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MEMORANDUM

To: Air Quality Permitting Staff

From: John Preczewski, P.E., Assistant Director
Air Quality Permitting Program 

Date: March 29, 2011

Subject: Confirmation of Minimum Enclosed Combustion Chamber Temperature

This memorandum confirms and clarifies the long standing State-of-the-Art (SOTA) for minimum temperatures of thermal oxidizers.

BACKGROUND

Enclosed combustion chambers, also known as afterburners, secondary combustion chambers, thermal oxidizers, and enclosed flares, are standard air pollution control devices that have been used in many applications to control volatile organic compounds (VOC), as well as organic hazardous air pollutants (HAP). The afterburner treats the VOC and organic HAP by creating an environment intended to promote contaminant reaction with oxygen to produce carbon dioxide and water. The four primary factors used to determine the afterburner's effectiveness are oxygen, time, temperature, and turbulence. Literature and stack test data both have demonstrated that sufficient oxygen and temperature are the critical parameters when determining if the afterburner can achieve the proposed destruction and removal efficiency. Lowering the temperature lowers combustion efficiency exponentially.

SOTA

The presumptive norm for State-of-the Art afterburners utilized to control VOC and/or HAPs is a design destruction efficiency (DE) of at least 99%. In the event a facility is unable to achieve, in practice, a minimum 99% DE, the Department may accept a lesser actual DE level provided a minimum 95% DE is achieved. Where less than 99% is accepted, a minimum 0.5 second residence time, and a minimum temperature of 1500 degrees Fahrenheit (^oF) must be

specified in the permit and achieved in practice for most VOCs. For refractory compounds, such as chlorinated hydrocarbons, higher temperatures are necessary.

PERMIT CONDITIONS

For a feed stream of consistent quality and consistent quantity, and for which a stack test has demonstrated a minimum 99% DE at a lower temperature, allowing a lower minimum temperature than 1500⁰F may be considered on a case-by-case basis. Where a lower temperature is accepted, monitoring to confirm compliance is to be included in the permit. The presumptive norm for permit conditions for monitoring afterburners is a continuous hydrocarbon emission monitor, and a maximum hydrocarbon discharge concentration. For landfill flares, and any other designs not meeting the presumptive norm, a case-by-case review, as discussed below, must be applied.

HARD TO BURN COMPOUNDS

When evaluating multipollutant exhaust streams, each contaminant's destruction temperature and emission rate without additional control must be evaluated. The temperature and residence time necessary to thermally destroy each individual VOC or organic HAP contaminant in the exhaust stream must be determined. As shown in the attached table, "Thermal Destruction of Organic Toxic Compounds," the minimum temperature necessary to thermally destroy a given contaminant at a unique residence time varies. For example, an afterburner with a residence time of 0.5 seconds with a minimum temperature of 1522 degrees Fahrenheit (⁰F) can achieve a destruction efficiency of 95% when processing a dichloromethane exhaust stream. The same afterburner would achieve the 95% efficiency when treating a tetrachloroethylene exhaust stream only if a minimum temperature of 1842⁰F is maintained.

OTHER CONSIDERATIONS

Incomplete combustion occurs when: 1) there isn't enough oxygen to allow the contaminants to react completely to produce carbon dioxide and water; and 2) when the combustion is hindered by insufficient temperature. Incomplete combustion results in the carbon monoxide emissions, as well as other products of incomplete combustion (PICs). For example, the partial oxidation of ethanol can produce acetaldehyde, which results in a non-HAP VOC being converted into a HAP VOC. The potential for the formation of HAP must be a factor in deciding the minimum operating temperature. The presence of chlorine is especially important because of the possibility for chlorinated PICs, which can be HAPs.

In summary, many variables must be considered when determining an afterburner's effectiveness. These include, but are not limited to, oxygen, time, temperature, turbulence, the types and quantities of contaminants being treated, and the potential for incomplete combustion. Please see attachment.

Pollution Engineering, Thermal Destruction of Organic Toxic Compounds, March 1990, Temperatures needed for a destruction efficiency of 95%, at a residence time of 0.5 seconds

Compound	Temperature (degree Fahrenheit)
Toluene	1,351
1,1,1 Trichloroethane	1,218
Xylene	2,116
Dichloromethane	1,522
Freon 113	1,473
Trichloroethylene	1,592
Tetrachloroethylene	1,842
Benzene	1,489
Chloroform	1,190
Carbon Tetrachloride	1,445
Methanol, Ethylene, Propylene, Styrene, Glycol Ethers	1,445