All of these depend on the availability of chlorinated precursor compounds in the fuel and/or waste being burned and the appropriate gas temperature conditions. One of the proposed formation mechanisms for dioxin-furan compounds involves reactions on the surfaces of particles entrained in the gas stream.

Dioxin-furan concentrations appear to increase over the temperature range from 400 to 1,000°F. However, at temperatures well above 1,000°F, dioxin-furan compounds are readily oxidized.

As Figure 1 illustrates, some dioxins and furans form and are destroyed (i.e. oxidized) in the burner flames of combustion chambers. Most of the chlorinated precursor compounds, which originated in the fuel and/or waste, volatilize and move with the gas stream through the combustion process until they reach the temperature range favorable for dioxin and furan formation (400 to 1,000°F). A small percentage of dioxins and furans can form in boilers where the economizers and heat exchange equipment are located. Since most dioxins and furans tend to form in control devices, gas streams leaving combustion processes should be cooled to temperatures below 400°F.

Figure 1. Location of Dioxin and Furan Formation in a Boiler



Practice Problems

Dioxins and Furans - Formation Mechanisms

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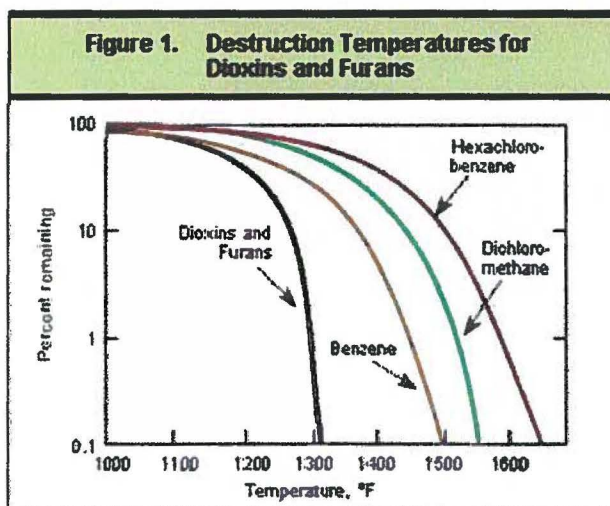
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Objective

1. Explain how concentrations of dioxin and furan compounds can be reduced.

Lesson Material

Combustion studies indicate that both dioxin and furan compounds are destroyed when the gas temperatures exceeds approximately 1400°F. In fact, oxidation of these compounds is completed at lower temperatures than some other forms of partially oxidized compounds as indicated in Figure 1. These temperatures usually exist in the combustion zones of incinerators and fossil-fuel-fired boilers.



The formation mechanisms decrease to negligible rates when the gas stream temperature decreases below 400°F. Accordingly, ensuring that the gas stream is sufficiently cooled prior to the air pollution control system can eliminate this formation mechanism. Cooling is accomplished in the heat recovery equipment ([economizers](#) and [air preheaters](#)) or in the incinerator waste heat boilers.

The best way to control dioxin and furan emissions is preventing their formation by reducing or eliminating the chlorine in the fuel and waste material being burned.

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