SECTION 3.2

DEGREASING

(Updated and Revised March 2000)

EMISSION INVENTORY SOURCE CATEGORY
Cleaning and Surface Coatings/ Degreasing

EMISSION INVENTORY CODES (CES CODES) AND DESCRIPTION

220-204-XXXX-0000	(11 Codes)	Cold Cleaning - Batch, Conveyor, Sprayer Gun
220-206-XXXX-0000	(7 Codes)	Vapor Degreasing - Batch, Conveyor
220-208-XXXX-0000	(14 Codes)	Handwiping

METHODS AND SOURCES

These categories are an inventory of the total organic gas (TOG) emissions resulting from the use of solvents in degreasing operations in the manufacturing and maintenance industries.

The category of ***Cold Cleaning - Batch, Conveyor, Sprayer Gun*** includes emissions from solvents used in degreasing equipment which are either cold or are heated to below their boiling point to dissolve contaminants. Other synonyms for cold cleaning equipment include: batch loaded cold cleaners, remote reservoir cold cleaners, parts washers, semi-aqueous cleaning equipment, aqueous cleaning equipment, film cleaning equipment, and gun cleaning equipment. The equipment types of this category are used with eleven different solvent types.

The subcategory, Batch, refers to a type of degreaser that is manually loaded with a group of parts to be cleaned. The subcategory, Conveyor, refers to a type of degreaser with a continuous mechanical system for moving parts to be cleaned into and out of the solvent or vapor. The subcategory, Sprayer Gun, refers to a type of degreaser designed to specifically clean spray guns used for coating and adhesive applications.

The category of ***Vapor Degreasing - Batch and Conveyor*** includes emissions from solvents used in degreasing equipment which are heated above their boiling point producing a vapor to remove contaminants. The equipment types of this category are used with seven different solvent types.

The category, ***Handwiping,*** refers to the application of solvent by hand to the surface to be cleaned. Other synonyms for handwiping include wipe cleaning, solvent flushing operations, and coating application equipment cleaning. This category has 14 different solvent types.

The 1993 emission estimates from this source category are primarily based on the E.H. Pechan and Associates, Inc. (Pechan) 1996 report titled, "Solvent Cleaning/Degreasing Source Category Emission Inventory."[1] Emissions were estimated for 32 equipment and solvent pairs (ESPs) for each county. The statewide emissions for 1993 are summarized in Table II.

Solvent users survey

To estimate degreasing emissions, Pechan collected activity data by surveying solvent users. Pechan surveyed the solvent users in two major groups Manufacturing and Maintenance. The industries that were determined to use degreasing solvents were split into nine groups based on Standard Industrial Codes (SICs) shown in Table I. Pechan used facility data from Dun and Bradstreet, a supplier of business/marketing information, to represent the universe of facilities to sample from.

The Manufacturing group includes facilities that manufacture furniture and fixtures (not including wood products), metal products, industrial machinery, electronics, transportation equipment, instruments and related equipment, and miscellaneous manufacturing. The Manufacturing group was surveyed for both use of solvent in their manufacturing processes and maintenance processes. Manufacturing processes refer to any activity where solvent is used to clean products during manufacturing, including cleaning prior to final packaging. Maintenance activities encompass any activity where solvent is used to clean machinery, tools, vehicle parts or other equipment not incorporated into a product.

The Maintenance group includes vehicular repair and maintenance facilities and manufacturing facilities not included in the Manufacturing group that use solvents solely for maintaining their equipment e.g. food products manufacturing and textile manufacturing.

The number of facilities that provided valid survey responses was approximately 1,400. These valid facility responses include responses that indicated no solvent use and responses that indicated use of water-based solvents. Pechan developed three emission variables for SIC Group 1-7 (see Table I), SIC Group 8, SIC Group 9, for each ESP from the survey data. The emission variables are based on approximately 960 facility responses and approximately 2,700 degreasing units or ESPs. To allocate the emissions to California counties and districts, total employment data by Standard Industrial Code (SIC) for each county was used from U.S. Census Bureau (Census Bureau).[2]

Emission variables

Three emission variables were used to estimate emissions: an activity factor, an emission factor, and a user's fraction. The activity factor for the Manufacturer's survey is gallons of solvent used minus gallons solvent recycled per total number of employees at a facility. For each ESP the activity factors were averaged and then weighted. The activity factor for the Maintenance survey, is the amount of solvent added to the degreaser to maintain an operational level. In this case, either a median or an average activity factor for each ESP was calculated.

For the Manufacturer's survey the emission factor for pure solvents is the density of the solvent. The emission factor for solvent blends is the density of the solvent multiplied by the total organic gas (TOG) content of the solvent. The emission factors were averaged and weighted. In addition, exhaust controls were taken into account if used. For the Maintenance survey the emission factors are the density of the solvent and no exhaust controls were used.

The purpose of the user's fraction is to determine the proportion of facility employees using a particular ESP in particular industries. The user's fraction is calculated using the survey data. The user's fraction is the total employees in all facilities using a particular ESP divided by the total employees of the SICs where that particular ESP is in use. In the Manufacturer's survey some ESPs have a user's fraction that was refined to specific SICs and Region level. This refining was done where the number of responses was greater than 10 in an SIC Group. Region levels were established based on federal ozone attainment status of each county where region 1= extreme and severe non-attainment, region 2 = serious and moderate non-attainment and region 3 = attainment.

Mining operations/Other Trades and Agricultural equipment

Mining operations/Other Trades and Agricultural equipment were not included in the user Universe determined by Pechan. Emissions from these sources were estimated by Pechan using data from Safety-Kleen. These emissions were added to the Maintenance Group/Petroleum Distillates/Batch Cold Cleaners; SIC group 8. Data used from Safety-Kleen included: number of degreasing units, typical annual solvent loss from the most popular degreasing units and estimates of their market share.

To allocate Mining operations/Other Trades emissions to the county level, Pechan assumed that all the users in this group were employed in the Oil/Gas Field Services. These emissions were allocated to the county level using the ratio of county to state Census Bureau employment data for the SIC 1380 Oil/Gas Field Services. For allocating the Agricultural equipment emissions to the county level, the ratio of county to state Census Bureau employment data for the SIC 710 Soil Preparation Services and 720 Crop Services was used.

The Mining operations/Other Trades and Agricultural equipment estimates include both Safety-Kleen users and non-Safety-Kleen users in these particular industries. However, these particular industries were determined based on only users of Safety-Kleen products. There is a small degree of overlap with the Mining operations/Other Trades and Agricultural equipment with the user Universe that was surveyed. For example, agricultural and refrigeration equipment repair were included in both sets of data.

Percent recycled solvent

For the Manufacturers' Survey some respondents answered that 100% of the solvent used was recycled. Since it is technically impossible to recycle 100%, these responses were determined to be invalid and were replaced with averages based on valid recycling responses from the survey. These averages were calculated for similar solvent groups and equipment types. The following are the percent recycled assumptions for the solvents used in the manufacturing process:

- 48% Halogenated-Batch Vapor Degreasers/Conveyorized Vapor Degreasers,
- 53% Halogenated/Batch Cold Cleaners,
- 62% Petroleum Distillates/Batch Cold Cleaners/Conveyorized Cold Cleaners,
- 59% Other solvent groups/Batch Cold Cleaners/Conveyorized Cold Cleaners/Sprayer Gun Cleaner**.**

The following are the percent recycled assumptions for the solvents used in the maintenance process:

- 35% Halogenated-Batch Vapor Degreasers/Conveyorized Vapor Degreasers,
- 34% Halogenated-Batch Cold Cleaners/Conveyorized Cold Cleaners/Sprayer Guns,
- 62% Petroleum Distillates/Batch Cold Cleaners/Conveyorized Cold Cleaners,
- 59% Other solvent groups/Batch Cold Cleaners/Conveyorized Cold Cleaners**.**

For the Maintenance Survey no assumptions were needed for the recycling component. This is because the amount of solvent emitted was estimated by surveying users on how much solvent is added to their degreaser to maintain an operational level. In addition, for all the handwiping ESPs it was assumed no disposal or recycling takes place due to the nature of the activity.

Modifications to Pechan method

Some modifications have been made to the methodology developed by Pechan. These modifications include: improving the weighting procedure for the activity factor and the emission factor for the Manufacturer's survey data, improving the proportion of emissions from agricultural and oil operations, and adding military point sources to the emission total. The federal government including military bases was not surveyed by

Pechan. Emissions from military point sources from ARB's California Emission Inventory Development and Reporting System (CEIDARS) database were added to this emissions inventory.

Point and area sources

The methodology described here represents the total emissions from solvent cleaning/degreasing; these emissions are summarized in Table II. Point sources, facilities that emit greater than 25 tons per year of any pollutant and are reported by the Air Pollution Control Districts, are subtracted from these total emissions. An exception to this is the military point sources which were added to the total emissions and not subsequently subtracted.

Growth

The 1993 base year emission estimates were updated to 1998 using growth factors for each county from the ARB's Emission Data Forecasting System.[3] This data system contains historical growth factors for the manufacturing and commercial sectors developed by DRI/McGraw Hill.[4] The growth factors for the manufacturing industry are based on total dollar output and the growth factors for the commercial sector are based on employment data. To apply the growth factors to each ESP, a fraction was determined based on where solvent use occurs; in the manufacturing sector or the commercial sector. The manufacturing sector consists of manufacturing (SIC Group 1-7 and SIC Group 9) and Mining/Other Trades. The commercial sector consists of vehicle repair and maintenance (SIC Group 8), and Agricultural Equipment. The majority of the ESPs are used in the manufacturing sector. Three ESPs are a composite of manufacturing and commercial growth factors.

TEMPORAL ACTIVITY

The annual activity is uniform throughout the year. The weekly activity is uniform on weekdays, with minimal activity on weekends. Most daily activity occurs during the daylight working hours from 7:00 a.m. to 6:00 p.m.

ASSUMPTIONS

1. The list of industries that use degreasing solvents by Standard Industrial Classification Codes (SICs) determined by Pechan is reasonable.

2. The facilities from Dun and Bradstreet represent the universe of facilities to sample.

3. The survey data collected for the Pechan study are a reasonable base for estimating use of degreasing solvents.

4. The method of using the ratio of solvent use to total employees at a facility and then distributing the emissions to counties by total employees in industries using U.S.

Census Bureau data is valid.

5. The growth factors from the DRI/McGraw Hill study are representative of the increase from 1993 to 1998 in the industrial and commercial sectors in each county.

CHANGES IN THE METHODOLOGY

The major change from the previous methodology is that emissions are now estimated for 32 equipment and solvent categories representing a process oriented approach. The previous five categories were based on the place where emissions occur and general solvent type.

Another major change is that the current methodology is based on a survey of solvent end users (a bottom-up approach), whereas the previous methodology is based primarily on solvent production data (a top-down approach).

The federal government including military bases was not surveyed by Pechan. Maintenance of military aircraft was included in the previous methodology. Although emissions from military point sources from ARB's CEIDARS database were added to this methodology the additional emissions were small. Many degreasers at military bases are not included in the point source database.

COMMENTS AND RECOMMENDATIONS

The change of solvent type is reflected from the previous methodology update; from halogenated solvents, TCA and TCE, to petroleum solvents. The estimation of degreasing solvent emissions by individual equipment and solvent types allows a more process oriented data analysis. Some ESP emission estimates have a greater certainty and some ESP emission estimates have less certainty. The new categorization by ESPs allows for emission categories to be improved and updated individually.

Emission estimates for degreasing will need to be updated as solvent types and technologies used to degrease continue to change. The solvents used will change as national, state and district regulations/rules limiting solvent types are implemented. For example, on the national level with the phase out of TCA, CFCs and HCFCs the use of these solvents will be discontinued. Alternatives to discontinued solvents include both traditional solvents such as acetone, Perc and petroleum distillates and new solvents such as water-based, perfluorinated compounds, synthetic blends, and volatile methyl siloxanes. New technologies to degrease include such processes as plasma cleaning, supercritical fluid cleaning and UV-ozone cleaning.

For future emission inventories new data sources at the state and national level should be explored. In addition, a survey of major solvent producers should be considered.

SAMPLE CALCULATION

Below is an example of how to calculate 1993 emissions of TOG in tons per year for the ESP, Petroleum Distillates-Batch Cold Cleaners/Conveyorized Cold Cleaners (BCC/CCC), for Fresno County. Some minor decimal differences may be found due to rounding differences as some of the numbers have more significant figures than shown here.

To calculate use the following equation:

$$AF \times EF \times UF \times CB \times \frac{1 \text{ ton}}{2{,}000 \text{ lbs}} = \frac{\text{tons TOG}}{\text{year}}$$

where:
AF = activity factor
EF = emission factor
UF = user's fraction, total employees for specific ESP/total employees of SICs ESP occurs
CB = total # of employees in county in SIC Group X from U.S Census Bureau

For Fresno County, sum the following equations:

Manufacturing Survey SIC group 1-7
manufacturing activities

$$\frac{4.62 \text{ ga solv.}}{\text{employee}} \times \frac{6.3 \text{ lb TOG}}{\text{ga solv.}} \times .23 \times \frac{1833}{\text{SIC Group 2 +3 employees Fresno County}} \times \frac{1 \text{ ton}}{2{,}000 \text{ lbs}} = 6.0 \frac{\text{tons}}{\text{year}}$$

$$\frac{4.62 \text{ ga solv.}}{\text{employee}} \times \frac{6.3 \text{ lb TOG}}{\text{ga solv.}} \times .24 \times \frac{4162}{\text{SIC Group 4 +5 employees Fresno County}} \times \frac{1 \text{ ton}}{2{,}000 \text{ lbs}} = 14.50 \frac{\text{tons}}{\text{year}}$$

$$\frac{4.62 \text{ ga solv.}}{\text{employee}} \times \frac{6.3 \text{ lb TOG}}{\text{ga solv.}} \times .08 \times \frac{1003}{\text{SIC Group 6 +7 employees Fresno County}} \times \frac{1 \text{ ton}}{2{,}000 \text{ lbs}} = 1.19 \frac{\text{tons}}{\text{year}}$$

Manufacturing Survey SIC group 1-7 maintenance activities

$$\frac{1.95 \text{ ga solv.}}{\text{employee}} \times \frac{6.44 \text{ lb TOG}}{\text{ga solv.}} \times .22 \times \frac{7105}{\text{SIC Group 6 +7 employees Fresno County}} \times \frac{1 \text{ ton}}{2{,}000 \text{ lbs}} = 9.61 \frac{\text{tons}}{\text{year}}$$

Maintenance Survey SIC group 8 maintenance activities

$$\frac{5.00 \text{ ga solv.}}{\text{employee}} \times \frac{6.6 \text{ lb TOG}}{\text{ga solv.}} \times .682 \times \frac{8179}{\text{SIC Group 8 employees Fresno County}} \times \frac{1 \text{ ton}}{2{,}000 \text{ lbs}} = 92.04 \frac{\text{tons}}{\text{year}}$$

Mining/Other Trades

$$2040 \frac{\text{tons}}{\text{year}} \text{ statewide} \times \frac{81}{6812} \frac{\text{(SIC 1380 Fresno County)}}{\text{(SIC 1380 statewide)}} = 24.26 \frac{\text{tons}}{\text{year}}$$

Agricultural Equipment

$$412 \frac{\text{tons}}{\text{year}} \text{ statewide} \times \frac{2{,}140}{13{,}457} \frac{\text{(SIC 710 \& 720 Fresno County)}}{\text{(SIC 710 \& 720 statewide)}} = 65.52 \frac{\text{tons}}{\text{year}}$$

Maintenance Survey SIC group 9 maintenance activities

$$\frac{11.15 \text{ ga solv.}}{\text{employee}} \times \frac{6.6 \text{ lb TOG}}{\text{ga solv.}} \times .605 \times \frac{16{,}858}{\text{SIC Group 9 employees Fresno County}} \times \frac{1 \text{ ton}}{2{,}000 \text{ lbs}} = 375.38 \frac{\text{tons}}{\text{year}}$$

Petroleum Distillates - BCC/CCC
TOG emissions for Fresno County = 588.57 $\frac{\text{tons}}{\text{year}}$

REFERENCES

1. Roe, S.M., Jones, La Weeda, Costello, P.J. Solvent Cleaning/Degreasing Source Category Emission Inventory. E. H. Pechan and Associates, Inc. Prepared for California Air Resource Board. Contract # 93-341. August 1996.

2. U.S. Census Bureau, U.S. Department of Commerce. County Business Patterns. 1993.

3. California Air Resources Board, Planning and Technical Support Division, Emission Inventory Branch, Emission Inventory Analysis Section. Growth and Control Data in the California Emission Forecasting System (CEFS). April 2000.

4. Kloepfer, Jay. A Study to Develop Statewide and County-Level Economic Projections - Volume II Methodology. DRI/McGraw-Hill. Prepared for California Air Resource Board. Contract # 92-326. March 1994.

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TABLE I
ASSUMED UNIVERSE OF SOLVENT CLEANING END-USERS

Survey	Group	SIC Group	Description
Manufacturer manufacturing and maintenance processes	1	2514, 2519, 2522, 2530-2539, 2542, 2599	Furniture and Fixtures (all products except wood products)
	2	3400	Fabricated Metal
	3	3500	Industrial Machinery
	4	3600	Electronic Equipment
	5	3700	Transportation Equipment
	6	3800	Instruments and Related Equipment
	7	3910-3919, 3949, 3965, 3993, 3999	Miscellaneous Manufacturing: jewelry, silverware and plated ware; sporting and athletic goods; fasteners, buttons, needles, and pins; signs and advertising specialties; manufacturing activities not elsewhere classified.
Maintenance	8	4170-4179, 4230-4239, 4490-4499, 4500, 5510-5519, 5540-5549, 5590-5599,7530-7539, 7600-7699	Bus terminal facilities; truck terminal facilities; marine transportation services; air transportation services; new and used car dealers; gasoline service stations; automotive dealers not elsewhere classified; auto repair shops; miscellaneous repair services.
	9	2000-2513, 2515-2518, 2520-2521, 2523-2529, 2540-2541, 2543-2598, 2600-3399, 3900-3909, 3920-3948, 3950-3964, 3966-3992, 3994-3998	Manufacturing Maintenance Activities e.g. Food products, textiles etc.

TABLE II
1993 UNRECONCILED EMISSIONS FOR DEGREASING

SOURCE CATEGORY				Tons/Year		Tons/Day	
	MATERIAL	EIC	CES	TOG	ROG	TOG	ROG
COLD CLEANING (BATCH, CONVEYOR, SPRAY GUN)							
	1,1,1,-TRICHLOROETHANE (TCA)	220-204-3344-0000	83733	627.6	0.0	1.72	0.00
	ALCOHOLS (UNSPECIFIED)	220-204-3022-0000	83667	1,127.0	1,127.0	3.09	3.09
	CHLOROFLUOROCARBONS (UNSPECIFIED)	220-204-3083-0000	83675	1,376.6	82.6	3.77	0.23
	DEGREASING SOLVENTS - BLENDS (UNSPECIFIED)	220-204-8106-0000	83758	4,111.1	3,648.2	11.26	10.00
	DEGREASING SOLVENTS - PURE (UNSPECIFIED)	220-204-8104-0000	83741	6.1	2.3	0.02	0.01
	GLYCOL ETHERS (UNSPECIFIED)	220-204-3176-0000	83683	53.6	53.6	0.15	0.15
	KETONES (UNSPECIFIED)	220-204-3204-0000	83691	1,101.3	22.0	3.02	0.06
	METHYLENE CHLORIDE (DICHLOROMETHANE)	220-204-3246-0000	83709	18.3	0.0	0.05	0.00
	PETROLEUM NAPHTHA	220-204-0500-0000	83659	31,363.7	30,272.2	85.93	82.94
	TERPENES (UNSPECIFIED)	220-204-3333-0000	83717	533.5	531.7	1.46	1.46
	TOLUENE/XYLENE	220-204-3339-0000	83725	32.8	32.8	0.09	0.09
	Subtotal			**40,351.6**	**35,772.5**	**110.55**	**98.01**
HANDWIPING							
	1,1,1,-TRICHLOROETHANE (TCA)	220-208-3344-0000	83931	5,678.9	0.0	15.56	0.00
	ALCOHOLS (UNSPECIFIED)	220-208-3022-0000	83840	2,635.7	2,635.7	7.22	7.22
	CHLOROFLUOROCARBONS (UNSPECIFIED)	220-208-3083-0000	83857	163.0	10.6	0.45	0.03
	DEGREASING SOLVENTS - BLENDS (UNSPECIFIED)	220-208-8106-0000	83964	2,837.8	1,142.2	7.77	3.13
	DEGREASING SOLVENTS - PURE (UNSPECIFIED)	220-208-8104-0000	83956	1,046.2	335.1	2.87	0.92
	DICHLOROFLUOROETHANE (HCFC-141B)	220-208-3107-0000	83865	0.3	0.0	0.00	0.00
	GLYCOL ETHERS (UNSPECIFIED)	220-208-3176-0000	83873	505.2	505.2	1.38	1.38
	KETONES (UNSPECIFIED)	220-208-3204-0000	83881	5,504.8	1,926.7	15.08	5.28
	METHYLENE CHLORIDE (DICHLOROMETHANE)	220-208-3246-0000	83899	2,493.4	0.0	6.83	0.00
	PERCHLOROETHYLENE	220-208-3300-0000	83907	3.3	0.0	0.01	0.00
	PETROLEUM NAPHTHA	220-208-0500-0000	83832	2,586.8	2,496.8	7.09	6.84
	TERPENES (UNSPECIFIED)	220-208-3333-0000	83915	12.2	12.2	0.03	0.03
	TOLUENE/XYLENE	220-208-3339-0000	83923	502.4	502.4	1.38	1.38
	TRICHLOROETHYLENE (TCE)	220-208-3346-0000	83949	20.8	20.8	0.06	0.06
	Subtotal			**23,990.8**	**9,587.6**	**65.73**	**26.27**
VAPOR DEGREASING (BATCH, CONVEYOR)							
	1,1,1,-TRICHLOROETHANE (TCA)	220-206-3344-0000	83808	6,304.7	0.0	17.27	0.00
	CHLOROFLUOROCARBONS (UNSPECIFIED)	220-206-3083-0000	83766	440.0	37.8	1.21	0.10
	DEGREASING SOLVENTS - BLENDS (UNSPECIFIED)	220-206-8106-0000	83824	37.0	0.4	0.10	0.00
	DICHLOROFLUOROETHANE (HCFC-141B)	220-206-3107-0000	83774	109.2	4.4	0.30	0.01
	PERCHLOROETHYLENE	220-206-3300-0000	83782	46.5	0.0	0.13	0.00
	PERFLUOROCARBONS (UNSPECIFIED)	220-206-3301-0000	83790	10.3	0.0	0.03	0.00
	TRICHLOROETHYLENE (TCE)	220-206-3346-0000	83816	39.2	39.2	0.11	0.11
	Subtotal			**6,986.9**	**81.8**	**19.14**	**0.22**
	Grand total			**71,329.3**	**45,442.0**	**195.42**	**124.50**