METAL

Generic Scenario: Degreasers

Introduction

Degreasing is an essential operation within industries using metal stock and components. Many types and designs of degreasers are available. This scenario deals with the standard unit designs that are common to the industry. The purpose of this Scenario is to provide a basis for estimating worker exposure and releases to the environment for either initial or standard review. References and points of contact listed in the appendix are the prime source of the information compiled herein.

Degreasers are used to clean all of the common industrial metals and are in widespread use throughout the manufacturing industries (Table I)[1].

Table I.

SOURCE TYPES UTILIZING DEGREASING

SOURCE TYPE	SIC	NUMBER OF PLANTS	DEGREASING OPERATIONS
Industrial degreasing:			
Metal furniture	25	9,233	24,361
Primary metals	33	6,792	19,105
Fabricated products	34	29,525	81,469
Nonelectric machinery	35	40,792	110,758
Electric equipment	36	12,270	38,022
Transportation equipment	37	8,802	24,673
Instruments and clocks	38	5,983	18,026
Miscellaneous	39	15,187	40,148
Automotive:			
Auto repair shops and garages	75	127,203	141,977
Automotive dealers	55	121,369	135,463
Gasoline stations	55	226,455	252,753
Maintenance shops	*	320,701	357,945
Textile plants (fabric scouring)	22	7,201	9,451
Total		931,513	1,254,151

*No applicable SIC for this category.

There are two principal types of degreasing operations:

(1) Cold cleaners and (2) vapors degreasers. Figures I-2 and 1 thru 12 in the Degreaser Primer (attached) are models of the designs common in the industry.

Common solvents for the respective systems are shown in Table II[2].

Table II

SOLVENTS USED IN DEGREASING

Solvent	Type of degreasing			
	Cold cleaning	Vapor (open top)	Vapor (conveyorized)	Fabric scouring
Butanol	x			
Acetone	x			
Methyl ethyl ketone	x			
Hexane	x			
Naptha	x			
Mineral spirits	x			
Toluene	x			
Xylenes	x			x
Cyclohexane	x			
Benzene	x			x
Ethers	x			
Carbon tetrachloride	x			
Fluorocarbons	x	x	x	
Methylene chloride	x	x	x	
Perchloroethylene	x	x	x	x
Trichloroethylene	x	x	x	x
Trichloroethane	x	x	x	

Cold cleaners are generally used for low volume workloads and maintenance operations while vapor degreasers are used primarily in production operations.

Cold cleaners have a very simple design configuration: dip tank. Dip Tank units are available in a range of sizes. A few standard capacity units are given in Table III[3].

Table III

Cold Cleaner Critical Design Data

Type Unit # Units	Unit size	Surface area (inches)	Capacity (gal)
Batch/Maintenance	Sml	31 x 20	17
	Med	33 x 22	30-35
	Lge	45 x 23	45-55
Batch/Production	Med	51 x 36	90-250
	Lge	47 x 74	525

Vapor degreasers are available in two basic designs: (1) open top vapor degreaser (OTVD), and (2) conveyorize or in-line degreaser. OTVD designs are available generally in standard sizes. Conveyorized units are generally customized to a specific application. Critical design data and quantity estimates by solvent usage are shown in Table IV[4].

Table IV
NUMBER OF HALOGENATED SOLVENT CLEANERS

Model Cleaner Size	Solvent/ Vapor/Air Interface m^2 (ft^2)	Solvent	Estimated Number of Cleaners
BATCH CLEANERS			
Small	0.4 (4.5)	MC	150
		TCE	1,270
		PCE	360
		TCA	2,320
		Total	4,100
Medium	0.8 (8.6)	MC	180
	0.8	TCE	1,530
		PCE	440
		TCA	2,780
		Total	4,930
Large	1.5 (16)	MC	150
		TCE	1,270
		PCE	360
		TCA	2,320
		Total	4,100
Very Large	3.5 (38)	MC	120
		TCE	1,020
		PCE	290
		TCA	1,860
		Total	3,290
		Total Batch:	16,420
IN-LINE CLEANERS	3.5 (38)	MC	880
		TCE	1990
		PCE	430
		TCA	4,390
		Total ILC:	8,000
		Grand Total:	24,500

MC = methylene chloride
TCE = trichloroethylene
PCE = perchloroethylene
TCA = 1,1,1-trichloroethane
ILC = In-line cleaner

Releases

A. Air

Air emissions are expected to be the major source of release from vapor degreaser operations. Emissions data estimates are often formulated on the basis of mass flow of solvent through a facility using information on solvent purchase request, solvent inventory and/or other pertinent statistics. A computational scheme is provided here which relies on empirically established emissions data from actual industrial degreaser unit operations in an industrial environment. These emission rates which take into consideration ambient factory conditions are thought to more accurately reflect realistic emission levels. Table V (developed from industrial test data[5]) provides empirically established emission rates and emissions factors for various vapor degreaser categories based on EPA recognized duty schedules[6].

The following operating schedules were selected by the U.S. Environmental Protection Agency (OAQPS) as typical schedules for use in the regulatory analysis:

- Small and Medium Batch Cleaners: Idling 6 hr/day, working 2 hr/day, down 16 hr/day for 260 days/yr; down 24 hr/day for 105 days/yr.
- Large and Very Large Batch Cleaners: Idling 2 hr/day, working 6 hr/day, down 16 hr/day for 260 days/yr; down 24 hr/day for 105 days/yr.
- In-Line Cleaners: Idling 0 hr/day, working 8 hr/day, down 16 hr/day for 260 days/yr; down 24 hr/day for 105 days/yr.

Table V

Vapor Degreaser Emission Factors

Vapor Cleaner Type	Size	Cross Sectional Dimensions $m^2(ft^2)$	Operating Emissions Kg/m^2hr	Operating Emissions Lb/ft^2hr	Idling Emissions $(Kg/m^2hr)(Lb/ft^2hr)$		Downtime Emissions $(Kg/m^2hr)(Lb/ft^2hr)$		Standardized duty cycle(c)	Compound Emission Factor (Kg/m^2-hr)	Compound Emission Factor $(Kg/m^2-hr)(c)$	Releases
Bench	Small	0.28(3.1)	1.05	0.21	0.76	0.15	0.24	0.05	working 20min idling 40min downtime 140min	10.5	0.83	* **
		0.4(4.3)	0.67	0.14			0.24	0.05	*	10.5	0.83	* **
	Med	0.6(6.2)	0.67	0.14			0.24	0.05	*	8.90	0.63	* **
		0.87(9.7)			0.62	0.12	0.24	0.05	*	8.90	0.67	* **
	Lge	1.8(20.0)	0.83	0.17	0.62(b)		0.24	0.05	working 40min idling 20min downtime 140min	10.1	0.67	* **
	Vy Lge	Treat same as Large							*			* **
In-Line		≥3.5(38)		4.2 Refer	0		—		continuous operation			

(a) Operating emissions take into account losses due to diffusion, load displacement, part carry-out, waste/heat induced heat fluctuations and ambient workspace effects.
(b) Assume idling losses for large units to be the same as medium and units (empirical data/test room testing)
(c) Duty cycles adopted by EPA as Typical schedules.
(d) Information/data given in Terms of Hr units use the compound factor, Kg/m^2hr, e.g., #units x factor = emissions + hrs of ops in one day These downtime emissions rise.

* Releases to water due to waste/wash-downs are thought to be minimal due to the volatility of the solvents used.
** Land discharge data on waste design a consultants.

Calculations:

<u>Estimate of # of user sites</u>

If the # of user sites is not estimated in the PMN submission, assume that the PV of the PMN chemical will be distributed among the various sizes of vapor degreasers according to some general information developed by OAQPS for # of degreasers: 20% small, 20% medium, 20% large, 10% very large and 30% in-line/conveyorized. As a rough estimate of the use volume per site, assume that

$$\text{Use Volume} = \left(\text{compound Emission Factor}\right) \times \left(\text{crosssectional Area}\right) \times \left(\frac{260\ \text{days}}{\text{yr}}\right) \times \left(\frac{\#\ \text{units}}{\text{site}}\right) \Big/ \left(\frac{\text{Emission Ratio}}{\text{Consumption}}\right)$$

PV for each Scenario = (PV) x (% Solvent Consumption/100)

PV for each Scenario used in controlled degreasers =
(PV) x (% solvent consumption/100) x (% controlled)

$$\#\ \text{sites/controlled} = \frac{\text{PV controlled}}{(\text{use volume})_{\text{controlled}}}$$

$$\#\ \text{sites/uncontrolled} = \frac{\text{PV uncontrolled}}{(\text{use volume})_{\text{uncontrolled}}}$$

Air Emissions

(cross sectional area vapor degreaser) x (compound Emissions* factor ($Kg/m^2.da$) = (Emissions per unit per day) x (# units/site)

* factor accounts for variation in level of emission over a normal daily duty cycle (i.e., working 6 hrs, Idling 2 hrs, downtiming/6 hrs); for shift work use computation shown in Table V footnote.

Water Emissions

Releases to water are not expected primarily because of solvent volatility.

Land Emissions/discharge

Sludge are likely to be hazardous waste. Not quantifiable at this time.

Exposure:

(a) Worker activities:

(b) Workers per site[7,8] = 3-7

(c) [Inhalation]

Work Conditions:

Ambient factory Windspeed[9] 130fPM
(assuming that the room is 10 ft high by 15 ft wide. The volumetric air flow rate Q is conservatively estimated to be 20,000 cw ft/min.)
Degreaser Site room volume[10] - $5000M^3 \approx 176,000$ cw ft
Worker Inhalation rate[11] - $1.25M^3/h$

Calc.

Assumptions: (1) Actual PMN Use conditions will be similar to those of the test conditions for generation data.
(2) uncontrolled sources

Assuming CEB's standard approach for modelling airborne concentration:

$$C = \frac{1.7 \times 10^5 T_a G}{MQK}$$

where:
c = contaminant concentration, ppm
T_a = ambient temperature of air, K
G = vapor generation rate, g/sec
M = molecular weight, g/g-mole

Q = ventilation rate, ft^3/min
K = mixing factor, dimensionless

M	should be available from either PMN submission or chemistry report
T_a	generally assumed to be 298K
Q	20,000 cfm for degreaser operations based on _____
k	0.5

This model assumes that G is constant. For the batch, open top vapor degreaser over a 24 hour duty cycle, G is known to vary. To approximate a constant value for G, we estimate an average G:

BATCH OPEN TOP VAPOR DEGREASER

$$G_{AVE} \text{ [g/sec]} = \frac{\text{[Operating Emission x Op Rate] + [Idling Emission x ID Rate]}}{8} \times \text{Cross Sect Area} \times \frac{1000g}{kg} \times \frac{1\ hr}{3600sec}$$

CONVEYORIZED VAPOR DEGREASER

$$G = \frac{6.2\ lb/hr \times 0.454\ kg/lb \times 1000g/kg}{3600\ s/hr} = 0.76\ g/sec$$

Note for conveyorized, most of G will be captured and emitted as stack emissions and not to the workplace, thus, G probably overestimates potential worker exposure.

Solve for:

$$C_p = \frac{1.7 \times 10^5\ (298)\quad G}{M\quad (20{,}000)\quad (0.5)} =$$

$$C_m = C_p \times M/24.45 =$$

Potential Dose Rate (PDR) = C_m [mg/day] x 1.25 m^3/hr x 8hr/day =

[Dermal]

These solvents tend to volatilize rapidly - CEB's current models do not address volatilization. Note whether dermal contact is likely but do not quantify exposure.

[Protective Wear]

No information was available relative to personal protective equipment used in Solvent Cleaning operations[12].

General ventilation is the engineering control of choice in occupational degreasing[13].

[Controls][14]

SOLVENT VAPOR EMISSION CONTROL EFFICIENCIES FOR VARIOUS CONTROL TECHNIQUES*

Cleaner	Control Technique	Control Efficiency (%)	
		Idling	Working
Batch Cleaner - OTVC's	Cover	40	0
	Bi-Parting Cover	40	40
	AFC	40	40
	BFC	40	40
	RPCT	40	40
	Lip Exhaust	40	45
	FBR 0.75-->1.0	20	20
	FBR 1.0-->1.25	10	10
	Reduce Wind Speed 100-->calm (<50 fpm)	50	50
	Hoist	NA	35
	Dwell	NA	30
Continuous Cleaners	AFC	60	60
	BFC	60	60
	CADS	60	60

AFC - above-freezing freeboard refrigeration device.
BFC - below-freezing freeboard refrigeration device.
RPCT - reduced primary condenser temperature is 30 to 40 percent of the solvent boiling point.
FBR - freeboard ratio.
CADS - carbon adsorption system.
NA - not applicable

References

1. U.S. EPA Research and Development Report, EPA-600/2-79-019 August 1979 (PB80-128812), Source Assessment: Solvent Evaporated-Degreasing Operations. Industrial Environmental Research Laboratory, Cincinnati, Ohio, Aug. 1979, P.9.

2. U.S. EPA Research and Development Report, EPA-600/2-79-019 August 1979 (PB80-128812), Source Assessment: Solvent Evaporated-Degreasing Operations. Industrial Environmental Research Laboratory, Cincinnati, Ohio, Aug. 1979, P.12.

3. Industry/Associations Communications and Vendor Literature.

4. Memorandum, From: Radian Corp.; To: Paul Almodovar, U.S. EPA/RTP; Dated: May 26, 1993; Subject: Estimate of Number of Halogenated Solvent Cleaners, P.3.

5. Draft Report, From: Radian Corp.; To: Paul Almodovar, U.S. EPA/RTP; Dated: Oct. 1, 1992; Subject: Organic Cleaner Characteristics and Emissions, PP. 4.6-4.10.

6. Memorandum, From: Radian Corp., To: Paul Almodovar, U.S. EPA/RTP; Dated: May 26, 1993; Subject: Estimate of the Number of Halogenated Solvent Cleaners, P.4.

7. U.S. EPA Interim Report: Hydrofluorocarbons and Hydrochlorofluorocarbons, U.S. EPA Office of Toxic Substances, Nov. 15, 1990, P.60.

8. PEI Associates, Inc. Occupational Exposure, Environmental Release, and Control Analysis of Aqueous Cleaning Substitutes for 1,1,1-Trichloroethane and CFC-113 For Cleaning of Electronic or Metal Objects (Revised Draft), Contract No. 68-08-0112, Work Assignment No. P3-8, PN3786-65. Nov. 16, 1990, P.3-8.

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10. PEI Associates, Inc. Occupational Exposure, Environmental Release, and Control Analysis of Aqueous Cleaning Substitutes for 1,1,1-Trichloroethane and CFC-113 For Cleaning of Electronic or Metal Objects (Revised Draft), Contract No. 68-08-0112, Work Assignment No. P3-8, PN3786-65.. Nov. 16, 1990, P.3-5.

11. Draft Report, From: Radian Corp.; To: Paul Almodovar, U.S. EPA/RTP; Dated: Oct. 1, 1992; Subject: Organic Cleaner Characteristics and Emissions, PP. 4-30.

12. PEI Associates, Inc. Occupational Exposure and Environmental Release Data for Chlorofluorocarbons (CFCs) and their Substitutes (Revised Draft). Contract #68-D8-0112, Work Assignment #P3-9, PN 3786-66. Nov. 19, 1990, P.7-9.

13. PEI Associates, Inc. Occupational Exposure, Environmental Release, and Control Analys.

of Aqueous Cleaning Substitutes for 1,1,1-Trichloroethane and CFC-113 For Cleaning of Electronic or Metal Objects (Revised Draft), Contract No. 68-08-0112, Work Assignment No. P3-8, PN3786-65. Nov. 16, 1990, P.3-6.

14. Draft Report, From: Radian Corp.; To: Paul Almodorar, U.S. EPA/RTP; Dated: Oct. 1, 1992; Subject: Organic Cleaner Characteristics and Emissions, PP. 4-3.

Contacts

Organizations

1. National Screw Machine Products Associations.
   Dave Burch 216/526-0300

2. Metal Fabricating Institute
   Ron Fowler 815/965-4031 [P.O. Box 1178, Rockford, Ill.]

3. Metal Finishing National Association
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4. Metal Finishing Suppliers Association
   ---------- 708/887-0797

5. Mass Finishing Job Shop Association
   ---------- 616/382-4317

6. Metal Treating Institute
   Mack 904/249-0448 [302 Third St, Ste 1, Neptune Beach, Fl 32266]

7. Metal Construction Association
   ---------- 202/371-1243 [1101 14th St, NW, Ste 1100, Wash. DC 20005]

8. American Electroplating and Surface Finishers
   --------- 407/281-6441

9. National Tooling & Machine Association
   Bill Tuston/Owen Hendricks, 301/248-6200

Suppliers

Contact		
1.	Tom Schwartz	Kleer Flo 800/328-7942, 612/934-2555
2.	----------	Tally 508/695-1007
3.	----------	Phillips 312/338-6200
4.	----------	Delta 213/945-1067
5.	----------	Tower Oil & Technology 312/346-0562

Other Organizations

Contact

1. Scrap Metal Institute
   Herchel Cutter, 662-8506 [1325 G St. NW, Wash, DC 20005]

2. Manufacturers & Fabricators
   Nancy Olson/Sue 815/399-8700

3. Robert Herztel 202/576-2354

4. Machinery Dealers National Association
   ------ 301/585-9494 [1110 Spring St., Silver Spring, MD 20910]

5. Material Handling Equipment Distributors Association
   -------- 708/680-3500 [201 Rt#45, Vernon Hills, Ill. 60061]

6. Process Equipment Manufacturers Association
   -------- 703/533-0286 [7297 Lee Hwy, Ste N, Falls Church, VA 22042]