# Public Comments on the Proposed Revisions to Section 3.2 Chapter 2 (Incinerators and Oxidizers) of the Control Cost Manual

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# List of Commenters

Comments were received from three trade associations: two trade associations representing industrial sources and one representing manufacturers of air pollution control devices. Table 1 lists the individuals that submitted comments on the proposed updates to Chapter 2, Incinerators and Oxidizers. All comments submitted by the commenters and EPA's responses to the comments are summarized in this document.

| Document Control Number | Commenter Name | Commenter Affiliation |
|---|---|---|
| EPA-HQ-OAR-2015-0341-0040 | Ted Steichen, Senior Policy Advisor | American Petroleum Institute (API) |
| EPA-HQ-OAR-2015-0341-0042 | Paul Noe, Vice President for Public Policy | American Forest & Paper Association, et al. |
| EPA-HQ-OAR-2015-0341-0043 | Michael Stafford, Interim Executive Director | Institute of Clean Air Companies (ICAC) |

## 1.0 General Comments

**Commenter: American Petroleum Institute (API)**
**DCN: EPA-HQ-OAR-2015-0341-0040**
**Comment:** The commenter recommended the title of the chapter be changed to clarify its applicability. While this chapter includes useful general information on oxidizers, the commenter contends it provides only detailed information on package units installed in open locations with virtually no associated facilities. The commenter cited text from page 2-20 of the draft (Section 2.2.4) that indicated that the equipment cost correlations included in the chapter are for packaged units only, with the cost correlations for regenerative oxidizers that are valid only for field-erected units. The commenter said there was nothing in the cost discussions to distinguish the differences in field-erected regenerative oxidizers from other types of oxidizers and thus the chapter appears to only discuss package units. The commenter noted that the cost estimates do not reflect the costs for field construction versus package installation or the auxiliary costs associated with installing the package units. To accurately reflect the limitations of the cost estimate information in this chapter, the commenter suggested: (1) the chapter title be changed to "Incinerators and Package Oxidizers"; (2) the title of section 2.5 be changed to "Cost Analysis for Package Thermal and Catalytic Oxidizers"; and (3) the text throughout Section 2.5 be revised to be clearer on the facilities that are not addressed.

**Response:** The EPA agrees that with the commenter that the cost correlations for regenerative oxidizers are for field constructed units, while the cost correlations for all other oxidizers are for package units. We have added text to section 2.5 to clarify the units that are covered by the cost equations in that section, as suggested by the commenter. However, we have not changed the chapter and section titles as recommended by the commenter. While we agree that many of the cost correlations included in section 2.5 were developed using data for package units, we disagree with the commenter's assertion that the chapter applies only to package units. We note that the detailed technical discussions regarding the design and operation of the various types of oxidizers included in sections 2.1 and 2.2 apply to both package and field erected units. Similarly, the procedures outlined in section 2.4 for determining the basic design characteristics for thermal and catalytic oxidizers apply are also of general applicability to both package and field erected units.

**Commenter: Institute of Clean Air Companies (ICAC)**
**DCN: EPA-HQ-OAR-2015-0341-0043**
**Comment:** Because of the influence the Control Cost Manual has on air pollution control and regulatory decisions made by the EPA, permitting authorities, and industry, the commenter stated that it is important that the information contained in the manual is of the highest quality possible so that decisions are equitable, sound, and will identify control strategies that are effective and economically feasible. The commenter noted that much work has been done to understand the mechanisms that influence the control of VOC emissions since these chapters were last published and a number of technical conferences that have recently been devoted to the control of VOC emissions. The commenter recommended that the EPA review the most recent information available and update its technical references and said that many of the references are

out of date and include references to companies that are no longer in business. The commenter said that technical papers should be used in instead of company web pages because the later are often drafted by marketing departments. The commenter said that the use of references from thirty or more years ago "significantly compromises the ongoing value of the cost manual." The commenter acknowledged that the engineering aspects addressed in the chapter are still valid but said there are advancements in VOC controls that need to be captured to address all the information a company needs to know to purchase, install and operate the state-of-the-art technology. The commenter noted that there have been advancements both in capital costs and in installation and operation of the equipment

**Response:** The EPA thanks the commenter for their input and note that the Agency conducted a review of current costs and technology advances through extensive searches of various information sources, including databases (e.g., the EPA's Clearinghouse), construction permits, journal articles, vendor information, EPA documents, and conference presentations. The EPA updated the chapter based on the information collected during this research. We also published a notice of data availability in the Federal Register that specifically solicited comment on the draft chapter, including comments on how the capital and operating costs should be updated and information on technology advances (see 81 FR 65353, September 22, 2016). In addition to this request, we also reached out to vendors through separate correspondence. New information provided by this and other commenters has been incorporated into the final chapter. The final chapter includes all the represent the best data currently available to us.

Although we agree that some references are several years old, we disagree with the commenter's assertion that the inclusion of older references "significantly compromises the ongoing value of the Cost Manual." We note that the basic engineering principles governing the design and operation of oxidizers remain the same and hence many of the original references included in earlier versions of the chapter remain valid. References to more recently published sources are included for the various technology advances presented and where more modern sources are available.

As noted by the commenter, we have included information gathered from manufacturers and provided references to these sources. We consider manufacturers to be an appropriate and valuable source of information, particularly for information on recent advancements and cost data. Our goal is to provide balanced, impartial and unbiased information that is accurate and useful to industry and regulators. To that end, the Cost Manual does not promote any control technology or manufacturer. We name a manufacturer where the information was available only through that specific manufacturer and we felt the information was sufficiently important and would be useful to readers. For example, we sometimes name a manufacturer where the manufacturer was responsible for developing a new or innovative technology and is the sole supplier. Where we cite an individual manufacturer's data, we make it clear that the information was reported by that manufacturer and is not based on independent testing or experience reported by industry. Where information is available from two or more manufactures, we provide references to all. Therefore, we consider the inclusion of manufacturer data to be reasonable and appropriate.

**Commenter: Institute of Clean Air Companies (ICAC)**
**DCN: EPA-HQ-OAR-2015-0341-0043**
**<u>Comment</u>:** The commenter suggested the Cost Manual could be made more useful it were updated to reflect today's information environment in people use Google and other "apps". The commenter suggested an "app" or online calculator for estimating costs or LEL would be useful and would likely reach a wider audience.

**<u>Response:</u>** The EPA agrees with the commenter and has developed an MS Excel spreadsheet that allows users to easily estimate capital and annual operating costs for thermal and catalytic oxidizers. The spreadsheet is available to the public via download from our website, https://www.epa.gov/economic-and-cost-analysis-air-pollution-regulations/cost-reports-and-guidance-air-pollution).

## 1.1 Introduction

**Commenter: American Petroleum Institute (API)**
**DCN: EPA-HQ-OAR-2015-0341-0040**
**<u>Comment</u>:** The commenter recommended Table 2.1 be removed. The noted that only one of the costs presented is from an actual installation (the sewage sludge incinerator) and that is the only entry for an incinerator. All the other entries, they argue, are estimates for Thermal Oxidizers (TOs), apparently mostly for only the major equipment and based on estimates using the Control Cost Manual. Some entries do not include a capital cost entry and none indicate what major equipment is included in the cited costs or indicate if any auxiliary equipment is included. The commenter said that the equipment costs are only a portion of total costs, even for small package units located on clear sites, where significant site and auxiliary facilities are not required. The commenter said that this table provides an incomplete representation of thermal oxidizer costs and does not provide any information that is independent of the Control Cost Manual. The commenter stated that it adds little to the introductory comments and for that reason recommended it be deleted.

**<u>Response</u>:** Table 2.1 is intended to provide example capital costs for past projects and to show the range and types of industries that have installed oxidizers over time. The EPA agrees with the commenter that the table includes both estimated costs and actual costs. However, we included a column in the table that clearly indicates whether the data reflects actual costs, estimated costs, or vendor quotes, as could best be determined with the available information for each unit. We also included references in the table so that users may access the original documents for additional information. Although we agree with the commenter the table does not show costs for all types, designs and sizes of the oxidizers, the table includes all information currently available to the Agency.

**Commenter: Institute of Clean Air Companies (ICAC)**
**DCN: EPA-HQ-OAR-2015-0341-0043**
**<u>Comment</u>:** In the introduction (section 2.1, second paragraph), the commenter said it would be useful to also mention waste heat recovery. In many VOC applications, the commenter said that

the value from the by-product streams can be extracted in the form of thermal energy for a range of uses (process heat, electrical power generation, etc). This should be factored in to overall costs considerations if possible.

**Response:** Based on this comment, the EPA has revised the paragraph to read as follows:

"Incineration, like carbon adsorption, is one of the best known waste treatment methods for industrial gas. Carbon adsorption allows recovery of organic compounds that may have value as commodity chemicals. In contrast, however, incineration is an ultimate disposal method in that the combustible compounds in the waste gas are destroyed rather than collected. A major advantage of incineration is that virtually any gaseous organic stream can be incinerated safely and cleanly, provided proper engineering design and management are used. **In some applications, waste heat from the oxidizer can be recovered and used in other processes or converted to electric power.**"

**Commenter: Institute of Clean Air Companies (ICAC)**
**DCN: EPA-HQ-OAR-2015-0341-0043**
**Comment:** In the introduction (section 2.1, third paragraph), the commenter noted that the statement about regenerative thermal oxidizers may no longer be accurate. The commenter said that Recuperative Thermal Oxidizers are likely more common across all industries and regions of US.

**Response:** Based on this comment, the EPA has revised the paragraph as shown below:

"The main types of thermal oxidizers are direct fire, catalytic, recuperative, and regenerative. **Historically,** the most commonly used is the regenerative thermal oxidizer (RTO)**, although the recuperative thermal oxidizer is becoming more common.**"

## 1.2 Process Description

**Commenter: American Petroleum Institute (API)**
**DCN: EPA-HQ-OAR-2015-0341-0040**
**Comment:** The commenter stated that the thermal oxidizer (TO) process discussions in sections 2.2 through 2.4 are "a good overview", but suggested the discussion of TO/scrubber systems should be expanded. They recommended the second paragraph of Section 2.2 be expanded to reflect the fact that thermal oxidizer/scrubber systems are often used as the control for the sulfur or halogen species in a vent and the associated hydrocarbon removal may be incidental and might not be required without the sulfur or halogen control need. Since it is often very difficult to control sulfur or halogen-containing releases, combustion followed by caustic scrubber is often the most cost effective and environmentally beneficial approach to control of compounds containing these species.

**<u>Response</u>:** The EPA agrees with the commenter's remarks and has made the following revisions to section 2.2:

"**Waste streams containing halogenated and/or sulfur compounds are difficult to control using only an oxidizer because** ~~When chlorinated~~ **the oxidizer converts the halogenated** or sulfur-containing compounds ~~are~~ present in the **waste gas** mixture~~, the products of complete combustion include the~~ acid components**, such as** HCl **and** ~~or~~ $SO_2$, ~~respectively,~~ in addition to $H_2O$ and $CO_2$. In general, **for waste** ~~these~~ streams **containing these compounds, plants may need to install** ~~would require~~ ~~removal of these components by~~ an acid gas removal system, such as a wet scrubber unit**, after the oxidizer**. **An oxidizer followed by caustic scrubber is can be a cost effective and environmentally beneficial approach to control waste streams containing these species. However, the additional cost of installing and operating an acid gas removal system must be considered as it** ~~which~~ could greatly affect the cost of the incineration system. (**For information on how to design of acid gas controls, please see Section 5 of Cost Manual.**~~The sizing and costing of these scrubbers is covered in the "Wet Scrubbers" chapter of this Manual.~~)"

**Commenter: American Forest & Paper Association, et al.**
**DCN: EPA-HQ-OAR-2015-0341-0042**
**<u>Comment</u>:** The commenter found that in general the process descriptions and other information that are presented in Section 2.2 regarding thermal and catalytic oxidizer technologies appeared to be complete and accurate.

**<u>Response</u>:** The EPA thanks the commenter for their input.

**Commenter: American Petroleum Institute (API)**
**DCN: EPA-HQ-OAR-2015-0341-0040**
**<u>Comment</u>:** The commenter recommended the discussion of RTOs mention the Eisenmann design. They noted that is a newer design that addresses many of the valving problems in traditional designs. In Eisenmann RTOs, there is no valve switching involved but a slowly rotating bed. This saves the wear and tear (frequent issues) with valve switching and the transition problems discussed in the current Cost Control Manual discussion. Additional information is available at http://www.eisenmann.com/en/products-and-services/environmental-technology/exhaust-air-purification.html.

**<u>Response</u>:** The EPA agrees with the commenter's recommendation and has made the following revisions to the discussion to Section 2.2.2:

"**The typical regenerative** ~~Regenerative~~ oxidizer~~s~~ uses valves (typically butterfly or poppet valves)[1] to alternate the airflow direction through the media beds and thereby maximize energy recovery. Since the late 1990s, some RTOs have been designed with a single rotary valve that reduces the number of moving parts and may require less maintenance. The high-energy recovery within these oxidizers reduces the auxiliary fuel requirement and saves operating cost.

[1] See http://airclear.net/regenerative-rto-thermal-oxidizer/.

At organic concentrations as low as 3 to 4 percent of the LEL, some of these oxidizers achieve high destruction efficiency and self-sustaining operation with no auxiliary fuel usage.[2,3]

**In recent years, a new system has been developed that uses a rotating distributor in place of the valve and damper system. In this system, the packed ceramic honeycomb elements of the heat exchanger are divided into sections and is rotated so that different sections of the heat exchanger serve the cooling phase while another section serves the heating phase. The waste gas flows through the RTO's heat exchanger from the bottom to the top, thereby heating the waste gas to the combustion temperature. The hot gases of combustion then flow down through the other side of the rotating heat exchanger where the waste heat is absorbed. This design eliminates the need for complicated valve and damper switching systems and is said to eliminate fluctuations in flow caused by valve switching.[4]"**

**Commenter: American Petroleum Institute (API)**
**DCN: EPA-HQ-OAR-2015-0341-0040**

**Comment:** The commenter recommended the discussion of flameless thermal oxidizers should be clarified. The commenter said that the discussion of flameless thermal oxidizers clarify that this process is not applicable to all situations and noted that it may only be used where there is enough hydrocarbon concentration to generate the heat required to maintain the reaction.

**Response:** The EPA disagrees with the commenter. Although flameless thermal oxidizers operate more efficiently and at lower operating costs with optimal hydrocarbon concentrations, FTOs can treat a wide range of waste gas compositions. However, waste streams with lower hydrocarbon concentrations can be treated in FTOs by using supplemental electric heating and addition of supplemental fuels to the waste stream. For clarification, we made the following changes to the discussion of flameless thermal oxidizers:

"In this process, the exhaust stream is mixed with air before entering the flameless reactor vessel. The air mixture is evenly distributed into a bed of inert ceramic material coated with a metal catalyst. This bed provides complete mixing of the VOC with oxygen. The VOC oxidizes into carbon dioxide and water vapor once the mixture reaches the combustion temperature. The released combustion energy is absorbed by the ceramic bed and is transferred to the exhaust stream leaving the catalytic oxidizer. The temperature control of the system is very important in effective oxidation of VOCs. This process is a flameless incineration, as opposed to catalytic incineration, which uses an external fuel source. The catalytic oxidizer uses the heat of the exhaust **to maintain combustion**. **To ensure the proper operation of the FTO,** ~~and~~ the exhaust gas entering the reactor needs to be at least 600°F. ~~for proper operation~~ **Ideally, the hydrocarbon concentration of the waste stream entering the system is high enough to generate the heat required to maintain the reaction**.[5] **However, FTOs can be used in applications where the hydrocarbon content of the waste stream is insufficient to maintain**

[2] See http://www.anguil.com/oxidizers/regenerative-thermal.aspx.
[3] See http://airclear.net/regenerative-rto-thermal-oxidizer/ .
[4] http://www.eisenmann.com/en/products-and-services/environmental-technology/exhaust-air-purification.html.
[5] http://www.arb.ca.gov/pm/pmmeasures/ceffect/reports/sjvapcd_4692_report.pdf

**the optimal operating temperature. In such situations, electric heat or supplemental fuels must be added to the waste stream to maintain the optimal operating temperature.[6]"**

**Commenter: American Forest & Paper Association, et al.**
**DCN: EPA-HQ-OAR-2015-0341-0042**
**Comment:** In response to the EPA's requested feedback on the accuracy of the VOC destruction efficiency estimates included in the draft chapter, the commenter agreed with the EPA's approach of presenting general information about the VOC destruction efficiency of thermal oxidizer systems, noting that this approach was appropriate because the level of VOC destruction that can be achieved depends on several factors, including the specific VOC constituents to be combusted, the temperature of the oxidizer's combustion chamber, and the residence time of the VOC constituents within the combustion chamber.

However, the commenter noted that section 2.2.2 references a VOC destruction efficiency of 98% for non-halogenated organics and states that field test data indicate that "commercial incinerators" should be operated at a combustion chamber temperature of 1600°F and a nominal residence time of 0.75 seconds to achieve this level. Because this Subsection is entitled "Thermal Oxidizers", the commenter said they assume that these data are intended to refer to oxidizers used for VOC control and not incinerators used for solid waste management. The commenter said they have found that oxidizer system suppliers are generally willing to offer performance guarantees for VOC destruction efficiency at this level (98%) or higher.

The commenter also agreed with the general information on provided in the chapter on factors influencing the destruction efficiency provided in section 2.2.3. They agreed that destruction efficiency achieved by catalytic oxidizers depends on several factors (including the specific VOC compounds being destroyed, catalyst operating temperature, residence time, and catalyst formulation).

**Response:** The EPA thanks the commenter for their input.

**Commenter: American Petroleum Institute (API)**
**DCN: EPA-HQ-OAR-2015-0341-0040**
**Comment:** The commenter noted that in the Incinerator Chapter, equation 2.1 is not balanced and contains an equal sign where a plus sign should be. The commenter said that Equation 2.1 should be:

$C_xH_yO_z + (x+y/4-z/2)O_2 \text{-->} xCO_2+(y/2)H_2O$

[6] http://www.lindeus-engineering.com/internet.le.le.usa/en/images/FTO%20Technology%20Datasheet%200716%20Web136_279769.pdf?v=1.0.

**<u>Response</u>:** The EPA agrees with the commenter that Equation 2.1 contained typographical errors. The EPA has corrected this equation in the final chapter.

**Commenter: Institute of Clean Air Companies (ICAC)**
**DCN: EPA-HQ-OAR-2015-0341-0043**
**<u>Comment</u>:** The commenter was concerned the information provided for the different types of oxidizers was sometimes uneven and not uniform in terms of depth and scope. The commenter said they would like to assist by providing more information.

**<u>Response</u>:** In preparing the Cost Manual, we strive to provide as much information as possible about each air pollution control technology. However, the information available to us is sometimes limited and in such cases the descriptions of the technology is not as detailed as we would like. In separate correspondence, ICAC provided additional information on catalyst life, catalyst regeneration methods, and other general information. We thank the commenter for providing this information and have incorporated it into the appropriate sections of the final chapter, as discussed in our responses to other comments from ICAC covered elsewhere in this document.

**Commenter: Institute of Clean Air Companies (ICAC)**
**DCN: EPA-HQ-OAR-2015-0341-0043**
**<u>Comment</u>:** In Section 2.2, second paragraph, the commenter noted that NOx and nitrogen bearing compounds may also be present.

**<u>Response</u>:** The EPA agrees with the commenter's remarks and has made the following revisions to section 2.2:

"When chlorinated, sulfur **and nitrogen** compounds are present in the mixture, the products of complete combustion include the acid components**, such as HCl, $SO_2$, and NOx,** in addition to $H_2O$ and $CO_2$. In general, these streams would require removal of these components by an acid gas removal system – such as a wet scrubber unit – which could greatly affect the cost of the incineration system. (The sizing and costing of these scrubbers is covered in the "Wet Scrubbers" chapter of this Manual.)"

**Commenter: Institute of Clean Air Companies (ICAC)**
**DCN: EPA-HQ-OAR-2015-0341-0043**
**<u>Comment</u>:** The commenter suggested that the following sentence be added to section 2.2: "Secondary energy recovery is generally not used unless there is a specific on site use for the steam or hot water, in which case it can be economically advantageous."

**<u>Response</u>:** The EPA agrees with the commenter's suggestion and has added the recommended text to section 2.2.

"Energy efficiency can be further improved by placing another ("secondary") exchanger downstream of the primary exchanger to recover additional energy from the effluent stream (e.g., to generate low pressure process steam or hot water). ~~However, S~~Secondary energy recovery **can be economically advantageous where there is a use for the steam or hot water. However, secondary energy recovery** is generally not used, unless there is a specific on-site use for **it**~~the steam or hot water~~."

**Commenter: Institute of Clean Air Companies (ICAC)**
**DCN: EPA-HQ-OAR-2015-0341-0043**
**<u>Comment</u>:** ***The commenter*** suggested using the term "Destruction and Removal Efficiency (DRE) since this phrase is commonly used in regulations and permits.

**<u>Response</u>:** The EPA agrees with the commenter and has revised the draft chapter to replace references to the control efficiency with the phrase "Destruction and Removal Efficiency (DRE)".

**Commenter: Institute of Clean Air Companies (ICAC)**
**DCN: EPA-HQ-OAR-2015-0341-0043**
**<u>Comment</u>:** For the last paragraph in section 2.2, the commenter thought it was confusing to cluster gaseous and solid waste units in the same paragraph. The first portion of this section focuses on gaseous waste streams and then solid waste is thrown in at the end of this paragraph. The commenter thought it would be helpful for the previous section to include a new opening paragraph organizing the content in this section and framing up gaseous and solid waste solutions.

**<u>Response</u>:** The EPA agrees with the commenter's remarks and has made the following changes to the last paragraph in section 2.2:

"~~There are a number of~~ **There are several** different ~~incinerator and~~ oxidizer designs. ~~For oxidizers, T~~**These** designs can be broadly classified as thermal systems and catalytic systems. Thermal systems may be direct flame incinerators with no energy recovery, flame incinerators with a recuperative heat exchanger, or regenerative systems ~~which~~ **that** operate in a cyclic mode to achieve high energy recovery. Catalytic systems include fixed-bed (packed-bed or monolith) systems and fluid-bed systems, both of which provide for energy recovery. ~~For solid waste incinerators, there are six different designs, all of which use thermal energy to combust waste materials and destroy VOC and HAP. These designs are grate incinerators (fixed or moving), rotary kilns, multiple hearth incinerators, fluid bed incinerators, controlled-air, and excess air incinerators.~~

Solid waste incinerators operate in a similar manner to oxidizers but receive solid and liquid waste, instead of waste gas streams. For solid waste incinerators, there are six different designs, all of which use thermal energy to combust waste materials and destroy VOC and HAP. These designs are grate incinerators (fixed or moving), rotary kilns, multiple hearth incinerators, fluid bed incinerators, controlled-air, and excess air incinerators.

**Oxidizers and incinerators vary in size. They** may be small, prefabricated, modular designs or larger units that must be constructed onsite. Some of the larger units, particularly those used to combust municipal waste, include heat recovery systems that can be used for steam and/or electricity production."

### 1.2.1 Solid Waste Incinerators

**Commenter: American Petroleum Institute (API)**
**DCN: EPA-HQ-OAR-2015-0341-0040**
**Comment: The commenter noted that t**he first sentence of section 2.2.1 is incomplete.

**Response:** The EPA has corrected the sentence to read as follows:
"Solid waste incinerators typically emit hazardous air pollutants, including dioxin, furan, mercury, lead, cadmium, and other heavy metals. . . ."

**Commenter: American Forest & Paper Association, et al.**
**DCN: EPA-HQ-OAR-2015-0341-0042**
**Comment:** The commenter said that most of the information presented in section 1.2.1 appears to be factually accurate, but, as the information addresses nine different incinerator types, the level of detail provided for each type is somewhat incomplete. The commenter disagreed with including incinerators in this chapter, stating that they are fundamentally different than oxidizers used for VOC emissions control, and the rationale for providing information about solid and liquid waste incineration in this revision is not clear. In some industries, solid or liquid waste incineration systems provide a secondary function, being used to combust gaseous process exhaust streams. However, the commenter argued that the primary purpose of these systems is to manage solid or liquid waste streams, not to control air pollution. The commenter recommended the EPA either remove the new information about solid waste incinerators, or better explain how including this information helps achieve the Agency's goals for the Manual.

**Response:** The EPA has decided to include general information regarding waste incinerators in the revised chapter because they employ the same thermal oxidation process used in oxidizers to control VOC and HAP destruction.

### 1.2.2 Thermal and Catalytic Oxidizers

**Commenter: Institute of Clean Air Companies (ICAC)**
**DCN: EPA-HQ-OAR-2015-0341-0043**
**Comment:** ***Table 2.3 – Temperature for toluene - T***his seems low. More like 450F. For toluene, data from Kenson, Plant Engineering, and Suter suggest the ignition temperature (50% conversion) ranges from 460°F to 560°F.

**Response:** The temperature for toluene destruction has been revised to reflect the new information provided by the commenter.

**Commenter: American Forest & Paper Association, et al.**
**DCN: EPA-HQ-OAR-2015-0341-0042**

**Comment: The commenter noted that t**he chapter provides very little information on the VOC destruction efficiency of incinerator systems and the information presented about the VOC destruction efficiency of thermal oxidizer systems is somewhat general. The commenter said that this is appropriate because as described on page 2-11 of section 2.2.2, the level of VOC destruction that can be achieved depends on a number of factors, including the specific VOC constituents to be combusted, the temperature of the oxidizer's combustion chamber, and the residence time of the VOC constituents within the combustion chamber. The revision of this Chapter appears to contain essentially the same discussion about VOC destruction efficiency and the factors that influence it as was included in the previous revision.

**Response:** The EPA agrees with the commenter that destruction efficiencies can vary based on site-specific factors, such as the composition of the waste stream, as well as on the design of the oxidizer used. However, we believe that the discussion included in section 2.2.2 of draft chapter adequately covers the factors that impact the control efficiency for thermal oxidizers. For catalytic oxidizers, we have added some additional information describing how higher efficiency can be achieved by increasing the amount of catalyst.

**Commenter: Institute of Clean Air Companies (ICAC)**
**DCN: EPA-HQ-OAR-2015-0341-0043**
**Comment:** For Section 2.2.2, the commenter suggested that the fundamentals of oxidation section should begin with the concept of time, temperature and turbulence. Turbulence in the form of "mixing" is discussed later in the section, but the commenter suggested revising this section to lead with a discussion of the time, temperature and turbulence.

**Response:** Although we agree with the commenter that time, temperature and turbulence are important concepts in the design of all thermal oxidizers, we believe that the current organization of section 2.2.2, where we begin with a description of the typical system, is a reasonable and appropriate approach. Consequently, not changes have been made to the structure of section 2.2.2.

**Commenter: Institute of Clean Air Companies (ICAC)**
**DCN: EPA-HQ-OAR-2015-0341-0043**
**Comment:** For the calculation in Section 2.2.2, the commenter noted that there are a number of independent sources and suggested a third party source not associated with a single supplier should be used. The commenter said they could help find such a reference.

**Response:** While we agree with the commenter that a third-party source for the calculation would be preferable, the commenter did not provide a reference and we were unable to located one. Consequently, no changes were made as a result of this comment.

**Commenter: Institute of Clean Air Companies (ICAC)**
**DCN: EPA-HQ-OAR-2015-0341-0043**
**Comment:** ***For section 2.2, the commenter recommended*** noting that mixing (or turbulence) is a feature that OEMs incorporate into their designs and that there may be additional adjustments that can be made after startup. The commenter said that this paragraph can be rewritten to be more specific about how turbulence is handled in the design and after startup.

**Response:** No changes have been made in response to this comment as it is unclear from the comment what other information regarding turbulence should be included.

**Commenter: Institute of Clean Air Companies (ICAC)**
**DCN: EPA-HQ-OAR-2015-0341-0043**
**Comment:** With reference to section 2.2.2 (regenerative thermal oxidizers) and the discussion of natural gas injection, the commenter said there may be ways to update and expand this section and to include insights on applicability and on limitations.

**Response:** No changes have been made in response to this comment as it is unclear what other insights or limitations should be included.

**Commenter: Institute of Clean Air Companies (ICAC)**
**DCN: EPA-HQ-OAR-2015-0341-0043**
**Comment:** The commenter recommended section 2.2.2 (regenerative thermal oxidizers) be updated to reflect even and odd, and multi-can/multi-chamber, single can, etc.

**Response:** Multi-chambered regenerative thermal oxidizers are discussed included in section 2.2.2, where we explain that this approach can be used to reduce the volume and frequency of "puffs" that result when the gas flow is reversed in a single-chambered regenerative thermal oxidizer.

**Commenter: Institute of Clean Air Companies (ICAC)**
**DCN: EPA-HQ-OAR-2015-0341-0043**
**Comment:** The commenter said that the example provided in the third paragraph in Section 2.2.2 (regenerative thermal oxidizers) appears to come from a single manufacturer's sales literature. The commenter felt it would be more balanced to either delete this sentence or revise the paragraph to mention alternate technologies as well. The commenter thought it is likely that recent TOs have been used on "lower concentration streams given the priority of promulgation of regulations for different industries...starting with the most polluting higher concentration sources and moving toward the lower concentration sources..."

**Response:** The example mentioned by the commenter is intended to help readers understand the relationship between residence time and temperature. It is provided only for illustrative purposes and is not intended to be used as a guide to the selection of any particular oxidizer design or manufacturer. Since we believe the example helps readers understand the impact of residence and it is the only data available to us, we decided to retain the example in the final chapter.

**Commenter: Institute of Clean Air Companies (ICAC)**
**DCN: EPA-HQ-OAR-2015-0341-0043**
**Comment:** In Section 2.2.2 (recuperative thermal oxidizers), the commenter said that the discussion of secondary heat recovery can be improved and recommended we include data on the level of heat recovery achieved and the combined total heat recovery. The commenter also said that it may be possible to include a better discussion of the boundary conditions for plate and tube and sheet HX, but did not provide any additional information.

**Response:** No changes have been made in response to this comment as it is unclear what other insights or limitations should be included.

### 1.2.3 Other General Comments

***Comments on the Expected Equipment Life:***

**Commenter: American Forest & Paper Association, et al.**
**DCN: EPA-HQ-OAR-2015-0341-0042**
**Comment:** The commenter noted that the EPA did not include information in this chapter on equipment life, but that the cost estimate example presented in section 2.5 uses an estimated equipment life of 20 years for the oxidizer and four years for the catalyst used in a catalytic oxidizer. The commenter said that establishing a "reasonable" estimate of equipment life is difficult for oxidizer systems because it varies depending on the conditions under which the oxidizer serves. They added that systems that handle corrosive waste gases have a relatively shorter operational life than other systems. They also noted that systems that operate continuously at the same temperature have longer operational lives than systems which undergo frequent startup and shutdown cycles. The commenter recommended the EPA conduct further research about actual installed oxidizer equipment systems to obtain the most technically supportable information about the range of expected equipment life and the factors that influence it.

**Response:** The EPA agrees with the commenters that equipment and catalyst life is impact by the conditions under which the oxidizers are operated. The data presented in the chapter provides the data we obtained from searches of publicly available information. In the Notice of Data Availability, we specifically solicited comment on the equipment life of oxidizers (see 81 FR 65353, September 22, 2016), but we received only very limited data from industry or vendors in response to our request. As we noted in Section 2.5, we believe that the 20-year equipment life for the oxidizer and 4 years for catalysts used in the example is reasonable for most oxidizers and catalysts based on information available to us. We agree with the commenter that the equipment and catalyst life vary and are impacted by the types of waste gases controlled and the operating conditions under which the system is operated. We note that a discussion of the factors impacting catalyst life are already discussed in detail in section 2.5.2. However, we agree with the commenter's recommendation that a more detailed discussion of the factors impacting equipment life be included in the chapter and have added the following text to section 2.2:

"Equipment life for an oxidizer is variable and depends on several factors, including the system design, composition of the waste gas stream, and the temperatures experienced by the oxidizer. In general, oxidizers that handle corrosive waste gases or higher levels of particulates will have a shorter operational life. Systems that undergo frequent fluctuations in temperature or more frequent startup-shutdown cycles will have a shorter operational life than systems where a steady temperature is maintained."

**Commenter: Institute of Clean Air Companies (ICAC)**
**DCN: EPA-HQ-OAR-2015-0341-0043**
**<u>Comment</u>:** The commenter said that over the last 30 years, the VOC oxidation industry has made many advances in technology. The commenter believed that the cost manual could be greatly enhanced and its effectiveness improved with more thorough treatment of the current state of the latest technology. The commenter believed that the draft manual "does not always effectively capture these innovations" and said they would work with the EPA to identify areas where recent innovations have resulted in advancements to oxidizers.

The commenter identified the following as key areas of advancement in thermal oxidizer technology:

1. Thermal efficiency of this technology.
2. Modularity of the components.
3. Integration of concentrators.

The commenter identified the following ask key areas of advancement for catalytic oxidizer technology:

1. Improved poison resistance.
2. Wider variety of technologies for specific pollutants.
3. Longer life.

In a subsequent letter in response to questions from the EPA, the commenter provided information on catalyst life and resistance to poisons. The commenter stated that catalysts for VOC control have proven to be extremely durable in commercial applications, as shown in the following table:

| Industry | | Typical Solvents and/or Misc. Compounds | Years on Stream | Average Catalyst Regeneration Performance | | |
|---|---|---|---|---|---|---|
| | | | | Before | Virgin | After |
| Can Coatings | 1 | MIBK, Mineral Spirits, Isophorone, DIBK, Buty Cellosolve | 11 | 66% | 90% | 86% |
| | 2 | | 7 | 60% | 95% | 95% |
| | 3 | | 7 | 65% | 95% | 85% |
| | 4 | | 7 | 70% | 95% | 94% |
| | 5 | | 14 | 85% | 95% | 95% |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 6 | | 10 | 73% | 90% | 90% |
| Metal Coatings | 1 | MEK, MIBK, Toluene, i-Butanol | 7 | 75% | 95% | 95% |
| | 2 | | 10 | 70% | 90% | 90% |
| Automotive Paint Bake | 1 | MEK, Toluene, Xylene, Isopropyl alcohol | 6 | 95% | 90% | 93% |
| | 2 | | 6 | 71% | 95% | 93% |
| | 3 | | 5 | 91% | 95% | 95% |
| | 4 | | 14 | 90% | 95% | 91% |
| Glove Manufacturing | | Formaldehyde, Phenolics | 5 | 85% | 90% | 87% |
| Phthalic Anhydride | | PA, MA, S | 16 | 70% | 95% | 92% |
| Synthetic Fabrics | | Scothguard, Thermosol Dye | 5 | 80% | - | 90% |

The commenter noted that some systems have operated continuously for more than ten years with little or no loss in control efficiency. In other cases, periodic maintenance, such as removing the catalyst bed (an easily-removable module) and blowing or washing off residues, restored the catalyst to original or near-original activity levels. The commenter said that catalyst suppliers have advanced the technology to improve poison resistance, including contamination from sulfur and phosphates. The commenter said that technologies vary, but are widely available from a variety of suppliers.

The commenter also noted that a wide variety of VOC are discharged from manufacturing processes and provided a table that lists some industries that utilize organic solvents and the kinds of solvents they typically employ. The commenter noted that a wide range of VOC are currently being controlled and that catalyst suppliers are working on new initiatives to support control of emissions that traditionally had been hard to control, including methane and other low molecular weight saturated hydrocarbons. These suppliers are also working on technologies to lower the ignition temperatures and other process parameters to improve the cost-effectiveness of catalytic oxidation technologies.

The commenter further noted that the ability to control VOC emissions in the presence of a wide variety of poisons with newly developed catalytic technology has had the impact of extending catalyst life. Commenter said that catalysts designed for specific applications have significantly impacted catalyst life. For applications, such as purified terephthalic acid (PTA), performance life can exceed ten years. The commenter noted that catalyst life depends upon the design of the system, the process streams to which the catalyst is exposed, and other upset conditions. However, the commenter said that catalyst suppliers have gained significant field experience allowing them to offer improved warranty conditions for a wider array of applications. The commenter said that catalyst technologies have proven to be robust and able to be restored with periodic cleaning.

**<u>Response</u>:** The EPA thanks the commenter for their input and has incorporated the information provided in a new paragraph inserted below Table 2.3, as follows:

"Catalytic oxidizers have been used to control VOC emissions from a variety of commercial applications. In many applications, catalysts have proven to be very durable with catalyst life ranging from 4 years up to as much as 16 years. Many catalysts have operated for over 10 years, with little or no loss in control efficiency. Table 2.4 shows the ranges for catalyst life observed in a range of different applications.

Table 2.4 Typical Ranges for Catalyst Life

| Industry | Typical Compounds Treated | Number of Years Before Catalyst Replacement |
|---|---|---|
| Can Coating | MIBK, Mineral Spirits, Isophorone, DIBK, Buty Cellosolve | 7 to 14 |
| Metal Coatings | MEK, MIBK, Toluene, i-Butanol | 7 to 10 |
| Automotive Paint Bake | MEK, Toluene, Xylene, Isopropyl alcohol | 5 to 14 |
| Glove Manufacturing | Formaldehyde, Phenolics | 5 |
| Phthalic Anhydride | PA, MA, S | 16 |
| Synthetic Fabrics | Scothguard, Thermosol Dye | 5 |

In many cases, periodic cleaning of the catalyst can restore the catalyst to original or near-original activity levels."

**Commenter: Institute of Clean Air Companies (ICAC)**
**DCN: EPA-HQ-OAR-2015-0341-0043**
**Comment:** In a subsequent letter submitted in response to questions from the EPA, the commenter provided information on regeneration of catalysts. The commenter said that in most VOC catalytic oxidation systems, masking is the primary cause of catalyst activity loss. The commenter noted that there are three methods for regenerating catalyst activity are used: thermal, physical and chemical treatment.

**Thermal Treatment** involves elevating the catalyst to high temperatures sufficient to vaporize or oxidize the organic compounds or char that may be masking the catalyst. This is most usually done by elevating the catalyst inlet temperature. The increased temperature is achieved by supplying additional heat from the system burner.
**Physical Treatment** uses mechanical means to remove particulates which have deposited on the catalyst. Most commonly, the catalyst is blown off with compressed air, or in some cases, with water. This technique is not frequently used for catalysts in VOC applications.

**Chemical Treatment** involves removing the catalyst module from the unit and cleaning it separately in acid or alkaline cleaning solutions, or a combination of both. Chemical cleaning, the most frequently used cleaning procedure for catalysts in VOC applications, can be done by the user in the field at the catalytic system installation, by the equipment supplier, or by the catalyst supplier at its own cleaning facility. Chemical cleaning does not affect the catalyst composition; it merely removes masking compounds from the catalyst surface. More than 40 years of chemical cleaning experience have proved it to be the most effective method for extending catalyst life in VOC applications where masking occurs. Depending upon the specific application, preventative chemical cleaning maintenance can be scheduled from every six months, for severe service applications, to every three or more years. In the wood products industry, chemical cleaning has extended catalyst life up to ten years.

The commenter said that performance of catalysts is as much dictated by the permit requirements as the technology itself. More stringent performance requirements and catalyst life requirements require the catalyst suppliers to design for longer life and performance**.** This is often lost in the evaluation. Suppliers may have provided catalysts capable of higher performance but warranted to a lower level since that was the design requirement. The impact of higher conversion requirements has a significant impact on both thermal and catalytic solutions. The change from 95% to 99% DRE conversion can cause the catalyst volume to increase by over 50%. In addition, the nature of the VOC is different for every process, so defining a cost is particularly problematic due to the very different compositions of flue gas streams.

**Response:** The EPA thanks the commenter for their input and has incorporated the information on control efficiency of catalysts into a new paragraph below Table 2.3:

"The control efficiency and performance of a catalytic oxidizer system is in part dictated by the permit requirements. More stringent performance requirements and catalyst life requirements require the catalyst suppliers to design for longer life and performance. Suppliers often provide catalysts capable of higher performance that are warranted to the lower level required by the permit. Higher levels of control and performance requirements have a significant impact on the cost. For example, changing from 95% to 99% DRE can cause the catalyst volume to increase by over 50%."

The information on catalyst regeneration has been included as a new subsection in section 2.2.3 as follows:

"**Catalyst Regeneration**

In some applications, catalyst activity can be restored by catalyst regeneration. There are currently three methods for regenerating catalyst activity.

**Thermal Treatment** involves elevating the catalyst to high temperatures sufficient to vaporize or oxidize the organic compounds or char any organic compounds that are masking the catalyst. The increased temperature is achieved by supplying additional heat from the system burner at the inlet to the catalyst chamber.

**Physical Treatment** uses mechanical means to remove particulates that are deposited on the catalyst. The most common approach blow compressed air and/or water across the surface of the catalyst to dislodge particulates.

**Chemical Treatment** involves cleaning with acid and/or alkaline solutions to remove compounds adhering to the catalyst surface. The catalyst modules are removed from the oxidizer and the chemical treatment performed either at the plant site by the user or returned to the catalyst supplier for treatment at their own cleaning facility. Chemical cleaning is the most frequently used cleaning procedure for catalysts in VOC applications. The treatment does not affect the catalyst composition, but merely removes masking compounds from the catalyst surface. Depending upon the specific application, preventative chemical cleaning maintenance can be scheduled from every six months in applications where catalyst masking is severe, to every three or more years. Chemical cleaning has been used for over 40 years and has proved to be an effective method for extending catalyst life in applications where masking occurs."

***Comments on Scrubbers Used in Combination with Oxidizers:***

**Commenter: American Petroleum Institute (API)**
**DCN: EPA-HQ-OAR-2015-0341-0040**
**Comment:** The commenter recommended the discussion of acid gas scrubbers should be expanded to discuss their potential significance and cost. The commenter noted that since scrubbers are covered in a separate chapter of the Control Cost Manual, it is appropriate to reference that chapter as the EPA has in section 2.2.4. However, the commenter recommended the following additional points be included in section 2.2.4, as follows:

"Scrubbers are sometimes available as part of the thermal oxidizer package and thus can be costed as part of the major equipment cost estimates. Advantage of that possibility should be taken whenever possible, but it should be recognized that there are major auxiliary costs associated with obtaining, storing and transferring the scrubbing medium and storing, transferring and disposing of the spent scrubbing solution.

Where outlet scrubbers are necessary, compliance with the associated sulfur dioxide and/or halogen release limits will incur additional performance testing and continuous compliance monitoring costs. The continuous compliance demonstration for a scrubber normally requires two continuous parameter monitoring systems (scrubbing liquid flow and scrubber pressure drop), but could require an $SO_2$ or halogen continuous emission monitoring system."

**Response:** The EPA agrees with the commenter's remarks and has added the following text to Section 2.2.4 as follows:

"Scrubbers are sometimes included by vendors as part of an integrated scrubber/thermal oxidizer package. Although equipment costs quoted for the systems include the cost of the scrubber and thermal oxidizer, the additional costs associated with the purchase, handling, and disposal of the scrubbing medium and spent scrubbing solution and monitoring of scrubber flow rate and pressure drop should be included in the operating costs for the integrated system. For information on estimating the capital and operating costs of scrubbers, please refer to Section 5.2 of the Cost Manual."

We have not included the commenter's remarks on the need for additional performance testing and $SO_2$ and halogen continuous monitoring systems, since these relate to regulatory compliance requirements that are beyond the scope of this chapter.

**Commenter: American Petroleum Institute (API)**
**DCN: EPA-HQ-OAR-2015-0341-0040**
**Comment:** The commenter recommended the following additional points related to scrubbers be included in section 2.2.4, as follows:

"In most cases acid gas scrubbers are located on the outlet of the thermal oxidizer as indicated in the discussion, but where the vent stream only contains certain acidic sulfur or halogen compounds, scrubbing is sometimes done on the thermal oxidizer inlet, to prevent corrosion and service factor issues at the oxidizer and save on upgraded thermal oxidizer materials."

**Response:** The EPA agrees with the commenter's remarks and has added the following text to Section 2.2.4 as follows:

"In most cases, acid gas scrubbers are located on the outlet of the thermal oxidizer. However, scrubbers may also be used on the inlet to the thermal oxidizer. This arrangement is sometimes used where the waste gas stream contains certain acidic sulfur or halogen compounds. The principal advantages of this arrangement are in reducing corrosion of oxidizer components and avoiding the additional costs associated with upgrading the materials used in oxidizer construction."

***Condensers Used in Conjunction with Oxidizers:***

**Commenter: Institute of Clean Air Companies (ICAC)**
**DCN: EPA-HQ-OAR-2015-0341-0043**
**Comment:** The commenter recommended more information be included on concentrators. The commenter noted that Table 2.1 mentions concentrators in three of the 12 examples.

**Response:** The EPA thanks the commenter for their recommendation and has included a discussion of condensers in section 2.2.4.

"**Condensers.**

For processes that generate large volumes of waste gas with lower concentrations of VOC, plants may install concentrators before the oxidizer inlet. These systems use an adsorption system to convert the stream to a smaller volume of highly concentrated gas that is optimized for treatment by the oxidizer. Typical concentrators use carbon or zeolite as the adsorbant. The waste gas entering the condenser passes through a cartridge where emissions are stripped from the air stream and adsorbed on the substrate. A small volume of heated air is passed over the substrate to release the VOC. The heated air with its high concentration of VOC can then be treated in the oxidizer. Various different designs of concentrators are available and may be purchased as part of an integrated oxidizer system."

*Monitoring Equipment:*

**Commenter: Institute of Clean Air Companies (ICAC)**
**DCN: EPA-HQ-OAR-2015-0341-0043**
**Comment:** The commenter said that it was important to consider the substantial advances in monitoring technology that have occurred and was concerned the information has not been updated significantly since the 1980s. The commenter recommended the EPA add a new discussion of emission monitoring equipment. They noted that there were no regulations in place for HAP and VOC monitoring and reporting at the time the original chapter was published. The commenter said they were working with an EPA Work Group to develop more stringent monitoring and reporting protocols and suggested they be incorporated into the revised chapter. The commenter said that the chapter should provide alternate monitoring methods based on throughput and said that they could provide technology and pricing insight and would be willing to work with the EPA to develop a tiered monitoring methodology base on size or throughput.

**Response:** We agree with the commenter that monitoring equipment is an important part any oxidizer or incinerator system. However, we note that monitoring equipment is important part of all air pollution control equipment. To avoid duplication, monitoring equipment is covered in Section 2, Chapter 4 of the Control Cost Manual.

## 1.3 General Treatment of Material and Energy Balances

No commenters on this section of the draft chapter were received.

## 1.4 Design Procedure

**Commenter: American Petroleum Institute (API)**
**DCN: EPA-HQ-OAR-2015-0341-0040**
**Comment:** The commenter recommended material upgrades and/or acid gas scrubbers be evaluated in the example in Section 2.4.1. The commenter stated that section 2.4.1 describes the steps used to determine the basic design characteristics for thermal and catalytic oxidizers. The example assumes the waste gas contains 1000 ppmv benzene and 1000 ppmv methylene chloride. The methylene chloride will generate hydrochloric acid during combustion. While the quantity that will be generated in this example is small and might not impact the facilities, it is worth specifically pointing out in the example discussion that whenever acid generation occurs there is a potential that TO materials upgrades and/or an acid gas scrubber will be required. The commenter recommended that the section clarify that users should check what the maximum methylene chloride concentration could be before assuming no materials upgrades or scrubbers are required.

**Response:** The EPA agrees with the commenter that oxidizers may need to be fitted with acid gas scrubbers and may require additional upgrades to component materials in situations where the waste stream contains halogenated and/or sulfur compounds. For this reason, we have added the following text to section 2.4:

"In the example provided, the waste gas streams contain methylene chloride, a halogenated compound that can result in acid gases being exhausted from the oxidizer. In situations where the waste gas stream contains halogenated or sulfur containing compounds, the concentration of acidic gases in the outlet to the oxidizer should be calculated to determine whether an acid gas removal system, such as a wet scrubber, is needed. For information on how to design of acid gas controls, please see Section 5 of Cost Manual."

**Commenter: American Forest & Paper Association, et al.**
**DCN: EPA-HQ-OAR-2015-0341-0042**

**Comment:** The commenter noted that section 2.4.1 refers to "standard temperature" of a waste gas stream being 77°F and noted that different organizations use different definitions of standard reference conditions, including standard temperature. They further noted that standard temperature is defined by the International Union of Pure and Applied Chemistry (IUPAC) as 0°C (32°F) and by the National Institute of Standards and Technology (NIST) as 20°C (68°F). They noted that the EPA does not use a single reference standard for temperature, citing 25°C (77°F) as the reference condition for ambient air quality standards,[7] and 68°F as the standard temperature for air pollution test methods.[8] To avoid confusion, the commenter encouraged the EPA to either use a single standard temperature or clearly state the basis of the standard temperature being used in the Manual.

**Response:** The EPA agrees with the commenter that there are several different definitions of standard conditions. To address this comment, we have moved the definition of the term "standard conditions" to a footnote that indicates alternative conditions definitions are sometimes used.

**"Step 1 - Establish design specifications.** The first step in the design procedure is to determine the specifications of the incinerator and the waste gas to be processed. The following parameters of the waste gas stream at the emission source must be available:

Volumetric flow rate, scfm[9] ~~— Standard conditions are normally 77°F and 1 atm. pressure~~

. . ."

## 1.5 Cost Analysis for Thermal and Catalytic Oxidizers

**Commenter: American Forest & Paper Association, et al.**
**DCN: EPA-HQ-OAR-2015-0341-0042**

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[7] National Primary and Secondary Ambient Air Quality Standards: Reference conditions (40 CFR 50.3).
[8] 40 CFR 60, Appendix A, Method 2, Section 12.1 (Nomenclature).
[9] For the purposes of the example shown in this chapter, standard conditions are defined as a temperature of 77ºF and 1 atmosphere pressure.

**Comment**: The commenter said that the specific cost data presented in Section 3.2, Chapter 2 are not accurate. They noted that the data presented in the chapter were gathered over 25 years ago, and the method EPA has used to escalate these costs to current dollars is not supportable. The commenter recommended the EPA gather current equipment cost data from vendors or other reliable sources of cost data. The commenter said that the Manual is an important resource for both regulators and the regulated community as it is used by EPA for estimating the cost impacts of prospective rulemakings and serves as a basis for industry to estimate costs of air pollution controls that may be considered as Best Available Control Technology (BACT) under the New Source Review (NSR) program, Best Available Retrofit Technology (BART) under the Regional Haze Program, and other programs (e.g., Reasonably Available Control Technology (RACT)). The commenter further noted that the EPA, states, and industry need reliable access to the most up-to-date technical and economic information on air pollution control systems as the data is used to evaluate alternatives to reduce emissions and to assess the feasibility and cost effectiveness of strategies to comply with the frequently-changing National Ambient Air Quality Standards (NAAQS) and pollutant transport rules. They noted that industry relies on the Manual, along with site-specific data, as they prepare BACT analyses for permit applications and evaluate feasibility of installing controls under programs such as BART and RACT. They argued that it is critical that air pollution control system performance data and cost information contained in the manual be of the "highest quality possible so that decisions will be equitable and technically sound, and applied control strategies will be effective and economically feasible." The commenter considers the methodologies for estimating capital and operating costs of air pollution control equipment described in Section 1, Chapter 2 to be acceptable, but they said they objected to the cost data presented in Section 3.2, Chapter 2.

The commenter also disagreed with the methodology used for escalating these cost data to current dollars, stating that the approach is "technically unsupportable and results in cost estimates that are very inaccurate." They noted that in a footnote on page 2-40, the EPA states that these nearly thirty-year-old equipment costs can be escalated to current prices using the CEPCI ratio and stated that this footnote contradicts a recommendation in section 2.4.4 of Section 1, Chapter 2 that escalation of costs should be limited to five years or less. They said that inaccurate data used for regulatory development will misrepresent the costs of prospective regulatory actions and noted that many advances in air pollution control technologies have occurred in the 30 or more years since the first edition of the Manual was published.

The commenter noted that the cost estimates calculated using escalation procedure are very inaccurate and noted that recent cost data presented in Table 2-1 are not consistent with the estimates calculated using the methodology in section 2.5.1.1. As an example, the commenter noted that in Table 2-1 a catalytic oxidizer system installed on a semiconductor industry source in 2014 cost $121,440. Using equations 2.35 to 2.38, the commenter said that the equipment cost priced in 1988 would have been between $146,700 and $201,400 depending on the degree of heat recovery. Escalating these prices to 2014 using the appropriate CEPCI values for 1988 and 2014, generates an oxidizer equipment cost estimate of between $247,000 and $339,000, which the commenter noted is 2.0 to 2.8 times higher than the 2014 cost quote cited. The commenter contends that this example shows that the methodology provides a completely inaccurate cost estimate.

The commenter also said that the cost data for regenerative thermal oxidizers were not accurate and that equipment costs for RTO systems installed by their organization members within the past two years are between 7% and 17% lower than the corresponding estimates obtained using equation 2.34 and escalating the resulting 1988-base cost to current dollars.

The commenter said that the EPA had made no effort to gather new data that reflect equipment advances and other developments and consequently the equipment costs presented in the chapter are inaccurate and unreliable. The commenter recommended the EPA collect more current equipment cost estimates to provide the most current and accurate information possible.

**Response:** The EPA thanks the commenter for their input and note that the Agency attempted to collect more current data on both costs and technology advances through extensive searches of various information sources, including databases (e.g., the EPA's Clearinghouse), construction permits, journal articles, vendor information, EPA documents, and conference presentations. However, the cost data we collected (summarized in Table 2.1) was not sufficient to allow us to develop new cost correlations. For this reason, we specifically solicited comment on cost correlations, factors, and equations and asked for input on how the capital and operating costs should be updated (see 81 FR 65353, September 22, 2016). In addition to this request, we also reached out to vendors through separate correspondence with ICAC. However, despite these efforts, no additional cost data was provided. Although we agree with the commenter's remarks regarding the age of the data and the problems associated with scaling the data to current costs, the cost correlations included in the manual nevertheless represent the best data currently available to us.

Although the data used to develop the cost correlations is dated, we concluded that this data was still useful for developing the study-level capital and operating cost estimates for which the Cost Manual is designed. Consequently, we have retained this data in the final chapter. However, we also agree with the commenter that these study-level estimates should not be used to selecting the most cost effective control device. Selection of the most cost-effective option for a control device should always be based on a detailed engineering study and cost quotations from system suppliers, rather than on the study-level estimates provided by the Cost Manual. For cost analyses conducted under the authority of the Regional Haze program, such as for Best Available Retrofit Technology (BART) and reasonable progress determinations, Reasonably Available Control Technology (RACT) determinations, and Best Available Control Technology (BACT) determinations, detailed itemized costs with appropriate documentation must be prepared for each control technology and reviewed by agency staff to ensure the costs provided are complete, correctly calculated, and supported by the documentation.

**Commenter: Institute of Clean Air Companies (ICAC)**
**DCN: EPA-HQ-OAR-2015-0341-0043**
**Comment:** The commenter said that developing cost data is difficult but said that their association would work with the EPA to develop metrics that would be more reflective of the current technologies. The commenter said that the actual costs cannot simply be translated with currency adjustments as the technology advancements and innovations have substantially improved the cost-effectiveness over time. In addition, the commenter said that the capital costs are the primary driver of VOC emission control costs. The commenter also said that the draft chapter relied on statements from a single supplier and were used in "an authoritative manner as representative of the entire industry." The commenter said there were gaps in EPA's information and offered to help assist the EPA by providing the latest information that is most representative of the industry as a whole. The commenter also said that cost factors and references used in Table 2.1 are dated and recommended they be revised. In reference to the use of data from 11 vendors to confirm the methodology (section 2.5.1), the commenter suggested the exercise should be repeated and offered to assist the EPA conduct a blind-study to collect current cost data from vendors.

**Response**: We agree with the commenter that the capital costs are a significant portion of the costs. We also agree that the more recent cost data is preferred. However, as discussed in our previous response, we currently have insufficient costs data to prepare new cost correlations despite our best efforts to collect new data.

**Commenter: American Forest & Paper Association, et al.**
**DCN: EPA-HQ-OAR-2015-0341-0042**
**Comment:** The commenters stated that the cost information presented in section 2.2.5 is only for new installations. The commenters recommended current cost data for retrofit oxidizer systems be included in the chapter.

**Response:** We thank the commenter for their input and agree that cost data for retrofitting existing emissions units with oxidizers would be helpful to users. However, as discussed in our previous response, we currently have insufficient costs data to prepare new cost correlations, including factors for retrofitting existing emissions units.

**Commenter: American Petroleum Institute (API)**
**DCN: EPA-HQ-OAR-2015-0341-0040**
**Comment:** The commenter noted that the piping factor Table 2.10 should be 0.02B, not 0.002B.

**Response:** The EPA agrees with the commenter and has corrected the factor in Table 2.10 to read "0.02B" instead of "0.002B".

**Commenter: American Petroleum Institute (API)**
**DCN: EPA-HQ-OAR-2015-0341-0040**
**Comment:** The commenter stated that the detailed cost discussions and examples reflect the costs for only the simplest package oxidizers and greatly understate the associated installation costs. The commenter noted that Section 2.5.1.1 discuses equipment costs for packaged oxidizers, except for regenerative oxidizers. For regenerative oxidizers, the equipment costs provided are identified as applying to field-erected units. The introductory paragraph explains that the equipment cost typically includes "all flange-to-flange equipment needed to oxidize the waste gas, including the auxiliary burners, combustion chamber, catalyst, primary heat exchanger (except for the "zero heat recovery" cases), weathertight housing and insulation, fan, flow and temperature control systems, a short stack, and structural supports." The commenter said that this approach leaves out many major costs and recommended the following costs for the feed transfer and control system should be individually estimated and noted that vendor costs for the required valves and instrumentation are readily obtainable as are the per foot installed cost for pipe and ductwork. The commenter recommended the following costs be included in the estimate:

(1) The cost of the piping or ductwork, including required valves or dampers, needed to transfer the waste gas from the generation location to the TO is a significant cost because of the relatively large volumes of gas that must be transferred at typically low pressure. This system must include a waste gas flow monitor and automatic feed cutoff (i.e., automated valves or dampers) should the TO trip and diversion facilities for the waste gas. Because of the spacing requirements for ignition sources the length of required piping can be significant, even if only one vent stream is being controlled.

(2) The cost of the fuel gas system, including a fuel gas knockout pot or drum and a significant pipe run to bring the fuel gas to the TO location and fuel gas controls, including an automatic fuel gas isolation system.

(3) In colder climes, an allowance for a waste gas feed knockout pot or drum to remove condensed liquids and heat tracing of the waste gas transfer pipe or duct, instrumentation, etc.

(4) The cost of a flare header, a knockout pot and connections to all TO and waste gas transfer equipment where hydrocarbon can be present. Safety valves for all equipment and connection of those valves to the flare header.

(5) Costs of foundations and supports can be a significant cost factor. When preparing estimates, plants should be able to consider whether there are unusual design conditions that should be reflected in the costs. For instance, the high design wind load associated with a gulf coast installation due to hurricane concerns or the extra foundations associated with raising the oxidizer above grade or with having a tall stack.

(6) An allowance for sewers, firewater systems, safety showers and bringing utilities to the location including steam, nitrogen and utility water.

(7) The cost of compliance demonstration facilities, including platforms and instrumentation for continuous monitoring of the firebox temperature, connection of

that temperature monitor to the centralized data system and ports and platforms for stack testing.

(8) The cost for a motor control station and wiring from the appropriate substation for the blower (fan) and pumps, etc.

(9) The instrumentation factor may be appropriate for equipment operated with local digital controllers, but is unrealistic for most facilities in our industry, where operations are monitored and controlled centrally.

(10) Several of the factors provided in the tables should either be fixed quantities or have a minimum cost because they are not primarily a function of the TO throughput. The commenter provided the following examples:

a. Onsite instrumentation is mostly a fixed a fixed cost for each TO design. The number of control loops is not a function of throughput for each design. Only the size of control values would be expected to change as a function of TO throughput. The instrumentation variable cost is the distance the instrument cabling must traverse to connect to the general plant systems. This can be a significant distance and cost, since the TO must have a safe zone around it. Thus, it would be best if a minimum instrumentation cost is established.

b. Performance test are not significantly different as a function of TO throughput and the indicated cost of $3000-5000 is unrealistic, even for only a stack total organic carbon determination. A more realistic estimate would be $20,000, regardless of TO throughput.

c. Permitting is not indicated as an installation cost. At least $10,000 should be assigned. Even for a small TO, New Source Review and Operating permit activities involve significant engineering effort and time.

The commenter said they have no data on which to question the other factors used to estimate costs for simple package systems, but believe it should be made clear in each Table, that these estimates are for package installations on open sites only. Based on their experience, they said the factors would be unacceptably low for controls of any complexity in their types of operations. The commenter noted that engineering costs for simple projects can typically range from 10-40%, and can be higher for systems with complex auxiliaries. They said that project management costs typically range from 20 to 40+ percent. The minimum engineering and project management cost could more appropriately be estimated at 30%, rather than 10%. They agreed that the 10% allowed for contractor profit was reasonable, based on their own limited historical information, but recommended the factor used to reflect these categories of costs should be set at a minimum of 40% (10% for engineering, 20% for project management, and 10% for contractor profit and other installation related costs).

The commenter also noted that on page 2-38 the manual says that “11 quotes from vendors for a specific configuration for three types of incinerator systems (recuperative, regenerative, fixed-bed catalytic) compared favorably to those generated using the cost equations." The commenter said that this confirms that the cost manual provides reasonable purchase cost estimates for package thermal oxidizer components, without including more than minimal installation costs or the costs for the extensive associated facilities needed when field constructing these units or installing them in refinery or petrochemical environments. It also leaves unclear when this comparison was made, what major components were included and whether the quotes were for equipment that would meet refinery or petrochemical facility design standards. The commenter considered this to be a significant issue, because historically the cost for oxidizer major components has been much higher than the Control Cost Manual estimates.

The commenter also referenced comments submitted by Exxon Mobile on the Polymer and Resins 1 Risk and Technology proposal[10] and recommended those comments be reviewed and considered in updating the Cost Control Manual. The comments include a side-by-side comparison of several specific thermal oxidizer projects that show the estimated capital and annual costs would be multiples of the cost estimated by EPA using the Control Cost Manual methodology.

**Response**: The EPA in part agrees with the commenter that the cost correlations included in the manual are for package oxidizers rather than field-constructed units. We are unable to confirm the commenter's statement regarding the higher costs of purchasing and installing oxidation systems at refineries and petrochemical plants, since we were unable to collect data to confirm this assertion and the commenter did not provide any supporting documentation as part of their comments. However, as a general principle, we agree with the commenter that the costs may vary from one site to another, based on the waste-stream composition and other site-specific characteristics. For example, oxidation systems designed to handle corrosive waste gas streams are often more expensive as they must be fabricated using higher grade, corrosive resistant materials. The installation costs included in the manual are for new construction. Oxidizers installed as part of a retrofit program or to replace or upgrade an existing system are likely to be higher as retrofit projects are generally more challenging. Hence, it is possible the capital and installation costs for a specific project may be higher than those estimated using the methodology provided in the Cost Manual.

While the costs may vary for individual installations, the methodology used in the chapter to calculate the cost is based on the methodology outlined in in Section 1, Chapter 2, Cost Estimation: Concepts and Methodology. This methodology is used as the basis for preparing the cost estimate methods for all pollution control equipment included in the Cost Manual. This methodology estimates real, not nominal (or including inflation) costs, and is a standard methodology for estimating equivalent uniform annual costs (EUAC) as stated in Section 1, Chapter 2 of the Cost Manual. The approach is primarily targeted toward study-level estimates that have an accuracy of ±30 percent and allows for a consistent and systematic approach to

[10] See Docket Document EPA-HQ-OAR- 2010-0600-0265, *Comments on EPA's Proposed Rule: NESHAP for Group I Polymers and Resins; Residual Risk and Technology Reviews 75 Fed. Reg. 65068 (October 21, 2010)*, December 6, 2010, pages 28-38.

estimating costs. By using the same basic methodology for all control equipment, the costs estimates can be used to compare the relative cost effectiveness of each system. For selecting a control device for a specific application, we recommend facilities prepare a detailed engineering study and obtain cost quotations from system suppliers. Cost analyses conducted under the authority of the Regional Haze program, such as for Best Available Retrofit Technology (BART) and reasonable progress determinations, Reasonably Available Control Technology (RACT) determinations, and Best Available Control Technology (BACT) determinations should prepare detailed itemized costs with appropriate documentation for each control technology considered.

## 1.6 Cost Analysis for Incinerators

**Commenter: American Forest & Paper Association, et al.**
**DCN: EPA-HQ-OAR-2015-0341-0042**
**Comment:** With respect to incinerator systems, the commenters noted that the information presented in section 2.6 is incomplete. The commenter noted that section 2.2.1 describes nine different types of solid waste incinerators, but section 2.6 provides equipment cost information for only one type (sewage sludge incinerators). The commenter said that these cost data are presented in an anecdotal fashion for only two installations, without any accompanying design information about either installation that would enable the data to be used to generate cost estimates for other systems. Given its shortcomings, the commenter recommended section 2.6 be removed.

**Response:** The EPA agrees acknowledges that the cost information provided for incinerators is incomplete. The cost data provided in this section is provided only for informational purposes to provide general information on costs for solid waste incinerators that is intended only to be used as a guide capital costs. The data presented provides the data we obtained from searches of publicly available information. However, the data currently available is unfortunately very limited and was insufficient for developing cost correlations. As noted by the commenter, the section provides only limited, anecdotal cost information and is not intended to be used to estimate capital or operating costs for the different designs of solid waste incinerators.

## 1.7 Other Miscellaneous Comments

***Comments on Appendix A:***

**Commenter: Institute of Clean Air Companies (ICAC)**
**DCN: EPA-HQ-OAR-2015-0341-0043**
**Comment:** ***The commenter recommended Appendix A i***nclude a more comprehensive list and possibly include a link to a more current list on-line. The commenter offered to find a more current on-line list.

**Response:** While we agree that the list of compounds is not comprehensive, we note that Appendix A includes data for VOCs and HAPs that are commonly emitted by many industrial processes. The list is included as a convenience to users but was never intended to be comprehensive. We believe that a full list of compounds would make the appendix too long and make it difficult to locate information within the chapter. We liked the commenter's suggestion of providing a link to a current, comprehensive list; however, we were unable to located an on-line source for this data and the commenter did not provide one. Consequently, no changes were made as a result of this comment.

### *Comments on Inclusion of Contingency in Total Capital Cost Estimation*

**Commenter: American Petroleum Institute (API)**
**DCN: EPA-HQ-OAR-2015-0341-0040**
**Comment:** The commenters recommended that an "undefined allowance of at Least 30% should be included in all Total Capital Investment (TCI) estimates. The commenter argued that this contingency factor is required for all project cost estimates, since direct estimates, particularly those based on only rough screening quality information, cannot anticipate every project need or impact. For instance, every potential siting and installation issue, every required upgrade to electrical, instrument or other utility services, every labor cost variation, every weather effect, etc. cannot be predicted in a screening quality estimate. The commenter said that project contingency factors used by the petroleum industry typically start quite high (e.g., 30-50%) and are reduced as project detail improves. However, even for projects with detailed process designs, the commenter said that project contingencies of at least 10-20% are still required (depending on company practice and experience). The commenter said that their historical data indicates that 30 – 50% is the amount of contingency typically required for screening estimates, such as those developed through the Control Cost Manual. The commenter recommends a project contingency of at least 30% to improve the probability that the cost estimate reflects the cost (±30%) of the control. Without inclusion of this allowance, the commenter said the estimate would not meet the desired ±30% intent, but rather would, at best, be 0-30% low.

**Response:** In the revised chapter, the contingency was increased from 3% of PEC (purchased equipment cost) to 5-15% of total capital investment (TCI) in response to public comments on the magnitude of the contingency and also a review of the available literature of the subject. After this review and consideration of public comments, the Agency concluded that this increase in contingency yields an estimate that is consistent with recent guidance in the form of a recommended practice from the American Association of Cost Engineering International (AACE) and well-recognized references on process engineering such as Peters, Timmerhaus and West's *Plant Design and Economics for Chemical Engineering* (5th edition, 2002). This revised contingency estimate is appropriate for mature technologies such as thermal and catalytic oxidizers.