



Designation: D8570 – 24

Standard Practice for Vented and Fugitive Gaseous Emissions Destruction by Thermal Oxidizer¹

This standard is issued under the fixed designation D8570; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice covers the destruction of gaseous vented and fugitive emissions by thermal oxidization (Test Method [D4891](#)) (non-catalytic, electrically heated) in the 0 kJ/h to 158 258 kJ/h (150 000 Btu/h) (Practice [D3588](#)) range with a high destruction or removal efficiency (DRE) of 95 % to 99.9 % ([1-4](#)).²

1.2 These gaseous emissions, referred to as waste gas, are listed as toxic release inventory (TRI) (Test Method [D4891](#)); volatile organic compounds (VOC) (Test Method [D4891](#)); hazardous air pollutants (HAP); and benzene, toluene, ethylbenzene, and xylenes (BTEX). Destruction of these gases should comply with applicable governmental guidelines and regulations for combustion air requirement(s) ([1](#)), operation of combustion chamber(s) temperature(s) at no less than 760 °C (1400 °F) ([5](#)), and designed with adequate residence time at said temperature in the combustion chamber(s) to achieve a DRE of 95 % to 99.9 % ([1-4](#)) destruction of waste gases.

1.3 Typical reporting requirements demonstrating compliance are for emissions from the combusted waste gas stream measured at the combustion tube exhaust. The temperature being reported shall have an accuracy of $\leq \pm 0.75$ % ([2](#)) of the temperature being measured.

1.4 The values stated in SI units are to be regarded as standard. The values given in parentheses after SI units are provided for information only and are not considered standard.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standard-*

ization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

2. Referenced Documents

2.1 ASTM Standards:³

- [C1055](#) Guide for Heated System Surface Conditions that Produce Contact Burn Injuries
- [D1356](#) Terminology Relating to Sampling and Analysis of Atmospheres
- [D3588](#) Practice for Calculating Heat Value, Compressibility Factor, and Relative Density of Gaseous Fuels
- [D4150](#) Terminology Relating to Gaseous Fuels
- [D4891](#) Test Method for Heating Value of Gases in Natural Gas and Flare Gases Range by Stoichiometric Combustion
- [D5466](#) Test Method for Determination of Volatile Organic Compounds in Atmospheres (Canister Sampling, Mass Spectrometry Analysis Methodology)
- [D6060](#) Test Method for Sampling of Process Vents with a Portable Gas Chromatograph
- [D6196](#) Practice for Choosing Sorbents, Sampling Parameters and Thermal Desorption Analytical Conditions for Monitoring Volatile Organic Chemicals in Air
- [D7339](#) Test Method for Determination of Volatile Organic Compounds Emitted from Carpet using a Specific Sorbent Tube and Thermal Desorption / Gas Chromatography

2.2 NFPA Standards:

- [NFPA 68](#) Explosion Protection by Deflagration Venting
- [NFPA 75](#) Fire Protection of Information Technology Equipment
- [NFPA 85](#) Boiler and Combustion Systems Hazards Code
- [NFPA 86](#) Chapter 10 Section 86-31 Thermal Oxidizers⁴

¹ This practice is under the jurisdiction of ASTM Committee [D22](#) on Air Quality and is the direct responsibility of Subcommittee [D22.03.01](#) on Source Emissions. Current edition approved Oct. 1, 2024. Published October 2024. DOI: 10.1520/D8570-24.

² The boldface numbers in parentheses refer to a list of references at the end of this standard.

³ For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at www.astm.org/contact. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

⁴ Available from National Fire Protection Association (NFPA), 1 Batterymarch Park, Quincy, MA 02169-7471, <http://www.nfpa.org>.

2.3 ASME Standards:⁵

ASME CSD-1 Controls and Safety Devices for Automatically Fired Boilers

2.4 EPA Standards:⁶

EPA Method 0031 Sampling Method for Volatile Organic Compounds (SMVOC)

Method 3A Oxygen and Carbon Dioxide Concentrations – Instrumental

Method 3C Carbon Dioxide, Methane, Nitrogen and Oxygen Concentrations – Thermal Conductivity Detector

EPA Method 10B Carbon Monoxide from Stationary Sources

Method TO-14A Determination of Volatile Organic Compounds (VOCs) In Ambient Air Using Specially Prepared Canisters With Subsequent Analysis By Gas Chromatography

Method TO-15A Determination of Volatile Organic Compounds (VOCs) in Air Collected in Specially Prepared Canisters and Analyzed by Gas Chromatography–Mass Spectrometry (GC-MS)

Method TO-17 Determination of Volatile Organic Compounds in Ambient Air Using Active Sampling Onto Sorbent Tubes

EPA Method 6010D(SW-846) Inductively Coupled Plasma – Atomic Emission Spectrometry

EPA Method 8240 Volatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC-MS)

EPA Method 8270 Semivolatile Organic Compounds by Gas Chromatography/Mass Spectrometry

3. Terminology

3.1 For definitions of terms used in this practice, refer to Terminology D4150 (for terms related to gaseous fuels) and to Terminology D1356 (for terms related to air quality).

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *combustion air, n*—air (~79 % N₂, ~21 % O₂) volume required for combusting hydrocarbons or other combustible gases (see Table 1 for details).

3.2.2 *excess air, n*—air (~79 % N₂, ~21 % O₂) volume that is above the stoichiometric combustion point (see Table 1 for details).

3.2.3 *flow rate, n*—a volume of gas flowing through a duct, pipe, or similar conduit per unit time at an agreed upon Standard Pressure and Temperature (STP), typically stated as 14.696 psia at 60 °F.

3.2.4 *fuel gas, n*—gases generated at a petroleum refinery or petrochemical plant, biogas facility, landfill or natural gas processing that is combusted separately or in any combination with any type of gas.

3.2.5 *gauge pressure, n*—the pressure measured relative to atmospheric pressure.

3.2.6 *residence time, n*—time of mass spent in a combustion chamber(s).

3.2.7 *standard flow rate, n*—standard flow rate is a correction applied to an actual flow measurement based on a given temperature and pressure that is based on the agreed upon STP.

3.2.8 *thermolysis, n*—the breakdown of molecules by the action of heat.

3.2.9 *waste gas, n*—gases or fumes from process, storage, or another source not used or combusted gas.

4. Significance and Use

4.1 This practice provides a standardized procedure for use of thermal oxidizers in the destruction of VOC, HAP, TRI, BTEX, and other vented and fugitive emissions on a continuous basis and is intended for use in regulatory compliance. This practice shall comply with NFPA 86 (6) guidelines and ASME CSD-1 requirements for the assembly, installation, maintenance, and operation of controls and safety devices.

5. Operation Requirements

5.1 Temperature and O₂ requirements for 0 kJ/h to 158 258 kJ/h (150 000 Btu/h) design require that the thermal oxidizer system have their thermolysis cell(s) (for example, firebox, combustion chamber) be monitored for the correct temperature and be maintained at not less than a temperature of 760 °C (1400 °F) and with an exhaust oxygen concentration not less than 3 % on a 6 min average while waste gas is being supplied to the oxidizer prior to initial stack testing. Two thermocouples (5) are to be used in each temperature control loop. Oxygen monitoring is typically not required for small oxidizers (1, 2) and as such, oxygen monitoring is only performed on initial startup and in conjunction with periodic spot samples as stated in Section 9 for verification requirements. These oxidizer systems are typically electrically powered heating sources for reaching and maintaining combustion temperatures.

5.2 The thermal oxidizer exhaust temperature shall be continuously monitored and recorded when waste gas is directed to the oxidizer (1, 2).

5.2.1 A thermal oxidizer's key to its functionality is a nozzle-stabilized (1, 4, 5) flame that is maintained by a mixture of waste gas and supplemental air added as required to provide excess oxygen. Upon passing through the flame, the waste gas is heated from its inlet temperature (for example, 37.8 °C (100 °F)) to its ignition temperature (1). The ignition temperature varies for different waste stream constituents and is typically determined empirically. It is the temperature at which the combustion reaction rate (and consequently the energy production rate) exceeds the rate of heat loss, thereby raising the temperature of the gases to some higher value (1). Thus, any organic/air mixture will ignite if its temperature is raised to a sufficiently elevated level.

5.3 The temperature measurement device shall reduce the temperature readings to an averaging period of 6 min or less and record it at that frequency. The temperature measurement device shall be installed, calibrated, and maintained according to accepted practice and the manufacturer's specifications.

⁵ Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Two Park Ave., New York, NY 10016-5990, <http://www.asme.org>.

⁶ Available from United States Environmental Protection Agency (EPA), William Jefferson Clinton Bldg., 1200 Pennsylvania Ave., NW, Washington, DC 20460, <http://www.epa.gov>.



TABLE 1 Physical Properties

NOTE 1—Compiled from Practice D3588 Ref 2, GPSA Data Book 1978, Babcock & Wilcox.

No.	Substance	Formula	Molecular Weight	Density lb per ft ³	Specific Volume ft ³ per lb	Specific Gravity (air = 1)	Heat of Combustion			Required for Combustion				ft ³ per ft ³ of Combustible			Flue Products	
							Net	Gross	Btu per lb	Net	O ₂	N ₂	Air	CO ₂	H ₂ O	N ₂ ^A		
1	Carbon	C	12.0110	—	—	—	—	14.093	21.511	2.0	7.547	1.0	3.773	1.0	—	3.773	—	—
2	Hydrogen	H ₂	2.0159	0.0053	188.245	0.0696	324.2	61.029	51.558	0.5	1.887	2.387	—	—	1.0	1.887	—	—
3	Oxygen	O ₂	31.9988	0.0844	11.850	1.1053	—	—	—	—	—	—	—	—	—	—	—	—
4	Nitrogen	N ₂	28.0134	0.0738	13.543	0.9671	—	—	—	—	—	—	—	—	—	—	—	—
4	Nitrogen (atm.) ^A	N _{2a}	28.1580	0.0742	13.474	0.9720	—	—	—	—	—	—	—	—	—	—	—	—
5	Carbon monoxide	CO	28.0104	0.0738	13.542	0.9672	320.6	4342	4342	0.5	1.887	2.387	—	1.0	—	1.887	—	—
6	Carbon dioxide	CO ₂	44.0098	0.1166	8.574	1.5277	—	—	—	—	—	—	—	—	—	—	—	—
Paraffin series C_nH_{2n+2}																		
7	Methane	CH ₄	16.0428	0.0424	23.608	0.5548	1012	23.891	21.511	2.0	7.547	9.547	1.0	2.0	2.0	7.547	—	—
8	Ethane	C ₂ H ₆	30.0697	0.0799	12.514	1.0466	1785	22.334	20.429	3.5	13.206	16.706	2.0	3.0	3.0	13.206	—	—
9	Propane	C ₃ H ₈	44.0966	0.1183	8.456	1.5489	2561	21.653	19.921	5.0	18.866	23.866	3.0	4.0	4.0	18.866	—	—
10	n-Butane	C ₄ H ₁₀	58.1235	0.1585	6.310	2.0758	3376	21.299	19.657	6.5	24.526	31.026	4.0	5.0	5.0	24.526	—	—
11	Isobutane	C ₄ H ₁₀	58.1235	0.1580	6.328	2.0699	3355	21.231	19.589	6.5	24.526	31.026	4.0	5.0	5.0	24.526	—	—
12	n-Pentane	C ₅ H ₁₂	72.1504	0.2019	4.952	2.6450	4258	21.085	19.498	8.0	30.186	38.186	5.0	6.0	6.0	30.186	—	—
13	Isopentane	C ₅ H ₁₂	72.1504	0.2001	4.999	2.6202	4210	21.043	19.455	8.0	30.186	38.186	5.0	6.0	6.0	30.186	—	—
14	Neopentane	C ₅ H ₁₂	72.1504	0.1984	5.040	2.5989	4159	20.958	19.370	8.0	30.186	38.186	5.0	6.0	6.0	30.186	—	—
15	n-Hexane	C ₆ H ₁₄	86.1773	0.2508	3.987	3.2849	5252	20.943	19.392	9.5	35.846	45.346	6.0	7.0	7.0	35.846	—	—
Olefin series C_nH_{2n}																		
16	Ethylene	C ₂ H ₄	28.0538	0.0744	13.447	0.9740	1609	21.643	20.282	3.0	11.320	14.320	2.0	2.0	2.0	11.320	—	—
17	Propylene	C ₃ H ₆	42.0807	0.1127	8.874	1.4760	2371	21.039	19.678	4.5	16.980	21.480	3.0	3.0	3.0	16.980	—	—
18	n-Butene (Butylene)	C ₄ H ₈	56.1076	0.1524	6.560	1.9966	3175	20.831	19.470	6.0	22.640	28.640	4.0	4.0	4.0	22.640	—	—
19	Isobutene	C ₄ H ₈	56.1076	0.1524	6.561	1.9964	3156	20.704	19.343	6.0	22.640	28.640	4.0	4.0	4.0	22.640	—	—
20	n-Pentene	C ₅ H ₁₀	70.1345	0.1947	5.135	2.5508	4032	20.704	19.343	7.5	28.300	35.800	5.0	5.0	5.0	28.300	—	—
Aromatic series C_nH_{2n-6}																		
21	Benzene	C ₆ H ₆	78.1137	0.2213	4.518	2.8989	4024	18.179	17.446	7.5	28.300	35.800	6.0	3.0	3.0	28.300	—	—
22	Toluene	C ₇ H ₈	92.1406	0.2750	3.637	3.6016	5068	18.430	17.602	9.0	33.959	42.959	7.0	4.0	4.0	33.959	—	—
23	Xylene	C ₈ H ₁₀	106.1675	0.3480	2.874	4.5576	6480	18.622	17.723	10.5	39.619	50.119	8.0	5.0	5.0	39.619	—	—
Miscellaneous																		
24	Acetylene	C ₂ H ₂	26.0379	0.0691	14.480	0.9046	1484	21.482	20.749	2.5	9.433	11.933	2.0	1.0	1.0	9.433	—	—
25	Naphthalene	C ₁₀ H ₈	128.1736	0.3384	2.955	4.4323	5866	17.335	16.739	12.0	45.279	57.279	10.0	4.0	4.0	45.279	—	—
26	Methyl alcohol	CH ₃ OH	32.0422	0.0846	11.820	1.1081	868	10.265	9073	1.5	5.660	7.160	1.0	2.0	2.0	5.660	—	—
27	Ethyl alcohol	C ₂ H ₅ OH	46.0691	0.1216	8.224	1.5927	1602	13.172	11.929	3.0	11.320	14.320	2.0	3.0	3.0	11.320	—	—
28	Ammonia	NH ₃	17.0306	0.0454	22.008	0.5951	440	9680	7998	0.75	2.830	3.580	—	SO ₂	1.5	3.330	—	—
29	Sulfur	S	32.0660	—	—	—	—	3980	3980	1.0	3.773	4.773	1.0	—	—	3.773	—	—
30	Hydrogen sulfide	H ₂ S	34.0819	0.0907	11.030	1.1875	643	7094	6534	1.5	5.660	7.160	1.0	1.0	1.0	5.660	—	—
31	Sulfur dioxide	SO ₂	64.0648	0.1722	5.806	2.2558	—	—	—	—	—	—	—	—	—	—	—	—
32	Water vapor	H ₂ O	18.0153	0.0503	19.863	0.6594	50.312	1059.8	0.0	—	—	—	—	—	—	—	—	—
33	Air ^A	—	28.9625	0.0763	13.098	1.0000	—	—	—	—	—	—	—	—	—	—	—	—

^A Composition from: F. E. Jones, J. Res. Nat. Bur. Stand., Vol. 83, 419, 1978. ~79 % N₂, ~21 % O₂, water vapor, and other trace gases such as carbon dioxide, helium, argon, ozone, or various pollutants. Note that the composition of air can also vary depending on factors like humidity, thus water vapor (H₂O) concentration increases significantly under humid conditions. STP is 14.696 psia at 60 °F).

device shall have an accuracy of the greater of $\pm 0.75\%$ of the temperature being measured expressed in degrees Celsius or $\pm 2.5\text{ }^{\circ}\text{C}$ ($\pm 4.5\text{ }^{\circ}\text{F}$) (2).

5.4 Flow of waste gas to the combustion system will require the automatic double blocking (5) of flow until the combustion chamber as shown in Fig. 1, has reached at least $760\text{ }^{\circ}\text{C}$ ($1400\text{ }^{\circ}\text{F}$) and uses a nozzle (1, 4, 5) for combustion.

5.5 Thermal oxidization (TO) is an established method for destroying waste gas stream components, such as VOCs, HAPs, ROGs, TRI, or BTEX, present in large quantities. Traditionally, TO devices have been installed in passive environments that can tolerate extreme external temperatures such as an open field or atop structural towers in a “non-hazardous environment.” Excess air, internal to the waste gas stream or mechanically injected by a separate supply device, provides the oxygen for oxidation.

5.6 The waste gas stream relates to those compounds (natural or man-made) which are known as toxic release inventory (TRI) gas or volatile organic compounds (VOCs), that require oxidization. The design and combustion air requirements are stated by NFPA, U.S. Environmental Protection Agency (EPA), or other jurisdictional air quality authorities requiring an adequate amount of oxygen to achieve the 95 % to 99.9 % (1-4) destruction requirement. Fig. 2⁷ shows the relationship between combustion flame temperature and combustion air; therefore, under controlled conditions, flame temperature can be a useful measurement of the air-fuel ratio, that is, how far we deviate from stoichiometric conditions as needed to maintain the required operating range of the oxidizer system based on temperature.

5.7 If perfect mixing of the fuel (C_nH_n) and air takes place it results in generation of only carbon dioxide (CO_2) and water vapor (H_2O), because the N_2 is inert under the idealized conditions, it will pass through the TO and trace NO_x may be formed. Fig. 3 shows various fuel (waste) gases and the flue (exhaust/vent) gas analysis by percentage of excess air.

5.8 Insufficient air will result in incomplete combustion with emissions of pollutants such as carbon monoxide, solid carbon particulates in the form of smoke or soot, and unburned or partially oxidized hydrocarbons, or both (7).

5.8.1 Burning carbon with insufficient oxygen can produce CO:



⁷ See <http://www.combustionsystemsinc.com>.

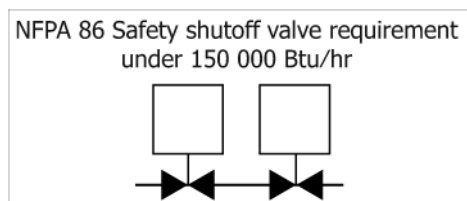
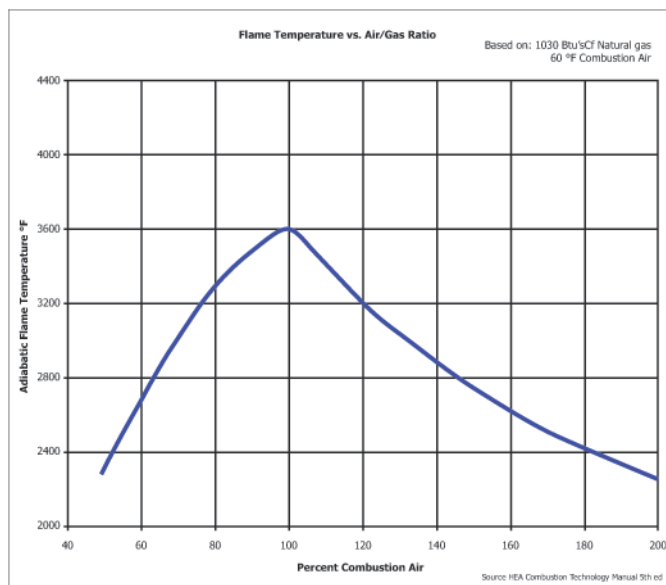
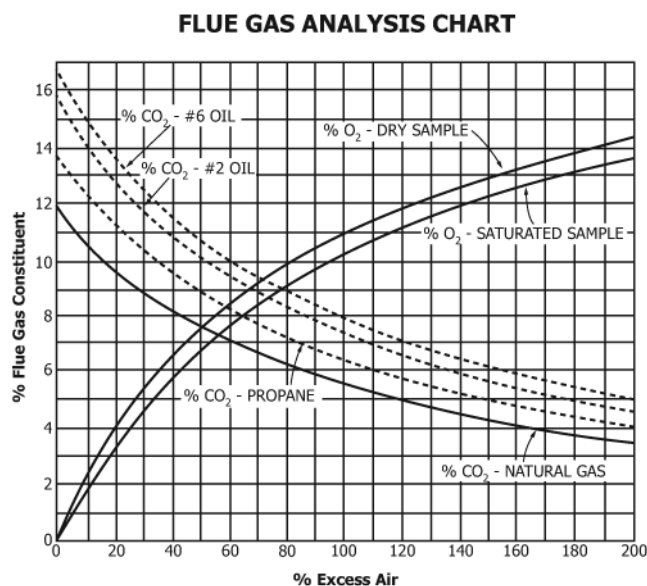


FIG. 1 Requiring Double Blocking (shutoff) Valve(s) for Furnaces, Ovens (Thermal Oxidizers) that are $<150\,000\text{ BTU/h}$ (5)



Combustion Systems Inc, IOM Appendix, 2018⁷

FIG. 2 Relationship between Combustion Flame Temperature and Combustion Air



Combustion Systems Inc, IOM Appendix, 2018⁷

FIG. 3 Flue Gas Analysis Chart

5.8.2 With additional oxygen, the carbon monoxide can be converted to CO_2 :



5.8.3 Gaseous fuels, such as methane, could produce pollutants (solids and particulate) when burned with too little oxygen.

5.8.4 The solid carbon particles can agglomerate, resulting in smoke and soot. Somewhat more oxygen, but still less than theoretical, could lead to carbon monoxide formation by the following reaction: