BACKGROUND DOCUMENT FOR COMMERCIAL AND CONSUMER SOLVENT USE[1]

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History

The per capita emission factor approach to inventorying area source emissions was developed to account for emissions from difficult to inventory sources. Emissions from the use of commercial and consumer products containing volatile organic compounds are representative of such a difficult to inventory source. Identifying individual types and quantities of solvent use require considerable resources and thus it is impractical to inventory emissions from this source category by other point and area source inventory methods.

Originally, commercial and consumer solvent use was included in a broad factor of 24 lbs/capita presented in the first edition of Procedures for the Preparation of Emission Inventories for Volatile Organic Compounds, Volume I[2] (1977). This factor was intended to act as a "catchall" estimate of other solvent use. End uses of solvents containing volatile organic compounds was better identified in reference 3 (1979). Based on this work a specific factor was derived for commercial and consumer solvent use.

The factor was presented in as a rounded off value of 10 lbs/capita in a memorandum of the Northeast Corridor Regional Modeling Project.[4] Review and recalculation of emissions data in reference 3 resulted in a new value of 9.2 lbs/capita.

A factor based on reactive volatile organics was also derived in reference 1 and then presented in Preparation of Emission Inventories, Second Edition (September 1980).[5]

The factor presented in this AP-42 section is the total volatile organic emission factor calculated in reference 1. The factors presented in Table 4.10-1 are based on the same method employed in reference 1 (Table 1) but are presented in units consistent with USEPA policy on the use of metric units. In addition, factors have been calculated in units which can be readily applied to State Implementation Plan (SIP) volatile organic compound (VOC) emission inventories.[5,6] Values in Table 4.10-1 represnt nonmethane VOC. Species data available in reference 3 indicate that no methane is included in commercial and consumer solvent emissions. (Table 2)

National consumption data are excerpted from page 1-21 of reference 3 which provides the most comprehensive breakdown of commercial/consumer solvent.

TABLE 1

COMMERCIAL AND CONSUMER SOLVENT END USES

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	Nationwide Consumption GG/yr (lbs x 10^6/yr)	
	Unadjusted	Adjusted
Aerosol products	293 (643)	342 (752)
Household products	158 (346)	183 (405)
Toiletries	113 (249)	132 (291)
Rubbing compounds	53 (117)	62 (137)
Windshield washing	52 (115)	61 (135)
Polishes and waxes	41 (91)	48 (106)
Non-industrial adhesives	25 (55)	29 (64)
Space deodorant	15 (34)	18 (40)
Moth control	12 (27)	16 (32)
Laundry detergent	3 (7)	4 (8)
TOTAL	765 (1684)	895 (1970)

The adjusted column represents only identified consumption data while the adjusted column includes unidentified solvent use allocated using a factor of 1.17. The rationale for this adjustment is discussed in references 1 and 3. The rationale is that 20 percent of an unidentified solvent use total of 90 gg/yr (200 x 10^6 lbs) is assumed to take place in the use of architectural surface coatings and commercial/consumer solvents. A release factor of 1.0 is assumed since no control of these emissions is practiced.

Speciation data indicates that all emissions consist of nonmethane VOC. Using Appendix A of reference 3, the following breakdown can be constructed.

TABLE 2

COMMERCIAL AND CONSUMER SOLVENT USE

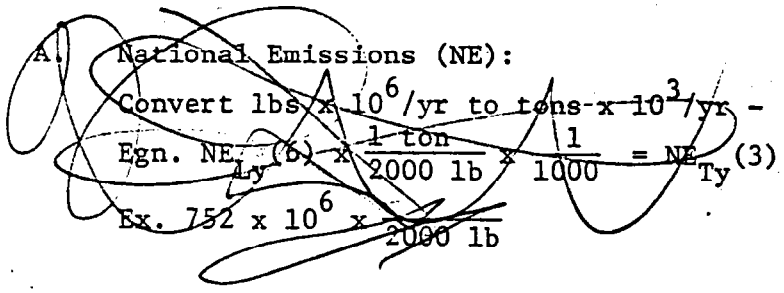
EMISSIONS SPECIE DATA[1]

Compound	Nationwide Consumption, GG/YR (lbs x 10^6/yr)
Special napthas	275 (605)
Fluorocarbons	87 (190)
Cholorocarbons	119 (265)
Methylene chloride	59 (130)
Isopropanol	104 (230)
Ethanol	132 (290)
Methanol	61 (135)
1,1,1-Trichloroethane	15 (33)
MIBK	4 (8)
MEK	2 (5)
Butyl acetates	1 (2)

Cont.

P-Dichlorobenzene	32 (70)
Perchloroethylene	4 (8)
TOTAL	895 (1970)

For convenience to the user, sample calculations are presented here to illustrate the methodologies employed in deriving per capita emission factors for commercial and consumer solvent use.



A. National Emissions (NE):

Convert lbs x 10^6/yr to tons x 10^3/yr -

Eqn. $NE_{Ly}(6) \times \frac{1 \text{ ton}}{2000 \text{ lb}} \times \frac{1}{1000} = NE_{Ty}(3)$

Ex. $752 \times 10^6 \times \frac{}{2000 \text{ lb}}$

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Ex. $752 \times 10^6 \times \frac{1 \text{ Ton}}{2000 \text{ lb}} \times \frac{1}{1000} = 376 \times 10^3$ Tons/yr

B. Per Capita Emission Factors (PF)

1. Calculation of a per capita factor from national emissions :

$$PF = \frac{NE}{\text{Population}}$$

$$= \frac{895 \text{ GG/yr}}{215 \times 10^6 \text{ people}} \times \frac{10^6 \text{ kg}}{1 \text{ GG}} = 4.2 \text{ kg/yr/cap}$$

2. Converting kg/yr to lb/yr :

$PF_{ky} \times 2.2 \text{ lbs/kg} = PF_{ly}$

4.2 x 2.2 lbs/kg = 9.2 lbs/yr/cap

3. Converting kg/yr (lbs/yr) to g/day (lb x 10^{-3}/day) :

$$PF_{ky(ly)} \times \frac{1 \text{ yr}}{365 \text{ days}} \times \frac{1000 \text{ g } (10^{-3} \text{ lbs})}{1 \text{ kg } (1\text{b})} = PF_{gd(1(-3)d)}$$

$$4.2 \text{ kg/yr} \times \frac{1}{365} \times \frac{1000}{1} = 11.6 \text{ g/day}$$

$$9.2 \text{ lb/yr} \times \frac{1}{365} \times \frac{1000}{1} = 25.2 \text{ lb} \times 10^{-3}/\text{day}$$

Population figure is recommended by reference 3. The days/year allocation is assumed uniform over each day of the year.

SUMMARY

These factors are based on the most recent consumption data available. However compound usage within the commercial/consumer category can rapidly change over a period of only a few years. For example, the degree of substitution of chlorinated/fluourinated hydrocarbons with parafins is unknown. Thus, while the factors are recommended for use in AP-42, these substitution trends must be indentified and the factors adjusted accordingly when data becomes available.

Based on the question of compound substitution (i.e., rapidly modified consumption trends) and the unaccountable solvent use in reference 3, these factors have been given a B rating.

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References

1. W. H. Lamason, "Technical Discussion of Per Capita Emission Factors for Several Area Sources of Volatile Organic Compounds", Monitoring and Data Analysis Division, U.S. Environmental Protection Agency, Research Triangle Park, NC, March 15, 1981, Unpublished.

2. Procedures for the Preparation of Emission Inventories, Volume I (First Edition), EPA-450/2-77-028, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 1977.

3. End Use of Solvents Containing Volatle Organic Compounds, E°A-450/3-79-032, U.S. Envioronmental Protection Agency, Research Triangle Park, NC, May 1979.

4. "Miscellaneous Commercial/Consumer Solvent Use", technical memorandum of the Northeast Corridor Regional Modeling Project (NECRMP), Monitoring and Data Analysis Division, U.S. Environmental Protection Agency, Research Triangle Park, NC, January 1980.

6. Final Emission Inventory Requirements For 1982 Ozone State Implementation Plans, EPA-450/4-80-016, U.S. Enviornmental Protection Agency, Research Triangle Park, NC, December 1980.

5. Procedures for the Preparation of Emission Inventories for Volatile Organic Compounds, Volume I, Second Edition, EPA-450/2-77-028 September 1980.

U.S. Environmental Protection Agency, Research Triangle Park, NC

TECHNICAL DISCUSSION OF PER CAPITA EMISSION FACTORS ~~AND NATIONAL EMISSIONS OF VOLATILE ORGANIC COMPOUNDS FOR SEVERAL AREA SOURCES EMISSION INVENTORY CATEGORIES~~

Final Emission Inventory Req. for 1982 Ozone SIPs

OVERVIEW:

The purpose of this paper is to document the development of several per capita emission factors to be used in 1982 State Implementation Plan (SIP) Volatile Organic Compound (VOC) emissions inventories. The per capita VOC emission factors ~~are to be~~ were released to local, State, and Regional control program offices through three vehicles: (1) ~~Federal Register;~~ (2) Procedures For The Preparation Of Emissions Inventories, Volume I, ~~revised~~ 2nd Edition 1980; and (3) ~~five~~ three Regional workshops. Inventories which will use the recommended factors are to be compiled for calendar year 1980 and submitted completed to EPA by December 31, 1981. By assuring agencies that these factors are the best available, the application of uniform per capita factors in SIP VOC emission inventories can be promoted.

EMISSIONS PER CAPITA INVENTORY METHOD:

VOC emission inventory methods identify emissions from individual point sources using permit files, plant visits and questionnaires mailed to facilities. However, several emissions categories cannot readily be inventoried by point source methods. Sources such as service stations, dry-cleaners, cold cleaning degreasing and architectural surface coating are better inventoried collectively as area sources.

Area source inventory methods include a gamut of techniques. Considerable emphasis is placed on methods which obtain local data specific to an inventory area. Still, certain source categories remain which are difficult to inventory using solvent distribution data, and employment, and tax statistics. For the difficult to inventory source categories, emissions per capita factors have been developed using national emissions data and national population statistics.

Emissions per capita factors are relatively easy to develop. Researching several references produces emissions data on source categories of interest. The data can be segregated into two types: (1) national emissions or national consumption data from which national emissions can be derived, and (2) locally derived emissions data usually modified to a per capita factor using the local population base. National emissions are converted to a per capita factor by dividing emission with the appropriate data base year national population. To compute area source emissions with the factor, multiply the inventory area population by the per capita factor which produces total emission. Then point source emissions are subtracted from total emissions to arrive at the area source emission totals for use in a VOC emissions inventory. An alternative approach is to identify national emissions from large sources (>100 tons/yr or 250 kg/day) and then to divide the remaining national emissions by national population. The resulting per capita factor would then apply to only smaller sources and emissions calculated using the factor would be added to point source emissions to obtain total

FACTOR DATA BASE:

Several problems are inherit with emission data which hinders the designation of factors for specific source categories. First and foremost is determining which emission data should be used in developing factors. National emissions data are more representative of all national urban areas as a whole but may not be directly applicable to local conditions. Locally derived factors reflect local conditions, but may be unacceptable nationally due to being unrepresentative. A range of locally derived factors would be acceptable but is often unavailable on a nationwide basis. Thus, the tendency is to employ factors based on national emissions or consumption data.

Determining which national emissions or consumption data to use is itself a problem. The ~~two~~ most reliable sources of national data are Control Techniques Guideline (CTG) documents[1-4] and End Uses of Solvents Containing Volatile Organic Compounds.[5] These documents differ by 5-34 percent for the four source categories that both cover. In addition, both documents have several specific limitations in estimating solvent use. Therefore, there is considerable uncertainty over which document is a better basis for the development of per capita factors.

TRC Report

Reference[5], commonly referred to as the "TRC Report", has three major drawbacks. First, the document reports consumption of solvent by end use, not emissions data. This technicality can be side stepped by making some appropriate assumptions on solvent release to the atmosphere to estimate national emissions. The second problem is that 910 gg/yr (200 x 10^6 lbs/yr) are considered unaccountable in the TRC Report. TRC believes that allocating this unaccountable use to identified uses will lead to less errors in inventories. The rational for allocation is based on the assumption that unidentified solvent consumption primarily ends up as minor components in solvent mixtures in the industrial ~~(20~~ percent) and consumer/commerical (~~50~~ percent) sectors.[5] This appears to be a logical assumption which provides a solution to the problem. Lastly, the TRC Report suffers from a lack of "hard" documentation and bases most of its estimates on simple discussion with industry. However, the report does approach solvent use by attempting to identify the end product or use of all the organic solvents produced for use in the United States. This document also represents the most current EPA work on identifying organic solvent use.

NSPS / CTG Documents

CTG documents for the respective area source categories also have several drawbacks. CTG documents are oriented towards specific subsections of a particular industry. Accordingly, emissions must be scaled up to account for the rest of the emissions category. For example, perchlorethylene emissions from drycleaners must be scaled up to account for petroleum solvent emissions which are not included in the CTG document.

Another problem is that emissions data were not obtained with the idea of a closed loop mass balance. Emissions data were obtained to identify the most important sources of VOC emissions, not all VOC emissions. Third, the emissions estimates in CTG documents are 4-12 years old. On the other hand, CTG documents are the result of considerable research and are foundation of VOC regulations nationwide. Also, information in the CTG can be updated for several source categories with data collated for new CTG documents. Three references were used in deriving per capita factors. Specific reasons on why one reference was used over another are given with each derivation. Where both references appear equally sound, the TRC Report is preferred based on the comprehensive approach to solvent consumption in the study and the relatively recent data.

DISCUSSION AND DERIVATION OF FACTORS:

National emissions data that are proposed for use in inventory guidance listed are in Table 1. The table lists per capita emission factors that are derived from national emissions totals, as well as a range of per capita factors included for comparison with selected values. All recommended factors are derived and compared with the data range in the discussion of this Section.

TABLE 1. VOC EMISSIONS AND PER CAPITA VOC EMISSION FACTORS FOR THE U.S.[a]

Category	Recommended Value for National Emissions x 10^9 lbs/yr	Recommended Value for National Emissions lb/cap-yr	Range of Per Capita Factors lbs/cap-yr
Drycleaning - commercial / - self-service (coin-op)	721	3.4 1.2 0.3	1.5 - 3.4[b]
Cold cleaning degreasing	627	3.0[b,c]	2.8 - 3.2
Architectural surface coating	981	4.6	3.8 - 8.4
Auto refinishing	398	1.8	0.5 - 1.8[d]
Graphic arts - Small Sources	672	3.1 0.5	2.5 - 3.1[d,e]
Consumer/commercial	1360	6.3[b,c]	N/A[f]

[a] References 1-11.
[b] Combined factors for entire drycleaning industry.
[c] Includes adjustment to exclude compounds exempted under EPA policy.
[d] Only two values.
[e] Includes major sources
[f] Only one value.

The discussion and derivation of factors presented in Table 1 is organized by source categories to allow independent source categories to allow independent review of factors for each category. However, for all

Other Factor - Another factor was developed and is presented for comparison.

CTG - The CTG on flexography and rotogravure can be used to compute a per capita factor from Equation 1 (Reference 4):

$$PF = \frac{270 \times 10^3 \text{ tons/yr} \times 2000 \text{ lb/ton}}{215 \times 10^6 \text{ (76 pop.)}} = 2.5 \text{ lbs/cap-yr}$$

Reference 4 assumes controlled emissions of 30 percent which is reflected in the factor. The TRC derived factor is preferred based on the general discussion at the beginning of this paper.

CONSUMER/COMMERCIAL SOLVENT:

Recommended Factor (TRC) - The TRC Report provides the most comprehensive breakdown of consumer/commerical solvent. National consumption data is excerpted from page 1-21 of the report.[5]

USE	Nationwide Consumption lbs x 10^6 yr.	
	Unadjusted	Adjusted
Aerosol products	643	752
Household products	346	405
Toiletries	249	291
Rubbing compounds	117	137
Windshield washing	115	135
Polishes and waxes	91	106
Non-industrial adhesives	55	64
Space deodorant	34	40
Moth control	27	32
Laundry detergent	7	8
TOTAL	1684	1970

$$PF = \frac{1970 \times 10^6 \text{ lbs/yr}}{215 \times 10^6} = 9.2 \text{ lbs/cap-yr (including exempt compounds)}$$

The unadjusted column represents only identified consumption data while the adjusted column includes unidentified solvent use allocated using a factor of 1.17 which has been discussed previously. The already adjusted total emissions are then used in Equation 1 to compute a per capita factor. A release factor of 1.0 is assumed since no control of these emissions is practiced. Speciation data indicates that a considerable quantity of the factor emissions consists of exempt compounds. Using Appendix A of the report, the following breakdown can be constructed.

CONSUMER/COMMERCIAL

Compound	Nationwide Consumption, GG/YR Exempt	Non-exempt
Special napthas		234
Fluorocarbons	74	
Chlorocarbons	102	
Methylene chloride	50	
Isopropanol		89
Ethanol		113
Methanol		52
1,1,1-Trichloroethane	13	
MIBK		3
MEK		2
Butyl acetates		1
P-Dichlorobenzene		27
Perchloroethylene		3
TOTAL	239	524
PERCENTAGE	31%	69%

Since non-exempt compounds represent only 69 percent of the consumer/commercial solvent consumption, EFA is equal to 0.69. Thus, the factor must be adjusted.

PF = 9.2 x 0.69 = 6.3 lbs/cap-yr

This factor is based on the most recent speciation data available. However compound usage within the consumer/commercial category can rapidly change over a period of only a few years. For example, the degree of substitution of chlorinated/fluorinated hydrocarbons with parafins is unknown. Thus, while the factor is recommened for inventory use, these substitution trends must be indentified.

SUMMARY:

The above derived per capita emission factors for release of organic into the atmosphere represent the best available data for area source per capita inventorying. However, while these factors are corrected for exempt solvents, they do not reflect possible changes in substitution patterns between the mid 1970's and the present. Changes in consumption need to be identified in the future to improve the available data base. In conclusion, the factors should be used in inventory guidance as they represent an improvement over per capita factors previously recommended for use in VOC emission inventories.