Pollution Prevention Seminar

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Textile Waste Streams

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Four general types of waste streams will be discussed: Air, Water, Solid Waste, and Hazardous Waste.

Air

Textile mills produce atmospheric emissions from all manner of processes, and gaseous emissions have been identified as the second greatest problem for the textile industry. (Mohr 1993) There has been much speculation about air pollutants from textiles (Zeller 1975, Smith 1986 A Workbook, Goodman 1980) but, in general, air emissions data for textile manufacturing operations are not readily available. Most published data are mass balance (EPA 560/4-88-004h Estimating Chemical Releases ..., Smith 1987 Identification and Reduction ... p 45), not direct measurements. Direct reading tubes and GC/mass spectrometry have been used more recently to get more reliable data. (McCune 1994 inventories, Castle 1992) As time goes on and air emissions data continue to be collected from textile operations, better definition of industry norms can be expected. Considerable effort is now underway in that regard. (Smith 1993 Indoor Air Quality, McCune 1994 inventories) No reliable set of emissions factors for textiles is available. Air pollution is the most difficult of all forms of pollution to sample, test and quantify in an audit.

That is not to say that P2 should not be done, or is not being done, in the area of air pollution. A study of 30 P2 projects at Union Carbide (a manufacturer of textile chemicals) showed that 21% related to gaseous waste, 33% to wastewater and 46% to solid waste. (Berglund, 1990)

Primarily because of the emissions of oxides of nitrogen and sulfur for boilers, most textile plants are likely to be considered as major sources of air toxics. The issues related to general air pollution are presented here, and those for air toxics, an emerging issue, are discussed later.

Sources

Unit operations of concern for air emissions are printing, coating, finishing and dyeing. Within these general facility identifications, specific point sources and general area sources can be identified. Textile air emission point sources include

- Boiler stacks
- Processing machines
  - ovens, for drying and curing
  - solvent processing units, eg dry cleaning
  - dyeing machines
  - mix kitchens, drug rooms
- Storage tanks (breathing losses)

Boilers
Due to time constraints, boiler information will not be reviewed in detail. As noted above, boiler emissions generally are large enough to cause most textile mills to be scrutinized as major sources. This in turn causes all emissions, as discussed here, to be controlled under the new clean air act, as major sources.

Ovens
Probably the most prevalent source in textile operations is high temperature drying and curing ovens. By far the highest levels of emissions come from ovens used for coating operations. In some cases, the solvent content of the air in coating ovens can reach levels of several percent. Also, lower levels of emissions come from heatsetting, thermofixation, drying and curing ovens. Typical operating temperatures are

drying	250 - 300 °F
curing of ordinary finishes	300 - 375 °F
thermofixation of dyes	350 - 400 °F
heatsetting	300 - 375 °F

Storage tanks / breathing losses
Typically, bulk storage tanks for textile chemicals have open vents to allow pressure equalization of pressures inside to outside. When the chemical is drawn out of the tank, or when air cools (at night), or when the ambient atmospheric pressure rises, air is forced into the tank. When the tank is filled, temperature rises or the barometric pressure falls, air is forced out of the tank. When the chemical in the tank contains volatile components, they contaminate the air inside of the tank. Thus the expelled air constitutes an emission source.

Fugitive / Area Sources
Textile air emission fugitive/area sources include

- Solvent-based cleaning activities
  - general facility cleanup, maintenance
  - implement and parts cleaning
  - print screen cleaning
- Spills
- Wastewater treatment systems
- General production area ventilation
- Warehouses

Fugitive emissions and spills are very important, especially for a highly dispersible waste form such as airborne pollution. (Berglund, 1990)

Wastewater treatment systems
Aeration of secondary activated sludge biological treatment lagoons strips most volatile components of the mixed liquor, and these emit from the waste treatment system as a general area source. Volatile components of spent processing baths (eg dye carriers, solvent scours) as well as degradation products of these components can

reasonably be expected to strip and emit during the treatment process. No data on this have been made public at this time.

Warehouses

Fabric stored in warehouses can produce volatile emissions from process residues, especially printing, dyeing or finishing chemicals which remain in the fabric. The most famous of these is formaldehyde but others, notably hydrocarbons from softeners and wax water repellent finishes, can be present.

Spills

Spills can emit volatile pollutants for months and even years, and they should be cleaned up promptly. The spill residues should be disposed of according to proper protocol, which in some cases may require handling as hazardous waste.

Pollutants of Concern

Common air pollutant emissions from ovens include mineral oil and other vapors. (Castle 1992) Others include knitting oils, fiber finishes, softeners, hydrocarbons, urea (from continuous printing and thermofix dyeing of fiber reactive dyes), and volatile disperse dye carrier components which are sorbed in the fabric during subsequent heatsetting, drying, and curing. (Mock page 54 "Fundamentals of Dyeing and Printing" 1984 and Kulube 1987 Masters Thesis, Residual Components of Exhausted Dyebaths, NC State University College of Textiles, Raleigh NC).

Fugitive/area emissions include not only formaldehyde and hydrocarbons from warehouses, but all manner of processing chemicals from routine handling, wastewater treatment systems and spills.

Toxics

Air toxics are a separate issue to be addressed in another section.

Indoor Air Pollution

Materials which emit pollutants (primary emitters) as well as those which sorb and reemit air pollutants indoors are of concern. (Smith 1994) OSHA has proposed an indoor air quality rule which will affect 21 million workers, and which will require the development and implementation of indoor air compliance programs. (Anon, Textile Chemist and Colorist, Aug, 1994, attached news article) Several issues identified as being important. (Leovic 1993 ... Leovic, Kelly, and White, James, EPA's Indoor Air/Pollution Prevention Workshop, presented at the 86th Annual Air and Waste Management Association Meeting in Denver CO, June 13-18, 1993) Some of the main priorities are to create an emissions database for textile products, which will lead to an understanding of exposures, health effects and issues for sensitive persons. This database will help to set priorities and evaluate P2 strategies such as chemical alternatives or process changes to improve indoor air quality.

At this time, primary emissions from several types of textile process residues listed below are under study. (Leovick 1993, Smith 1994 Indoor Air)

Chemical Finishes
Dyeing Process Residues
Assembly, Fabrication Residues

In addition, sorption/reemission characteristics of textile materials are of interest. Knowledge of these will facilitate (Leovick 1993, Smith 1994 Indoor Air)

Proper Use
Developing Better Purchasing Specifications
Understanding Synergisms in Pollutant Release
Understanding Sorption/Desorption from Textile Surfaces
Modeling of Workplace exposure.

Several tests of textile air emissions from various products have been done and from draperies materials, for example, the following have been identified. (Bayer 1992 ... Bayer, C; Indoor Environment Testing Using Dynamic Environmental Chambers, ITEA Journal, December 1992 24-26, 1992)

From the Drapery Material	
Acetone	Decane
2,5-Dimethylfuran	Toluene
Benzaldehyde	Decenal
1,4-Dioxane	1,1,1-Trichloroethane
Benzene	Dichlorobenzene
Ethanol	Trimethylbenzenes
Butanol	1,2-Dichloroethane
Methylene Chloride	m-Xylene
p-Xylene	Chloroform
Dimethyldisulfide	Tetrachloroethene
... plus 100 more VOC's	

From the Drapery Linings	
Acetone	Benzene
Chloroform	Decane
Decenal	1,4-Dioxane
Ethanol	Ethyl Acetate
Ethylmethylbenzenes	Hexanes
3-Hexanone	Methylene Chloride
2-Methylfuran	Pyridinone
Pyrollidine	Toluene
Trichloroethene	m-Xylene
... plus 80 additional VOC's	

These can result either from process residues or from materials sorbed during fabrication, storage, installation, or consumer use. A survey of finish chemical components listed on MSDS for typical commercial finishes include a variety of somewhat volatile materials which might be emitted. (Smith 1994 Indoor Air)

Listed Chemical from MSDS	Listed CAS#
Acetic Acid	64-19-7
Acetone	67-64-1
Ethyl Acetate	141-78-6
Ethylene Glycol	107-21-1
Fatty Glyceride Based Softener	N/A
Formaldehyde	50-00-0
Hydrocarbon Wax Emulsion (4 reported)	N/A
Methanol	67-56-1
Methylhydrogen Polysiloxane	063148572
Nonylphenolpolyethylene Glycol Ether	9016-45-9
2-Pentanone, 4-methyl-	108-10-1
Polyoxyethylated Tridecyl Alcohol	024938918
Proprietary Materials	N/A
Residual Monomers (Acrylic)	N/A
Tetrachloroethylene	000127184
Toluene	000108883
Triethanolamine	000102716

These, plus volatile components of synthetic polymers, fiber finishes and dyeing and printing process chemical residues may survive the process, and later be emitted. (Smith 1994 Indoor Air) Here again, there is the frequently mentioned issue of proprietary products, chemical specialties and finishes.

Indoor Air P2 Strategies

Review all MSDS information to identify potential latent emissions in manufactured textile products. (Smith 1994 Indoor Air) Ensure that all reactive finishes receive appropriate curing conditions (eg time, temperature, moisture) so that reactive volatile components (eg formaldehyde) are properly bound.

Do not store volatile organic chemicals and textile products in proximity in a warehouse, which can result in sorption and later release of indoor air pollutants. (Smith 1994 Indoor Air)

Control perchloroethylene dry cleaning processes solvent by textiles stored near recently cleaned clothing. (Brodmann 1975 .... Brodmann, G; Retention of Chlorinated Solvents in Fabrics Textile Chemist and Colorist **7** 20-23, 1975)

Minimized or eliminate the use of chemical finishes. Instead, substitute better fabric design and mechanical finishing whenever possible.

Reduction Strategies

It is often very difficult for a textile mill to specifically identify critical air issues and P2 targets. In many cases, P2 targets must be identified not by the actual presence of air pollutants, but by the inputs to processes, and the suspicion that air emissions may be occurring, rather that the same kinds of hard audit data which are used to identify water, solid, and hazardous wastes.

Applicable strategies for P2 of air pollutants are site specific, but some of the main ideas are noted below. These are discussed in more detail for each process and for each technique on other sections.

Design products which do not require volatile chemicals to produce. In particular, avoid specifying finishes which are solvent based (eg water repellent) unless absolutely necessary.

Identify and quantify sources, if possible, by direct measurement. If that is not possible, use the MSDS information for input chemicals and knowledge of the process to estimate emissions. All chemicals should be prescreened and tested for incoming quality.

Optimize boiler operations.

Improve solvent processing operations in terms of the possibility of using non-volatile alternatives as well as solvent selection. Keep detailed (redundant tracking) records of all solvents purchased, issued, reclaimed, reused, recovered, and disposed to facilitate emissions mass balance. For these operations use special monitoring procedures (direct reading tubes) in work areas and ventilation stacks. Install direct solvent dispensing to machines where ever possible, and utilize the best equipment design and maintenance procedures. Optimize capture efficiencies for all air handling, exhaust and ventilation near solvent operations.

Prescreen fibers for volatile spin finishes and develop raw material specifications for finish content of fibrous raw materials. A simple test is to heat a large fabric sample in a vented laboratory oven at the processing temperature (or higher) and watch for visible grey smoke from the oven vent.

Trap bulk storage tanks with carbon canisters. Maintain these on a regular basis.

Minimize/eliminate the use of volatile chemical auxiliaries in aqueous processes.

Water

Textile manufacturing is one of the largest industrial producers of wastewater. (Smith 1989 A Workbook) About 160 pounds of water (20 gallons) is required to produce one pound of textile product, on average. Textiles is also a chemically intensive industry, and therefore the wastewater from textile processing contains processing bath residues from preparation, dyeing, finishing, slashing, and various other operations. When discharged to the environment, these residues can cause damage if not properly treated. (Smith 1987 Ident and Reduction ...)

Setting P2 Targets

Since textile operations produce so much wastewater as a routine matter, it is tempting for a mill to assume that large volumes of wastewater are unavoidable, and thus to become lax in P2 relative to water and water pollution. Sometimes it is difficult to know where to start. In practice, mills vary considerably in the amount of water and wastewater pollutants they discharge. One critical and often very difficult step in P2 of water pollution is for a mill to accurately assess its status and the realistic potential for improvement. This is necessary in order to target specific waste streams which will maximize P2 results for a given level of effort.

The first step in P2 of water pollution is a thorough audit and characterization of wastewater from an operation. Comparing this audit information to various benchmark "norms" allows realistic goal setting and economic projections for water pollution reduction activities. There are several ways to benchmark an operation, hence to identify P2 targets.

Any wastewater stream deserves attention if (Smith 1989 ADR Mar - Apr - May - Jun, Pollutant Source Reduction Parts I - IV)

- it exceeds industry norms
- it exceeds POTW pretreatment or NPDES permit limits
- it is economically advantageous to eliminate
- it is one of the four types most amenable to P2
  - high volume
  - offensive
  - persistent or resistant to treatment
  - dispersable

Defining Norms

Many studies have been published on water pollution from textile operations. One excellent and definitive source of accurate and current information is the Development Document for Effluent Limitations Guidelines and Standards for the Textile Mills, published by USEPA, Document EPA 440/1-79/022b. This document is about the only one with decent information in it, most of the others so often quoted in the literature are obsolete. In that document, the characteristics and amount of wastewater pollutants is accurately assessed on a process-by-process and pollutant-by-pollutant basis. The data are based on accurate current commercial practice in the US textile industry.

Using these tables and an accurate audit, a mill has a firm foundation to ascertain its performance in comparison with industry norms, identify targets for P2, and set realistic P2 goals. The data in the tables are presented in terms of industry subcategories, and are tabulated relative to not only the wastewater produced, but also relative to the amount of production being run in the mill.

Comparison to typical permits

Certain pollutants in "typical" wastewater are of more concern that others. For example, most dyeing machines have lint filters and other primary control measures to keep lint out of heat exchangers

Table 1.1-I

Water Usage and Mill Wastewater Discharge - Summary of Historical Data [10]

Subcategory	Water usage, ℓ/kg (gal/lb) of production			Discharge, cu m/day (MGD)	No. of
	Min	Med.	Max.	median mill	mills
1. Wool scouring	4.2 (0.5)	11.7 (1.4)	77.6 (9.3)	103 (0.051)	12
2. Wool finishing	110.9 (13.3)	283.6 (34.1)	657.2 (78.9)	1892 (0.500)	15
3. Low water use processing	0.8 (0.1)	9.2 (1.1)	140.1 (16.8)	231 (0.061)	13
4. Woven fabric finishing					
a. Simple processing	12.5 (1.5)	78.4 (9.4)	275.2 (33.1)	636 (0.168)	48
b. Complex processing	10.8 (1.3)	86.7 (10.4)	276.9 (33.2)	1533 (0.405)	39
c. Complex processing plus desizing	5.0 (0.6)	113.4 (13.6)	507.9 (60.9)	636 (0.168)	50
5. Knit fabric finishing					
a. Simple processing	8.3 (0.9)	135.9 (16.3)	392.8 (47.2)	1514 (0.400)	71
b. Complex processing	20.0 (2.4)	83.4 (10.0)	377.8 (45.2)	1998 (0.528)	35
c. Hosiery products	5.8 (0.7)	69.2 (8.3)	289.4 (34.8)	178 (0.047)	57
6. Carpet finishing	8.3 (1.0)	46.7 (5.6)	162.6 (19.5)	1590 (0.420)	37
7. Stock and yarn finishing	3.3 (0.4)	100.1 (12.0)	557.1 (66.9)	961 (0.254)	116
8. Nonwoven manufacturing	2.5 (0.3)	40.0 (4.8)	82.6 (9.9)	389 (0.100)	11
9. Felted fabric processing	33.4 (4.0)	212.7 (25.5)	930.7 (111.8)	564 (0.149)	11

Table 1.1-II

Raw Waste Concentrations - Conventional and Nonconventional Pollutants
Historical Data - Median Values [10]

Subcategory	BOD (mg/ℓ)	COD (mg/ℓ)	COD/BOD	TSS (mg/ℓ)	O&G (mg/ℓ)	Phenol (μg/ℓ)	Chromium (μg/ℓ)	Sulfide (μg/ℓ)	Color APHA Units
1. Wool scouring	2270	7030	3.1	3310	580	†	†	†	†
2. Wool finishing	170	590	3.5	60	†	†	†	†	†
3. Low water use processing	293	692	2.4	185	†	†	†	†	†
4. Woven fabric finishing									
a. Simple processing	270	900	3.3	60	70	50	40	70	800
b. Complex processing	350	1060	3.0	110	45	55	110	100	†
c. Complex processing plus desizing	420	1240	3.0	155	70	145	100	†	†
5. Knit fabric finishing									
a. Simple processing	210	870	4.1	55	85	110	80	55	400
b. Complex processing	270	790	2.9	60	50	100	80	150	750
c. Hosiery products	320	1370	4.5	80	100	60	80	560	450
6. Carpet finishing	440	1190	2.7	65	20	130	30	180	490
7. Stock and yarn finishing	180	680	3.77	40	20	170	100	200	570
8. Nonwoven manufacturing	180	2360	13.1	80	†	†	†	†	†
9. Felted fabric processing	200	550	2.75	120	30	580	†	†	†

†Insufficient data to report value.

Table 1.1-III

Raw Waste Loads - Conventional and Nonconventional Pollutants
Historical Data - Median Values [10]

Subcategory	BOD	COD	TSS	O&G	Phenol	Chromium	Sulfide
	(kg/kkg)				(g/kkg)		
1. Wool scouring	41.8	128.9	43.1	10.3	†	†	†
2. Wool finishing	59.8	204.8	17.2	†	†	†	†
3. Low water use processing	2.3	14.5	1.6	†	†	†	†
4. Woven fabric finishing							
a. Simple processing	22.6	92.4	8.0	9.1	8.2	4.3	7.6
b. Complex processing	32.7	110.6	9.6	3.8	7.7	2.6	12.5
c. Complex processing plus desizing	45.1	122.6	14.8	4.1	13.1	20.9	†
5. Knit fabric finishing							
a. Simple processing	27.7	81.1	6.3	4.0	8.7	7.8	13.0
b. Complex processing	22.1	115.4	6.9	3.5	12.0	4.7	14.0
c. Hosiery products	26.4	89.4	6.7	6.6	4.2	6.4	23.8
6. Carpet finishing	25.6	82.3	4.7	1.1	11.3	3.4	9.4
7. Stock and yarn finishing	20.7	62.7	4.6	1.6	15.0	12.0	27.8
8. Nonwoven manufacturing	6.7	38.4	2.2	†	†	0.5	†
9. Felted fabric processing	70.2	186.0	64.1	11.2	247.4	†	†

†Insufficient data to report value.

Table 1.1-IV

Raw Waste Concentrations - Conventional and Nonconventional Pollutants
Results of Field Sampling Program [10]

Mill Subcategory	BOD (mg/ℓ)	COD (mg/ℓ)	TSS (mg/ℓ)	O&G (mg/ℓ)	Phenol (μg/ℓ)	Chromium (μg/ℓ)	Sulfide (μg/ℓ)	Color APHA Units	pH Units
Wool scouring	1900	6100	2300	-	-	10	500	2200	10.4
Wool scouring	5000	24000	87000	1100	220	220	-	-	7.8
Wool finishing	450	1700	160	90	190	190	6000	2000	10.7
Wool finishing	330	1100	70	160	880	880	1100	1000	9.2
Low water use processing	-	1900	-	-					
Low water use processing	-	720	15	80	10	80	1000	-	-
					4	-	ND	10	6.9
Woven fabric finishing									
Simple processing	50	-	55	-	4	20	1000	500	9.0
Simple processing	400	1100	200	-	8	90	200	-	-
Complex processing	500	500	30	-	70	70	7600	1300	9.5
Complex processing	450	1700	90	-	280	280	1000	1500	10.5
Complex processing	-	2000	-	-	150	150	1000	-	-
Complex processing	1500	-	500	20	-	-	-	-	11.2
Complex processing	600	1600	15	-	-	-	-	-	9.3
Complex plus desizing	290	320	40	-	-	-	20	1200	10.0
Complex plus desizing	20	2700	50	-	70	70	1000	250	10.0
Complex plus desizing	400	1500	110	-	55	55	5600	3200	10.0
Complex plus desizing	560	1700	70	-	65	65	1000	40,000	10.0
Complex plus desizing	440	800	50	-	75	75	5200	2600	10.2
Complex plus desizing	350	800	20	-	55	55	2500	500	10.0

Notes: A dash indicates that analyses were not performed.
ND indicates "Not Detected".

Table 1.1-IV (continued)

Mill Subcategory	BOD (mg/ℓ)	COD (mg/ℓ)	TSS (mg/ℓ)	O&G (mg/ℓ)	Phenol (μg/ℓ)	Chromium (μg/ℓ)	Sulfide (μg/ℓ)	Color APHA Units	pH Units
Knit fabric finishing									
Simple processing	-	-	6	-	230	-	6000	300	10.0
Simple processing	200	580	25	-	740	6	2100	150	9.2
Simple processing	240	780	20	320	940	20	750	740	10.2
Complex processing	220	560	25	-	110	1	9200	250	10.0
Complex processing	-	730	25	-	1	10	1000	-	-
Hosiery products	-	880	20	180	-	660	1800	820	7.5
Hosiery products	-	820	180	340	-	8	ND	220	9.1
Hosiery products	-	2900	95	630	-	-	ND	270	6.4
Carpet finishing	200	1300	40	-	30	4	1000	300	11.0
Carpet finishing	-	940	-	-	45	25	1000	-	-
Carpet finishing	180	740	20	-	-	55	-	-	-
Stock and yarn finishing	1100	1300	30	-	40	10	1400	1400	10.5
Stock and yarn finishing	380	1100	20	-	40	3	4500	1300	7.4
Stock and yarn finishing	120	460	35	-	65	25	1000	10,000	10.5
Stock and yarn finishing	-	-	-	-	-	650	-	-	-
Stock and yarn finishing	-	640	125	210	-	-	ND	310	6.2
Nonwoven manufacturing	-	340	-	-	45	10	1000	-	-
Nonwoven manufacturing	-	220	35	-	-	4	ND	140	9.4
Nonwoven manufacturing	-	480	15	-	-	-	ND	35	6.3
Felted fabric processing	-	1100	40	-	-	-	1200	190	7.3

Notes: A dash indicates that analyses were not performed.
ND indicates "Not Detected".

Table 1.1-XXI

Raw Waste Concentrations - Conventional and Nonconventional Pollutants
Summary of Historical and Field Sampling Data [10]

Subcategory	BOD (mg/ℓ)	COD (mg/ℓ)	TSS (mg/ℓ)	O&G (mg/ℓ)	Phenol (μg/ℓ)	Chromium (μg/ℓ)	Sulfide (μg/ℓ)	Color APHA units
1. Wool scouring	2300	7000	3300	600	†	(120)	(500)	(2200)
2. Wool finishing	170	600	60	†	(120)	(500)	(3500)	(1500)
3. Low water use processing	290	690	180	(80)	†	(4)	†	(10)
4. Woven fabric finishing								
a. Simple processing	270	900	60	70	50	40	70	800
b. Complex processing	350	1100	110	50	50	110	100	(1400)
c. Complex processing plus desizing	420	1240	150	70	150	100	(1700)	(1900)
5. Knit fabric finishing								
a. Simple processing	210	870	50	80	110	80	55	400
b. Complex processing	270	790	60	50	100	80	150	750
c. Hosiery products	320	1370	80	100	60	80	560	450
6. Carpet finishing	440	1190	70	20	130	30	175	490
7. Stock and yarn finishing	180	680	40	20	170	100	200	570
8. Nonwoven manufacturing	180	2360	80	(60)	(40)	(10)	†	(90)
9. Felted fabric processing	200	550	120	30	(580)	†	(1200)	(200)

†Insufficient data to report value.

and off of the cloth, therefore TSS levels are quite low in raw textile dyeing wastewater, compared to many other industries (and compared to POTW pretreatment or NPDES discharge limits). On the other hand, BOD and COD as measures of oxygen demand are relatively higher, therefore are of more concern as P2 targets.

NPDES and POTW pretreatment permit limits can be compared to the audited characteristics of textile wastewater to identify further targets and P2 goals. Comparing typical raw textile wastewater to typical municipal sewer pretreatment requirements for indirect dischargers, one can see the following areas as opportunities for P2.

Prohibited Discharges (Survey of 6 NC cities, 1991-1994)

Limit (max ppm)	Item
40	Ammonia N
0.004 - 1.0	Arsenic
1 - 100	Barium
1.0	Boron
0.005 - 0.7	Cadmium
0.03 - 1.0	Chromium
0.07 - 1.0	Copper
0.03 - 2.0	Cyanide
0.03 - 0.6	Lead
1.0	Manganese
0.0002 - 0.1	Mercury
0.02 - 0.08	Nickel
10	Nitrous Oxide
50 - 200	Oil and Grease
5 - 6 (units)	Low pH limit
9 - 10 (units)	High pH limit
10	Phenol
0.03 - 0.05	Selenium
0.02 - 0.7	Silver
0.25 - 0.50 (inch)	Solids
5 - 10	Sulfide
10	Sulfur Dioxide
104 - 140 (°F)	Temperature
1.0	Tin
0.1 - 1.0	Zinc

Also, the following are prohibited in a more general way, but without a specific numerical limit:

Color	Radioactive
Paint	Explosive
Flammable	Mud
Straw	Grit
Fibers & Feathers	Noxious and Malodorous
Cinders	Grain
Straw	

... Plus other parameters, controlled in POTW pretreatment regulations by the practice of surcharging.

Item	Typical POTW Limit (ppm)	Surcharge (1991-1994 survey)
Flow	all	$0.123 - $0.35 per CCF
BOD	250 - 325	$0.04 - $0.186 per excess pound
COD	600	$0.122 per excess pound
TSS	250 - 300	$0.021 - $0.223 per excess pound

future Wastewater Issues

In the future, several new issues will emerge for the textile industry to address. (Wagner 1984, Smith 1994 CHMR) In general, textile wastewater treatment methodologies are mature and well developed. Improving the efficiency of treatment processes has dominated the environmental attention of the industry and the regulators for some time. But new issues are generally ones which are not amenable to treatment, therefore P2, not treatment, must play a primary role in attacking these. They are

Color Residues in Dyeing Wastewater
Electrolytes in Dyeing Wastewater
Toxic air emissions
Elimination of low metals in Dyeing Wastewater
Aquatic toxicity in Dyeing Wastewater

In addition, the subjects of water conservation and improving treatability of wastes needs to be addressed. These all are covered in other sections of this document.

P2 Strategies

Appropriate P2 strategies for wastewater are discussed in various sections on P2 techniques, and on each individual unit process. Although it is difficult to generalize, most textile water intensive operations can implement a P2 plan to reduce the following problem areas.

Operation	Typical P2 Targets
Slashing and Sizing	BOD, COD
Fabric Formation	Water volume (from water jet looms)
Preparation	BOD, COD, Temperature, pH, metals, Aquatic toxicity
Dyeing	BOD, COD, Temperature, pH, Aquatic toxicity, Color, Salt, Air emissions
Printing	BOD, COD, TSS, Cu, pH, Temperature, Water volume, Air emissions
Finishing	BOD, COD, TSS, Water volume, Air emissions

In terms of the types of activities that have been most productive in P2 for water pollution reduction, studies have shown that process modifications are the most prevalent P2 technique for water. (Berglund, 1990) In one company, about 60% of proposed process modifications and about 80% of administrative changes were actually adopted commercially. (Berglund, 1990) Appropriate specific techniques (see individual sections for more details) are

Design stage planning for processes and products
Equipment maintenance and operations audit
High extraction, low carryover process step separations
Incoming raw material quality control
Maintenance, cleaning, nonprocess chemical control
Process alternatives
Optimized chemical handling practices
Raw material prescreening (prior to use)
Scheduling to minimize machine cleaning
Training programs, worker attitudes
Waste audit
Segregation, transfer
Better Controls
Water conservation

Solid Waste

Very comprehensive studies have been done of solid waste generation in textile operations. (LeJeune 1993) The main types are listed below for 290 facilities that participated in a survey.

Waste Material
Aluminum cans
Ash
Bale wrapping
Card waste
Cardboard
Carpet backing
Carpet remnants
Carpet trim
Carpet waste
Compacted trash
Computer paper
Fabric waste
Fiber waste
Garbage
Glass
Hard thread (sized)
Hard Plastic
Latex foam solids
Metal drums
Office Paper
Paper bags
Paperboard drums
Plastic bale wrap
Plastic drums
Plastic film

Plastic containers
Plastic drum liners
Rags
Scrap metal
Scrap wood
Selvage trimmings
Slasher waste
Soft thread
Surface finishing waste
Sweeps
Wastewater treatment sludges
Wooden pallets
Yarn waste

Two hundred ninety facilities were surveyed, and they produced over 51 tons per month. Of these wastes, 64% goes to public landfills, about 23% is recycled and the rest goes to other disposal methods such as incineration or private landfills. Most of the recycled materials are cardboard (2943 tons/month), fiber waste (1881 tons/month), card waste (1646 tons/month), and selvage trimmings (1089 tons/month). (LeJeune*1993)

Sources
Sources of solid waste are usually obvious.

Ash and sludge
Two of the major sources, ash from boilers and wastewater treatment solids, are directly process related and are difficult to eliminate. These amount to about one fourth of the total, or over 6,000 tons per month in 290 facilities surveyed (LeJeune 1993). Conservation of energy can reduce ash. Reduction of chemical content of wastewater and efficient wastewater treatment system operation can result in decrease of treatment solids disposal needs.

Packing materials
Another major source is packaging materials, including cardboard boxes, bale wrapping film/fabric, bailing wire, wooden crates, paper sacks and drums made of paperboard, plastic or metal. Survey forms have been developed by ATMI and others for the purpose of identifying sources of solid waste. (LeJeune 1993, Tuggle 1993) Once identified, these can be systematically eliminated if there is a commitment to do so. In one operating division comprising 5 plants, the following packaging materials were used in one year, which amounted to about 500 tons total. (Smith 1989, unpublished results)

Bale Wrap (T)	100 tons
Cardboard boxes (T)	230 tons
Metal Drums (C)	3250 count
Paper Bags (C)	41500 count, or 10 tons
Paper Drums (C)	6850 count
Plastic Drums (C)	1150 count
Wooden Pallets (C)	1550 count
Paper tubes and cones	n/a

Reducing these is simply a matter of establishing and enforcing proper purchasing specifications. All raw materials should be received in bulk or returnable IBC's if possible. Returnable IBC's or bulk purchases of raw materials eliminate the waste packing materials as well as providing other benefits.

reduces spillage
reduces handling costs

: to chemicals

:mical itself
ıey're stackable)

Dru
If ... ıms, returnable containers should be ... .d accept drums for return without bei ... t each drum before pickup causes sig

Bag
Mar ... ıgs (eg salt, TSP, TSPP, soda ash, war ... source of breakage and spillage, as ... of. They can not be stored near hig ... ns. They must be moved around on ski ... they require a lot of labor to handle. All of the above chemicals are available in IBC's, and it is very useful to specify that form of packaging.

Most chem's

Paper cones and tubes
Yarns can be supplied on reusable plastic cones, and cardboard yarn cases can be substituted with plastic yarn pallets, which are reusable for many cycles. PVC pipe is used as a durable replacement for paper tubes in many operations. In addition to the waste savings, rigid PVC tubes reduce fabric distortion in knits.

Processing wastes
Waste fabric, yarn and fiber from processing accounts for a third major fraction of solid waste. In one multi facility company (spinning, weaving, dyeing and finishing), annual processing waste amounted to 1000 tons of fiber/fabric/yarn and 150 tons of sweeps.

Selvage trimming and seam cut out waste in many operations amounts to over 2% of the fabric produced. Proper training, even for such a simple thing as sewing seams straight, can significantly reduce seam waste as well as prevent creases and dye streaks at seams. This reduces the mill-end remnants which are produced. In a million yard per week production facility, this alone could easily gain or lose several thousand yards per week of fabric waste.

Miscellaneous
Other solid wastes include scrap metal, trash, paper and semisolid waste oils, solvents and sludges.

P2

Most solid waste P2 is simply common sense. Typical measures taken by mills include the following (Smith 1989 unpublished results) Several similar ideas (eg drum survey) are published in industry reports. (Tuggle 1993, LeJeune 1993)

Some companies "advertise" potentially reusable materials for other sites so the off-site reuse/recycle of waste materials can be improved, often by a waste exchange newsletter. An example of waste reuse would be to use waste curing paper from coatings operations for roll and beam covers in other operations. Savings are equal to the purchase cost of wrapping paper plus disposal costs of paper from coating operations.

Common wastes such as paper, cardboard and empty paper drums, must be baled, crushed or shredded prior to disposal or recycling. This may well be better and more economically handled at one central waste processing center due to the cost of the equipment such as shredders and balers. The disadvantage is the cost and logistics of transportation to the central location. However, the feasibility of establishing a waste center as a central waste pickup point for outside recyclers should be considered.

Assigning cost factors to each kind of waste can be useful in evaluating plants or departments. For example, fiber sweeps have almost no value and are to some extent preventable by orderly work practices, so these should count a lot against a mill. Clean reprocessable fiber waste on the other hand should count less against a mill, since its reuse value is higher. Another example is pallets which, if handled carefully, are reusable for a long time, so a broken pallet should count fairly heavily against the mill on its "waste score". The following are basis points for determining incentive or worker reward programs.

- Cost of disposal
- Value of salvage
- Loss of value from next best salvageable form
  - eg value difference of broken vs intact pallet
- Influence a worker has on the waste
  - eg boiler ash is not preventable and should not count much, but broken pallets are preventable and should count more

Example of factors which should be taken into consideration:

Type of waste	Disposal/Salvage per unit (ton/cnt/etc)	Next best form	Worker influence
Pallets	$2 gain	none	none
Broken pallets	$6 loss	Pallet	much
Empty size bags	$6 loss	none	none
Waste fiber	$2 gain	rewrkbl waste	moderate
Sweeps	$6 loss	fiber waste	great

A system such as this is appropriate to compare similar operations, such as greige mills. This makes workers more aware of he amount of waste and their performance, and keeps waste in its in highest value form.

Fibers, sweeps, rags, yarn and cloth scraps have salvage value and should generally be collected and sold. This is standard practice in most mills. There are many possible buyers.

Pallets should be minimized in number by buying as many large volume chemicals as possible in IBC's, bulk, or returnable containers, especially bagged chemicals such as warp size. Scrap pallets can be recycled and/or used in two ways -- either as pallets or as fuel. There are many pallet recyclers. Not all pallets are recyclable, and it pays to use recyclable pallets, in spite of their higher initial cost. Important factors in recycling of pallets are weight, exact stringer length and size (typ 2X4 = 1.5X3.5), number of deck boards (top and bottom), dimensions and length of deck boards, and configuration (are they 2-way or 4-way--accessible from 2 or 4 sides).

Pallets which can not be sold can be chipped and burned in boilers, but this generally requires chipping and removal of the nails, staples and other metal. Pallet chippers are readily available. A drum shredder, if available, can be used for shredding pallets, but the cost of a drum shredder is high compared to a pallet chipper. Drum shredders cost up to $80,000 and have a capacity of up to 500 pallets drums, pallets, etc, per day.

To avoid these wastes, take the following actions:

Buy bulk chemicals or IBC's to reduce number of bags/pallets
Sell used pallets to a recycler
Recycle bags
Donate damaged pallets to employees or institutions
Chip, then burn in boilers

Metal drums, like pallets, can be recycled and/or shredded. Several drum recyclers will pick up part loads as small as 50 drums. Other options for drums include returning them to the supplier and internal reuse. Purchasing contracts for chemicals should specify returnable drums (or other containers, such as gas cylinders). This should be part of the prescreening protocol. One problem is the variety of drum sizes. This creates problems in handling, storage, as well as reuse. The main plastic and metal drum sizes are listed below.

Chemical	height (in)	diameter (in)
Sodium bromate (oxidizer)	18	17
Misc processing assistants	38	22
Dyes	31	22
Dyes	27	22
Dyes	35	22
Misc (eg shop solvents)	27 or 37	22

Bags (empty chemical sacks), paper and cardboard can be baled and resold for about $12 per ton. Most recyclers require that paper be bailed, so a baler costing about $6,000 is required. Of course, it is possible to reuse cardboard yarn cases several times, and many cases this is being done now. An alternative to yarn cases is plastic yarn pallets, which are shrink wrapped to pack the yarn for shipment.

Buying chemicals in bulk or IBC's not only gives a cost break on the chemical, but also reduces or eliminates problems such as waste paper sacks and pallets. Other advantages include reduction in costs of storage, handling, labor/lifting, employee exposure, spillage (broken bags), inventory and warehouse space, etc. Chemicals which are often purchased in bags include common salt, GL salt, warp sizes, soda ash, TSP, TSPP.

Reworkable fiber waste of 5% is typical in spinning operations and is completely reclaimed by introducing it back into the opening line through a waste hopper.

Burlap bale wrap can be sold with the rags and other fiber waste. Most bale covers, however, are either polypropylene or Tyvac. The Tyvac covers can be sold. Polypropylene is not reusable, and should be avoided.

Bale straps and bailing wire can be sold to scrap metal dealers only if they are cut up into short pieces.

Used paper tubes and cones can be sold back to the suppliers. Intact tubes can be reused directly, and damaged tubes can also be reused by salvaging shorter pieces from longer damaged tubes (eg a 60" tube with damaged end can be cut off and used at standard 48" length).

Fabric trimming can be difficult to compact, and thus produces a very low density waste that takes up a lot more space in the landfill than it needs to.

Hazardous Waste

Most textile operations produce little or no hazardous waste as a routine matter, but a small percentage (perhaps 10 to 20%) of textile mills are hazardous waste generators. Any facility which uses chemicals can, of course, produce hazardous waste if a corrosive, ignitable, etc, chemical is spilled on the ground. The contaminated soil from such a spill is often hazardous waste by the legal definition, and must be handled accordingly.

Policies

Generators must be prepared for both routine handling of hazardous waste and for emergencies through training, equipment and policies. Policies are very important--especially that they are realistic and actually do encourage proper practices. Policies based simply on posturing to protect the employer from liability, and which do not actually promote safety and P2 of hazardous waste should be avoided.

Generation and Storage
Treatment and disposal of hazardous waste is expensive and difficult, and the associated liability is great, so the key is to minimize these wastes. Therefore the economic incentive to eliminate these by P2 is great. Many textile mills have completely screened out materials which produce hazardous waste, and continue to do so, to avoid production of these hazardous wastes.

Those who produce or transport, store and dispose (TSD) of hazardous waste must obey very specific regulations. Any hazardous waste generator must be aware fully aware of these, obtain proper permits, keep proper records, etc. Any facility which stores hazardous waste more than 30 days is by legal definition a storage facility.

Generators are classified according to the amount of hazardous waste they produce. Large generators are those who produce over 1000 kg per month and small generators are those who produce 100 to 1000 kg per month. Each mill must determine its hazardous waste status, and understand and abide by the appropriate regulations.

Disposal - Contractors
The generator has ultimate responsibility for safe removal and disposal of hazardous waste he produces. The mill's liability can not be assigned or transferred to a contractor who removes or disposes of the waste. Therefore, one of the most important items for the hazardous waste generator is to monitor TSD contractor activities. The credentials of TSD's should be carefully checked with local, state and Federal authorities.

If a transporter fails to properly handle hazardous waste, both the transporter and the generator(s) that produced the waste are jointly liable for damages. Suffice it to say that it is critical for a generator to ensure that the transporter who picks up his waste is perfectly reliable, trained and prepared. It is common practice for a generator to accompany the transporter to verify the proper ultimate destruction or disposal.

Sources - Textile Processes which produce hazardous waste
Several textile processes can potentially generate hazardous waste as normal and a routine by product. In addition, spills, process excursions, etc can produce unexpected hazardous waste. Since many textile mills have screened out chemicals which have potential for hazardous waste generation, the role of spills is very important.

Routine sources include

Dry cleaning
Solvent scouring
Solvent-based coating operations
Various shop activities

Spills
Bulk off-loading and storage areas are susceptible to spills. Discharge of a reportable spill quantity of hazardous material beyond a preplanned containment constitutes a hazardous spill and the associated problem of hazardous waste to dispose of. The key concept is "preplanned". To avoid producing hazardous waste from this source, there must be advance planning of

employee training regarding spill response
policies regarding off-loading practices and activities
preplanned containments
facility design to ensure ease of spill cleanup
absorbent materials on hand
prescreening--avoid having hazardous materials on site
audit and preventive maintenance on a regular schedule

Dry cleaning
Some mills use chlorinated solvents for batch dry cleaning as well as spot removal in the final inspection department. These materials are very efficient in removing oil stains from cloth and sewn products, but they have the potential to become hazardous waste, even if recycled on site through distillation processes. In that case, the still bottoms are hazardous waste to be disposed of.

There are several site-specific ways of avoiding hazardous wastes from these processes. Often the source of oil contamination is lubricating oils which drip or sling from moving or rotating machine parts (eg oven stacks and dampers, tenter frame drive chains, sewing machines, knitting oils). Often the main function of the drycleaning or spot removing operation is for repair work. In this case, an improvement in preventive maintenance, better employee training in the use of lubricants, or selection of better lubricants can reduce or eliminate the need for extensive repair work.

Solvent coating operations
Coating operations based on latex materials and solvents such as MEK, MIK, acetone, toluene, xylene, etc are perhaps some of the largest hazardous waste generators in the textile industry. These fabrics are used in various waterproof products, offset printing blankets, landfill liners and the like. They are produced in many cases by swelling or dissolving natural or synthetic rubber or latex materials in mixture solvents as noted above. These solutions or plasticized materials are then applied in various ways, eg spreading or spraying, onto fabrics, then dried or cured.

The residual portions of these solutions must be handles as hazardous wastes. As in printing or finishing, one P2 key is making up only the exact amount of coating material which is necessary for the run. This is often not the case, because many coated products are very high value-added items. Therefore waste control is often looked on a secondary issue because economic incentives are relatively less than in commodity products.

Another key is the possibility of using water based emulsions for coating. In many applications this can be done, however it is not applicable in all situations.

It is also possible that in some cases, newer forms of materials (eg fiber reinforced composites) may be a reasonable replacement for coated fabrics in certain applications. In the case that aqueous substitutes are not suitable, alternative product design should be considered for the specific end use.

Shop Chemicals
Many shop chemicals are hazardous, and when they become obsolete or are used, they are hazardous waste. These include insecticides, cooling tower treatment chemicals, weed killers, biocides, machine cleaners, paint strippers, floor finishes, etc. These often are not evaluated with the same care as production chemicals. Every chemical in the mill, including shop chemicals, deserves the same attention in terms of hazardous waste screening.

Handling and Record Keeping
Once produced, it is very important to keep the proper documents and properly handle the hazardous waste. It should be segregated from other wastes and raw materials. This reduces the amount of hazardous waste by not mixing hazardous and non hazardous wastes. Proper storage facilities are necessary to avoid leaks, seepage or other release of the waste prior to proper pickup and disposal. Records and manifests are required and should be available for review at any time.

Any chemical which potentially could become or contribute to a hazardous waste should be subjected to special audits and record keeping. Some important items are amount, characteristics, disposal practices, annual reports submitted, and permits (generator and TSD).

Permits are required if not only for producing the waste, but also for storage if the waste is held on site for over 30 day. A storer who is not a generator (eg a trucking company depot) must be permitted no matter how briefly the waste is held on site.

Shipping records must be carefully kept, and the shipper must maintain careful security of the waste, as well as a paper trail that identifies the generator.

Appropriate training of truck drivers other involved personnel is required.

Any losses or spills must be reported immediately. Delivery must be made only to a permitted facility. All transportation vehicles must carry emergency equipment on board.

Before disposal, hazardous wastes must be analyzed so that their nature is known. Security must be provided for the waste prior to disposal, and for the disposal site in general. Inspections of disposal facilities are performed by state and federal agents on a regular basis. Specialized training, especially emergency preparedness is required of all workers who handle hazardous waste. Specific documented spill control plans must be maintained. Record keeping and reporting are required, and monitoring is extensive. The permitting process requires facility design specifications, operation plans, monitoring, closure certification and post closure maintenance.

<u>Prevention Strategies</u>
The most powerful P2 strategy for hazardous waste, and the most widely used in textiles is total avoidance by prescreening chemicals.

<u>Chemical Prescreening and Raw Material Control</u>
Dividing textile chemicals into two groups, commodities and specialties, one can set up methods to prescreen and check raw materials as they arrive to avoid many hazardous waste problems.

One of the main reasons for chemical prescreening is to avoid the introduction into the plant of a material which will become or contribute to hazardous waste. This information must by law be specifically noted on the MSDS, along with appropriate spill control information.

Commodities are usually bought by the truck (or railway car), stored in bulk tank farms, and used in massive quantities. Many of these materials are corrosive or highly reactive. These materials are often handled in automated bulk chemical handling to reduce cost and potential for routine wastes. However, with bulk handling, the potential for large scale spills from tank trucks and bulk handling systems, and associated production of hazardous waste.

Several important P2 considerations with these commodity chemical materials are

proper receiving, storage and handling procedures

routine incoming raw material testing for impurities (eg metals) which might produce hazardous process wastes or treatment sludges

a strong program of preventive maintenance for bulk handling facilities

thorough training of employees using automated bulk chemical handling systems

proper training with respect to large scale spill response

Specialties, on the other hand, are generally complex mixtures of unknown composition to the user (and often to the vendor as well), and can not be handled the same way as commodities. Testing and prescreening of specialties must follow a less specific and more generic protocol. It is even more important in the case of specialties to carefully review all of the MSDS information, because there are many insidious hazards in seemingly innocent specialty chemicals.

To avoid the production of hazardous waste, look for any component which

- is a listed HAP or TAP
- is a listed priority pollutant
- exhibits high aquatic toxicity
- contains hazardous or toxic metals
- tends to accumulation in facility or in treatment sludges
- will react with other chemicals to produce hazardous waste
- will be a hazardous waste if spilled on the ground
- is the plant is equipped to handle in terms of
    - worker expertise, training
    - engineering controls, and storage facilities
    - personal protective equipment
    - spill procedures (preplanned)

The plant should request all necessary information from the vendor before even starting to evaluate the chemical in production. If the vendor can not or will not help in such an evaluation, find another vendor.

Process Review

In reviewing processes, the following types of questions should be raised

- what is mixed together?
- what reaction might occur under normal conditions?
- what reaction might occur under exceptional conditions?
- is the level of expertise of the operator sufficient?
- is the process machinery adequate?
- is the process control system adequate?

If a hazardous waste is produced, ask

- where does waste originate from in the process?
- can the hazardous waste be reused or recycled on site?
- what are the alternative processes?