BACKGROUND DOCUMENT

SECTION 4.6 SOLVENT DEGREASING

1.0 INTRODUCTION

The information on emissions from solvent degreasing was developed from (1) telephone surveys of responsible persons in industries engaged in degreasing, and (2) a series of studies carried out under EPA sponsorship to evaluate various emission control devices. Information from both sources was used to compute emission factors. A detailed discussion of these computations follows.

2.0 FACTORS BASED ON SURVEY DATA

A nationwide survey of metal working industries was conducted by the Dow Chemical Company to obtain information on emissions from solvent degreasing (Reference 3, Appendix Report). Metal working industries employing 20 or more people were surveyed within the following industrial classifications:

- Furniture and fixtures
- Primary metal industries
- Fabricated metal products
- Machinery (except electrical)
- Electrical and electronic equipment
- Transportation equipment
- Instruments and related products
- Miscellaneous manufacturing industries

A representative sample of 2,578 out of a possible 41,670 plants was surveyed by telephone to ascertain the types of degreasers employed, the specific solvents used, and the quantities consumed and disposed of by various routes. The results of this survey were as follows:

● Number of maintenance cold cleaners in the U.S. in 1974	880,000
● Number of manufacturing cold cleaners	340,000
● Number of open top vapor degreasers	21,000
● Number of conveyorized vapor degreasers	3,170
● Number of conveyorized nonboiling degreasers	530

The estimates of solvent usage from the survey were compared with similar estimates from other surveys (Table 1), and a weighted average solvent consumption for each type of degreaser was computed.

2.1 COLD CLEANING

Of the 450×10^3 MT/yr of solvents consumed in cold cleaning, 25×10^3 MT/yr are used in wiping operations, which are not considered cold cleaner emissions, and another 25×10^3 MT/yr are used in conveyorized nonboiling degreasers, which are considered separately. Another 20×10^3 MT/yr are incinerated or landfilled after use in such a manner that no emissions occur. Thus, 380×10^3 MT/yr of solvents find their way into the atmosphere as a result of cold cleaning operations. The average emissions per unit can be computed as

$$\frac{380 \times 10^3 \text{ MT/yr}}{\underset{\text{maintenance units}}{880{,}000} + \underset{\text{manufacturing units}}{340{,}000}} = \underset{\text{cold cleaning unit}}{0.31 \text{ MT/yr per}}$$

If it is assumed that manufacturing cold cleaners have twice the emission rate of maintenance cold cleaners, then by simple algebra manufacturing units average 0.48 MT/yr and maintenance units average 0.24 MT/yr. By using their best engineering judgement, the authors of Reference 2 estimated that 55 percent of cold cleaning emissions are due to waste solvent evaporation, 20 percent to bath and spray evaporation, and 25 percent to carryout losses. The emission factors for each part of the cold

Table 1. U.S. CONSUMPTION OF DEGREASING SOLVENTS[a]
1974 (10^3 metric tons/year)

Solvent Type	Weighted Average	Monsanto-S.A.D. Tom Hoogheem-1974	U.S. Tariff Comm. Report for 1974	Dow Final Report Survey for 1974	Dow Chart for 1974	Detrex 1975	Estimates Projected 1974	J.S. Gunnin Shell Chemical Solvent Bus. Ctr
	VD+CC=Total	VD + CC = Total	VD + CC = Total	VD + CC = Total	VD only	VD	VD	
Halogenated								
Trichloroethylene	128 + 25 = 153	157	142 + 8 = 150	103 + 39 = 142	143	114	124	
1,1,1 trichloroethane	80 + 82 = 162	90 + 78 = 168	73 +106 = 179	110 + 63 = 173	73	63	53	No data
Perchloroethylene	41 + 13 = 54	43 + 11 = 54	40 + 19 = 59	41 + 9 = 50	40	45	40	
Methylene chloride	7 + 23 = 30	10 + 46 = 56	7 + 18 = 25	7.5 +6.3 = 13.8	9	8	6	
Trichlorotrifluoroethane	20 + 10 = 30	- - 17	- - -	34 + 18 = 52	20	20	18	
Total	276 +153 = 429	-	-	296 +135 = 431	285	250	241	
Aliphatic	222	225						218
Aromatic								
Benzene	7	7						-
Toluene	14	14						-
Xylene	12	12	No data	No data	No data	No data	No data	-
Cyclohexane	1	1						
Heavy aromatics	12	-						12
Total	46	-						-
Oxygenated								
Ketones								
Acetone	10	10		10				
Methyl ethyl ketone	8	7.5		8				
Alcohols			No data		No data	No data		No data
Butyl	5	3.3		7				
Ethers	6	6		-				
Total	29	26.8		-				
TOTAL	726							

Breakdown:		Expected Accuracy:	Ranges:
Vapor deg. solvents =	VD = 276≈275	±10 percent	→ VD = 275 ± 25 = 250 to 300 (x 10^3 metric ton/yr)
Cold clean. solvents =	CC = 153 + 222 + 46 + 29	±15% ± 30% ± 50%	→ CC = (155 ± 25) + (220 ± 65) + (75 ± 35)
	= 153 + 222 + 75		= (130 + 155 + 38) to (180 + 285 + 112)
	= 153 + 297		= 323 to 557
	= 450		= 450 ± 127

[a]From Reference 2 (EPA 450/2-77-022)

cleaning process were derived by applying these percentages to the overall factor for the entire unit. Emission factors were not computed for individual solvent types, but represent composite factors for all solvents.

2.2 OPEN TOP VAPOR DEGREASING

According to Table 1, 275 x 10^3 MT/yr of solvents are used in vapor degreasing. Based on information from the survey and best engineering judgement, the authors of Reference 2 estimated that 75 x 10^3 MT/yr are from conveyorized vapor degreasing, and the remaining 200 x 10^3 MT/yr from open top vapor degreasing. The emissions per unit were computed as

$$\frac{200 \times 10^3 \text{ MT/yr}}{21{,}000 \text{ units}} = 9.5 \text{ MT/yr per open top vapor degreasing unit}$$

No attempt was made to separate this emission factor into subfactors that represent various parts of the vapor degreasing operation (as was done for cold cleaning).

2.3 CONVEYORIZED DEGREASING

Solvent usage in conveyorized nonboiling and vapor degreasing was estimated to be 25 x 10^3 MT/yr and 75 x 10^3 MT/yr, respectively (refer to Sections 2.1 and 2.2). Emission factors for each type of unit were computed as follows:

$$\frac{25 \times 10^3 \text{ MT/yr}}{530 \text{ nonboiling units}} = 47.2 \text{ MT/yr per conveyorized nonboiling unit}$$

$$\frac{75 \times 10^3 \text{ MT/yr}}{3{,}170 \text{ vapor units}} = 23.7 \text{ MT/yr per conveyorized vapor unit}$$

As in the previous cases, these factors apply to composite average units and solvent types.

3.0 FACTORS BASED ON TEST DATA

One study (Reference 3, Appendix C-6) was carried out on a Baron Blakeslee Model HD 425 vapor degreaser, which was operated both as a cold cleaner and as a vapor degreaser by the Prestolite Corporation at Bay City, Michigan, using 1,1,1 trichloroethane as the solvent. When used as a vapor degreaser for one year, the unit operated for 16 hours per day for 250 days and consumed 550 gallons (2,737 kg) of solvent. When used as a cold cleaner for 25 days at 16 hours per day, the unit consumer 18 gallons (90 kg). No waste solvent disposal was carried out during the 25 day test, so these losses are not included as they are in the 250 day test of vapor degreasing. These figures equate to 1.5 lb/hr for the vapor degreaser and 0.49 lb/hr for the cold cleaner. Waste solvent disposal was estimated to add 0.3 lb/hr for the cold cleaner.

The cleaner used for this test had a surface area of 10.2 ft^2 (.95 m^2), so the emissions were calculated to be 0.048 lb/hr·ft^2 (.23 kg/hr·m^2) for the cold cleaner without waste solvent disposal, and 0.077 lb/hr·ft^2 (.37 kg/hr·m^2) for the cold cleaner including the estimated emissions from waste solvent disposal. Emissions from the vapor degreasing test are calculated as 0.15 lb/hr·ft^2 (.71 kg/hr·m^2) for the entire operation. The factors listed in AP-42, Table 4.6-1 are based entirely on the Prestolite Corporation tests for the applications where activity measures were given in terms of the unit's surface area and duty cycle (Reference 3, Appendix C-6).

Evaporation rate tests were also conducted for two cold cleaners under a variety of operating conditions for periods of 16 to 164 hours, and loss rates of 0.006 to 0.59 lb/hr·ft^2 (.003 to 2.8 kg/hr·m^2) were measured (Reference 1, Appendix A-2). These tests illustrate the extreme range of emission rates that may be encountered; they did not define typical, real-world operation and therefore were not used in the development of emission factors.

4.0 EMISSION REDUCTION FACTORS

The authors of Reference 2 made the emission reduction factor estimates given in AP-42, Table 4.6-2 by combining their best engineering judgment and the results of the tests summarized in Table 2.

5.0 EMISSION FACTOR RATING

The conventional rating system gives the following weighting to the various information categories: measured emission data, 20 points maximum; process data, 10 points maximum; engineering analysis, 10 points maximum. In the case of solvent degreasing, where the most accurate estimate of emissions is based on a material balance, less importance was assigned to measured emission data because they do not appreciably increase the accuracy of an emissions estimate based on solvent consumption. The following rating system was used:

	Maximum Points	Solvent Degreasing
Measured emission data	10	4
Process data	10	6
Engineering analysis	20	15
TOTAL:	40	25

The emission factor rating for 25 points is C.

Table 2. TEST RESULTS FROM DOW REPORT[a]

Satisfactory Control Systems

Dow Report[b] Appendix No.	User	Degreaser[b]	Vapor Area	Solvent	Uncontrolled Emission Rate (gal/unit)	Uncontrolled Emission Rate ($lb/ft^2 \cdot hr$)	Controlled Emisson (gal/unit)	Controlled Emisson ($lb/ft^2 \cdot hr$)	Controlled Efficiency n%	Control System	Comments
C-5	Pratt & Whitney	OTVD	65 x 110 in. 49.6 ft^2	1,1,1	97.5 gal/wk	0.16	58.4 gal/wk	0.10	40%	Cover-pneumatically powered	Uncovered for 24 hr/day and 7 day/wk
C-2	Eaton	OTVD	-	Tri. 1,1,1	129 lb/ton 111 lb/ton	- -	99 lb/ton 80 lb/ton		23% 28%	Cover (manual)	No much information on the test
C-12	Dow Lab	OTVD	24.2 x 22 in. 3.7 ft^2	1,1,1		0.373 0.373 0.373		0.373 0.273 0.167	0 27% 55%	FR = 0.5 = 0.75 = 1.0	Idle (no work loads), moderate draft
			24.2 x 22 in. 3.7 ft^2	1,1,1		0.955 0.955 0.955		- 0.051 0.054	- 46% 43%	FR = 0.5 0.75 1.0	Idle, quiet air
C-3	Hamilton Standard	OTVD (No. 203)	15 ft^2	Methylene chloride	7.5 gal/opday 6.43 gal/day	0.186	4.53 gal/opday 3.67 gal/day	0.112	40%	Cold trap FR = 0.81 (covered during disuse)	Work load when CT on was 50% more than when CT off -n>40%
		OTVD (O&R)	11.1 ft^2	Methylene chloride	3.63 gal/opday 2.9 gal/day	0.450	2.60 gal/opday 1.73 gal/day	0.322	28% 40%	Cold trap FR = 0.75 (never covered)	Inaccurate results. The O&R deg is expected to have a higher n, due to being uncovered. O&R had only ~3 work loads per operating day whereas No. 201 had 28 to 43 wkld/opday.
C-10	Vic	OTVD	12 x 4.5 ft. 54 ft^2	Tri.	108 gal/wk	0.605	38 gal/wk	0.213	65%	Carbon adsorption	Ventilation rate of 103 cfm/ft^2. Accuracy of record-keeping is reported by Dow to be poor. Thus, accuracy of results would be poor
C-7	Schlage Lock	CVD-monorail	41.3 ft^2	Perc.	19.5 gal/wday	0.79	7.5 gal/wday	0.304	62%	Chiller	Range of n is 45 to 65%
C-11	W. Electric Hawthorne	CND defluxer	-	Tri.	0.063 gal/ft^2 of circuit board 23.8 gal/wday	-	0.025 gal/ft^2 10.4 gal/wday	-			
Unsatisfactory Control Systems											
C-5	Pratt & Whitney	OTVD	56 x 90 in. 35 ft^2	1,1,1	58 gal/wk	0.138	49 gal/wk	0.117	16%	Cold trap	FR = 59%, cold trap design tested here was reported as an obsolete model. Covered during disuse.
C-8	Super Radiator	OTVD	6 x 12 ft. 72 ft^2	Perc.	49 gal/day	1.53	37 gal/day	1.14	-8%	Carbon adsorption	Defective adsorption system - breakthrough; insufficient FR≥0.04 ≥ FR 0.1. Only 37 cfm/ft^2
C-4	Hewlette Packard	CND monorail developer		1,1,1	0.33 gal/board		0.26 gal/board		21%	Carbon adsorption	Low control efficiency of the adsorption system is thought to be because of poor ventilation design
C-9	J.L. Thompson	CVD crossrod		Tri.	1.4 gal/hr		1.06 gal/hr		25%	Carbon adsorption	Material balance results
					50.5 gal/wk		49.5 gal/wk		50%	Carbon adsorption	Results from purchase records

Abbreviations: OTVD = Open Top Vapor Degreaser, CVD = Coveyorized Vapor Degreaser, CND = Conveyorized Nonboiling Degreaser, Opday = Day degreaser is in operation, wday = working day, CT = Cold Trap, FR = Freeboard Ratio lb/ton = pounds of solvent emittel per ton of parts degreased, WKLD = work load, 1,1,1 = methyl chloroform, Tri. = trichloroethylene, Perc. = perchloroethylene.

[a]From Reference 2 (EPA 450/2-77-022)

[b]The appendix of the Dow Report describes each test in detail.

References:

1. Marn, P.J.: Hoogheem, T.J.; Horn, D.A.; and Hughes, T.W. Source Assessment: Solvent Evaporation-Degreasing. Draft document. Monsanto Research Corporation, Dayton, Ohio. Prepared for U.S. Environmental Protection Agency, Research Triangle Park, N.C. 27711, under Contract No. 68-02-1874, January 1977.

2. Control of Volatile Organic Emissions from Solvent Metal Cleaning. EPA-450/2-77-022 (OAQPS No. 1.2-079). U.S. Environmental Protection Agency, Research Triangle Park, N.C. 27711, November 1977.

3. Suprenant, K.S. and Richards, D.W. Study to Support New Source Performance Standards for Solvent Metal Cleaning Operations, Final and Appendix reports. Dow Chemical Company, Midland, Mich. Prepared for U.S. Environmental Protection Agency, Research Triangle Park, N.C. 27711, under Contract No. 68-02-1329, Task No. 9, June 30, 1976.