This is the document referred in a number of Ap-42 sections by:

13799.000

REF: 1

2.3 Conical Burners

Air Pollutant Emission Factors. Final Report. Resources Research, Inc. Reston, Va Prepared for National Air Pollution Control Administration, Durham, N.C., Contract Number CPA-22-69-119. April 1970.

This document is in two parts: The main volume (April 1970) and a Supplement dated August 1970.

AIR POLLUTANT EMISSION FACTORS

April 1970

Prepared for

Department of Health, Education and Welfare
Public Health Service
Environmental Health Service
National Air Pollution Control Administration
Washington, D. C.

TRW
SYSTEMS GROUP OF TRW INC.

1. INTRODUCTION

This report represents a compilation of the latest atmospheric emission data available for a wide variety of selected processes. One-half of the 40 processes discussed in this report involve an updating or review of existing emission factors presented in Public Health Service Publication 999-AP-42, "A Compilation of Air Pollutant Emission Factors" by R.L. Duprey. The remaining factors represent new processes for which emission factors were not previously reported. All emission factors refer to uncontrolled processes unless otherwise stated.

Information for emission factors was gathered primarily from the technical literature up to November 1969, state and local air pollution control agencies, trade and professional associations, releasable portions of data obtained by TRW in various past studies, and individual companies and persons within the various industries under study. In all cases, attempts were made to obtain some idea of the validity of the information obtained, and thus place each bit of data relative to other data in the same area. Greatest weight was given to actual measured emission data, i.e., source tests, especially when the measuring technique was known. Estimates of emissions were also made when feasible by making material balances and process loss or yield calculations.

In general, it was found that except for the combustion and incineration fields, very little new emission factor data has been made public since Duprey's work in 1967. In the metallurgical and mineral industries, additional emission data has been obtained by various companies and control equipment manufacturers. This information has not been made public, however. Some emission data was available for most of the new factors developed in this report. Frequently, however, these data were in the form of concentrations

This is the document referred in a number of Ap-42 sections by:

13799.000

REF:1

Air Pollutant Emission Factors. Final Report. Resources Research, Inc. Reston, Va Prepared for National Air Pollution Control Administration, Durham, N.C., Contract Number CPA-22-69-119. April 1970.

2.3 Conical Burners

This document is in two parts: The main volume (April 1970) and a Supplement dated August 1970.

AIR POLLUTANT

EMISSION FACTORS

April 1970

Prepared for

Department of Health, Education and Welfare
Public Health Service
Environmental Health Service
National Air Pollution Control Administration
Washington, D. C.

TRW
SYSTEMS GROUP OF TRW INC.

1. INTRODUCTION

This report represents a compilation of the latest atmospheric emission data available for a wide variety of selected processes. One-half of the 40 processes discussed in this report involve an updating or review of existing emission factors presented in Public Health Service Publication 999-AP-42, "A Compilation of Air Pollutant Emission Factors" by R.L. Duprey. The remaining factors represent new processes for which emission factors were not previously reported. All emission factors refer to uncontrolled processes unless otherwise stated.

Information for emission factors was gathered primarily from the technical literature up to November 1969, state and local air pollution control agencies, trade and professional associations, releasable portions of data obtained by TRW in various past studies, and individual companies and persons within the various industries under study. In all cases, attempts were made to obtain some idea of the validity of the information obtained, and thus place each bit of data relative to other data in the same area. Greatest weight was given to actual measured emission data, i.e., source tests, especially when the measuring technique was known. Estimates of emissions were also made when feasible by making material balances and process loss or yield calculations.

In general, it was found that except for the combustion and incineration fields, very little new emission factor data has been made public since Duprey's work in 1967. In the metallurgical and mineral industries, additional emission data has been obtained by various companies and control equipment manufacturers. This information has not been made public, however. Some emission data was available for most of the new factors developed in this report. Frequently, however, these data were in the form of concentrations only, not quantitative emission rates. Process weight rates were also frequently not given or reported. Considerable engineering calculations were thus required in order to put these data into a form usable for emission factors. These calculations, based on material balances, combustion reactions, humidity balances, and comparisons with similar processes with available emission data, allowed one to relate the reported data with process throughputs and develop a factor which is usable until better data are made available.

Detailed information used to obtain the emission factors is generally presented in an appendix to each section. Selection of a final emission factor depended on the amount and range of data available. Where considerable data existed a direct arithmetic average was used. Values on order of magnitude greater or less than the bulk of the data were not considered in determining the arithmetic average. Where limited data were available (1 to 5 values) and the values covered a wide range, the selected factor was based on our best judgment considering the factors affecting emissions. Whenever possible, the range or variation in emission factors was reported and shown in parenthesis following the factor. This range represents the range of values used in obtaining the factor and represents the expected variation in emissions. A lack of information sometimes prevented the reporting of a reasonable factor range.

Standard statistical deviations of the emission factors were not generally reported since insufficient or only widely scattered data were available and a significant deviation could not be calculated.

All emission factors in this report were ranked according to the available data upon which they were based. A system which weighted various information categories was used to rank the final factors. These categories were: measured emission data with a

3. REFUSE DISPOSAL

While incineration from an air pollution viewpoint is not a recommended form of solid waste disposal, it does occur in almost every part of the country and forms a significant part of the air pollution problem. More than five pounds per day of solid waste are currently collected from every person in this country, and this value is increasing by 2-3% per year.

Process	Approximate Particle size, microns - % by weight >44	20-44	10-20	5-10	<5
Municipal Incineration	45	18	15	10	12

Atmospheric emissions, both gaseous and particulate, result from refuse disposal operations which utilize combustion to reduce the quantity of refuse. Many types of solid waste are currently disposed of by a wide variety of combustion methods including both enclosed and open burning. Emissions from these combustion processes cover a wide range because of their dependence on the refuse burned, the method of combustion or incineration, and the efficiency of combustion. Many of these variables are not well controlled during incineration.

Reported factors were largely based on measured emission data. These data were found to vary considerably. The number chosen as the emission factor represented our best judgment based on the available data.

3.3 MUNICIPAL REFUSE AND WOOD DISPOSAL IN CONICAL BURNERS

Process Description

Conical burners are generally a truncated sheet metal cone with a screened top vent. The charge is placed on a raised grate by conveyor or bulldozer, the former method resulting in more efficient burning. No supplemental fuel is used but limited control of combustion air is often effected by means of a blower which supplies underfire air below the grate and peripheral openings in the shell which provide overfire air. For best results, each of these supply air systems is designed to create a cyclonic action. Excessive combustion air prevents good control of the combustion process and results in excessive smoke and other air contaminants.

The cylindrical or silo incinerator consists of a steel silo lined with refractory materials. Air is admitted through openings near the base of the incinerator. It is generally held that more efficient combustion can be attained in a cylindrical incinerator since the refractory-lined chamber maintains higher operating temperatures than the standard conical burner. However, emission test data does not indicate any significant reduction in contaminants emitted and, for the purpose of this study, no distinction is made between these two types of incinerators.

Factors Affecting Emissions

Many factors affect combustion within conical and cylindrical type incinerators. Quantity and types of pollutants are dependent on the makeup and moisture content of the charged material, control of combustion air, type of charging system used, and the condition in which the incinerator is maintained. It is difficult to establish what effect each of these factors has on the emission of contaminants. The most critical single factor seems to be the lack of maintenance on the incinerators. It is not uncommon for conical incinerators to have doors missing and a multiplicity of holes in the shell, all resulting in excessive combustion air, low temperatures, and therefore high emission rates.[1]

Particulate control systems have been adapted to conical burners with some success. These control systems include water curtains (wet caps) and water scrubbers.

Emissions

Published emission data for waste combustion in conical burners are very limited. Regarding municipal waste, some particulate data were available, but gaseous emission factors were estimated based on open burning and incineration test data. Detailed emission data are presented in the Appendix and summarized in Table 3.3-1.

Table 3.3-1. Emission Factors for Waste Incineration in Conical and Cylindrical Burners

Type of Waste	Emissions, lb/ton of waste as fired[d]				
	Particulate	CO	HC[e]	NO_x[f]	SO_2
Municipal Refuse	30 (10 to 60)	60	20	5	3
Wood	1[a] 10[b] 20[c]	130(30 to 360)	10(0.8 to 43)	1.2	0.15

a) Properly maintained burner with adjustable underfire air supply and adjustable, tangential overfire air inlets; approximately 500% excess air and 700°F exit gas temperature.

b) Properly maintained burner with radial overfire air supply near bottom of shell; approximately 1200% excess air and 400°F exit gas temperature.

c) Improperly maintained burner with radial overfire air supply near bottom of shell and many gaping holes in shell; approximately 1500% excess air and 400°F exit gas temperature.

d) Moisture content as-fired is approximately 50% for wood waste.

e) HC expressed as methane.

f) Expressed as NO_2.

Note: Use high side of range for intermittent operations charged with a bulldozer.

Reliability of Emission Factors

Particulate emission factors for combustion of municipal refuse or wood waste in conical burners are good even though they cover a range of values. However, gaseous emission data are very scarce and difficult to estimate. Emission factor rankings are presented in Table 3.3-2.

Table 3.3-2. Emission Factor Ranking for Conical Burners

	Emission Data 0-20	Process Data 0-10	Engineering Analysis 0-10	Total
Particulate	14	5	5	24
Gases	7	5	3	15

No major assumptions were made in obtaining the factors presented in this section, except that inferences were drawn from incineration emission data to determine gaseous emissions from conical burners.

APPENDIX 3.3

Municipal Waste

There are no published results of incineration of municipal waste in conical or cylindrical burners. The results of one unpublished test for particulate emissions made on a conical burner by the Bureau of Solid Waste Management[2] are shown in Table 3.3-3. Note that there is no correlation between the rate of feed and the particulate emissions. For instance, while the feed rate of test No. 1 was 50% greater than test No. 4, the emissions were substantially less. Comparing tests 4, 5, and 6, we find there is no correlation. Since all tests were made under identical conditions on the same burner it can only be concluded that the particulate emissions are greatly affected by the composition of the charged material. Due to the limited sample size, a statistical evaluation of the data has not been made. Under the circumstances, it seems more reasonable to assign a range (10-60) to the particulate emission factor.

Table 3.3-3. Particulate Emissions From a Pilot Scale Conical Burner

Test No.	Feed Rate, lbs/hr	Particulate Emission, lb/hr	lb/ton	% of feed
1	1670	8.65	10.3	0.5
2	1670	8.70	10.5	0.5
3	1460	13.26	18.2	0.9
4	1190	32.44	54.6	2.7
5	1190	17.46	29.4	1.5
6	1190	4.41	7.4	0.4

Values for gaseous emissions must be approximated from the values found for other types of incinerators. These values are shown in

Table 3.3-4. Incineration in conical and cylindrical burners tends to resemble open burning in that the fire must support itself, no auxiliary fuel being used. Unlike open burning, however, outside wind conditions do not appreciably affect the combustion and the combustion air supply can be regulated. The ambient temperature is a factor since the metal skin has no significant insulation value. Except for size, the backyard incinerators are seemingly most similar to the conical burners, but the data from Reference No. 6, shown in Table 3.3-4, are so high, relatively speaking, as to preclude full consideration. More complete combustion may generally be expected from flue fed and single chamber incinerators since they control the overfire and underfire air rates to a greater extent.

Analyzing the above, it must be concluded that the incineration of municipal waste in conical and cylindrical burners is more efficient than open burning and less efficient than single chamber incinerators.

Table 3.3-4. Gaseous Emissions From Municipal Waste Incineration

Type of Incineration	Emissions, lb/ton of waste				Reference
	SO_2	CO	HC[a]	NO_x[b]	Number
Open Burning and Single Chamber	3	40	8	4	3
Open Burning	-	85	30	4-9	4
Single-Chamber (Commercial)	1.5	20	15	2	5
Backyard Incinerator		600	115[c]	1	6

a) HC expressed as methane.

b) NO_x expressed as NO_2.

c) Reported values for saturated HC (30) and methane (85) were assumed to be expressed as methane.

Wood Waste

Very little testing has been done to measure emissions from the incineration of wood waste in conical and cylindrical burners. Almost all the reported figures are confined to particulate emissions. Table 3.3-5 compares the available test data with the open burning figures developed by Gerstle and Kemnitz.[4]

There is no correlation between the particulate emission figures which range from 1 to 20 lb/ton of wood waste. The highest figure was obtained from a conical burner having radial air openings and many gaping holes all over the shell. The exit gas temperature averaged about 400°F with approximately 1500% excess air while the burner which emitted only 2 lb. particulate matter/ton of wood waste, averaged approximately 700°F exit gas temperature with 500% excess air. Thus three particulate emission factors are given in Table 3.3-1 based on the condition and operation of the equipment.

Table 3.3-5. Emissions From Wood Waste Incineration

Type of Incineration	Emissions, lb/ton of waste as-fired[b]					Reference Number
	Part.	SO_2	CO	HC[a]	NO_x	
Open Burning	17		50	3	1	4
Cylindrical (Silo)	20	0.15			1.3	7
Cylindrical (Silo)	2	0.16		20	1.2	8
Conical - Satisfactory Operation	0.2-2.8					9
Conical - Unsatisfactory	7.3					9
Conical - Very Unsatisfactory	20.2					9
Cylindrical (Silo)	12					10
Conical			130(30-360)	11(0.8-43)		11
Conical	10.7(0.2-19.9)					12

a) Hydrocarbons expressed as methane.

b) Moisture content as-fired is approximately 50%.

Carbon monoxide emissions from conical burners have been measured by Droege and Lee.[11] These measurements are the basis for carbon monoxide emission factors. The emission factors for hydrocarbon and oxides of nitrogen are based on measured data.[8]

REFERENCES 3.3

1. Kreichelt, T.E. Air Pollution Aspects of Teepee Burners. National Air Pollution Control Administration. Raleigh, N.C. Public Health Service Publication 999-AP-28. September 1966.
2. Private Communication with Public Health Service, Bureau of Solid Waste Management, Cincinnati, Ohio. October 31, 1969.
3. Weisburd, M.I., and S.S. Griswold (eds.). Air Pollution Control Field Operations Manual. National Air Pollution Control Administration. Raleigh, N.C. Public Health Service Publication 937. 1962. p. 29.
4. Section 3.4, infra.
5. Section 3.1, supra.
6. Feldstein, M., et al. The Contribution of the Open Burning of Land Clearing Debris to Air Pollution. J. Air Pollution Control Association. 13:542-545, November 1963.
7. Magill, P.L., and R.W. Benoliel. Air Pollution in Los Angeles County, Contribution of Combustion Products. Industrial and Engineering Chemistry. 44:1347, June 1952.
8. Anderson, D.M., J. Lieben, and V.H. Sussman. Pure Air for Pennsylvania. Pennsylvania Department of Health. Harrisburg, Pa. November 1961. p. 98.
9. Boubel, R.W., et al. Wood Waste Disposal and Utilization. Engineering Experiment Station, Oregon State University. Corvallis, Oregon. Bulletin No. 39. June 1958. p. 57.
10. Netzley, A.B., and J.E. Williamson. Multiple Chamber Incinerators for Burning Wood Waste. In: Air Pollution Engineering Manual, Danielson, J.A. (ed.). National Air Pollution Control Administration. Raleigh, N.C. Public Health Service Publication 999-AP-40. 1967. p. 436.
11. Droege, H., and G. Lee. The Use of Gas Sampling and Analysis for the Evaluation of Tepee Burners. Bureau of Air Sanitation,

California Department of Public Health (Presented at the Seventh Conference on Methods in Air Pollution Studies. Los Angeles. January 25 and 26, 1965.) 7 pages.

12. Boubel, R.W. Particulate Emissions from Sawmill Waste Burners. Engineering Experiment Station, Oregon State University. Corvallis, Oregon. Bulletin No. 42. August 1968. p. 7 and 8.

total possible weight of 20, process data with a weight of 10, and engineering analysis with a weight of 10. The highest possible score for any factor was thus 40. Any factor ranking less than 20 was considered questionable and those ranked 20 or greater were considered reliable.

The emission data category rated the amount of measured emission data, i.e., stack test data available with which to develop an emission factor.

The process data category included such factors as the variability of the process and its effect on emissions, and available data on the variables. The engineering analysis category included the data available upon which a material balance or related emission calculation could be based.

The range of values for many emission factors is large. However, when the factors are applied to a large number of sources, the calculated overall emissions should approximate the true value. When applied to a single isolated source, an emission factor may yield emissions that differ considerably from the true value. Measured emission data should therefore be used, if possible, for single sources.