Multilateral Investment Guarantee Agency

Environmental Guidelines for

Textiles Industry

Industry Description and Practices

The textile industry uses vegetable fibers such as cotton, animal fibers -- such as wool and silk, and a wide range of synthetic materials such as nylon, polyester, and acrylics. The production of natural fibers is approximately equal in amount to the production of synthetic fibers. Polyester accounts for about 50% of synthetics. (chemical production of the polymers used to make synthetic fiber is not covered in this document.)

The stages of textile production are: fiber production, fiber processing and spinning, yarn preparation, fabric production, bleaching, dyeing and printing, and finishing. Each stage generates wastes that require proper management.

This document focuses on the wet processes (which includes wool washing, bleaching, dyeing, printing, and finishing) used in textiles processing.

Waste Characteristics

Textile production involves a number of wet processes that may use solvents. Emissions of volatile organic compounds (VOCs) mainly arise from textiles finishing, drying processes, and solvent use. VOC concentrations vary from 10 milligrams of carbon per cubic meter (mg/m^3) for the thermosol process to 350 mg carbon/m^3 for drying and condensation process. Processes wastewater is a major source of pollutants. It is typically alkaline and has high BOD_5 (700 to 2,000 milligrams per liter (mg/L)) and chemical oxygen demand (COD) (approximately 2 to 5 times the biochemical oxygen demand (BOD) level), solids, oil and possibly toxic organics, including phenols (from dyeing and finishing) and halogenated organics (from processes such as bleaching). Dye wastewaters are frequently highly colored and may contain heavy metals such as copper and chromium. Wool processing may release bacteria and other pathogens. Pesticides are sometimes used for the preservation of natural fibers and these are transferred to wastewaters during washing and scouring operations. Pesticides are also used for moth proofing, brominated flame retardants for synthetic fabrics, and isocyanates for lamination (*Note*: The use of pesticides and other chemicals which are banned in OECD countries is discouraged and in general, not acceptable). Wastewaters should be checked for pesticides (such as DDT and PCP), and metals (such as mercury, arsenic, and copper).

Air emissions include dust, oil mists, acid vapors, odors, and boiler exhausts. Cleaning and production changes result in sludges from tanks and spent process chemicals, which may contain toxic organics and metals.

Pollution Prevention and Control

Pollution prevention programs should focus on reduction in water use and on more efficient use of process chemicals. Process changes might include the following:

- Match process variables to type and weight of fabric (reduces wastes by 10 to 20%).

- Manage batches to minimize waste at the end of cycles.
- Avoid non-degradable or less degradable surfactants (in washing and scouring), and spinning oils.
- Avoid the use, or at least the discharge of, alkyllphenol-ethoxylates. Oone depleting substances should not be used and the use of organic solvents should be minimized.
- Use transfer printing for synthetics (reduces water consumption from 250 to 2 L/kg of material and also reduces dye consumption). Use water-based printing pastes, when feasible.
- Use pad batch-dyeing (saves up to 80% of energy requirements and 90% of water consumption, as well as reducing dye and salt usage). For knitted goods, exhaust dyeing is preferred.
- Use jet dyers (with a liquid to fabric ratio of 4 to 8) instead of winch dyers (with a ratio of 15), where feasible.
- Avoid benzidine-based azo dyes and dyes containing cadmium and other heavy metals. Do not use chlorine-based dyes.
- Use less toxic dye carriers and finishing agents. Avoid carriers containing chlorine (such as chlorinated aromatics).
- Dichromate oxidation of vat dyes and sulfur dyes should be substituted by peroxide oxidation.
- Reuse dye solution from dye baths.
- Use peroxide-based bleaches instead of sulfur and chlorine-based, where feasible.
- Control make-up chemicals.
- Reuse and recover process chemicals such as caustic (reduces chemical costs by 30%) and size (up to 50% recovery is feasible).

Wastewater Characteristics

Process	*Unit (U)*	*Waste volume m^3/U*	*BOD_5 kg/U*	*TSS kg/U*	*Other Pollutants Name kg/U*	
Wool processing[a]						
Average unscoured stock[b]	metric ton of wool	544	314	196	Oil	191
					Cr	1.33
					Phenol	0.17
Average scoured stock	metric ton of wool	537	87	43	Cr	1.33
					Phenol	0.17
Process-specific						
Scouring	metric ton of wool	17	227	153	Oil	191
Dyeing	metric ton of wool	25	27		Cr	1.33
					Phenol	0.17
Washing	metric ton of wool	362	63			
Carbonizing	metric ton of wool	138	2	44		
Bleaching	metric ton of wool	12.5	1.4			
Cotton processing						
Average compounded[c]	metric ton of cotton	265	115	70		
Processing-specific						
Yarn sizing	metric ton of cotton	4.2	2.8			
Desizing	metric ton of cotton	22	58	30		
Kiering	metric ton of cotton	100	53	22		
Bleaching	metric ton of cotton	100	8	5		
Mercerizing	metric ton of cotton	35	8	2.5		
Dyeing	metric ton of cotton	50	60	25		
Printing	metric ton of cotton	14	54	12		
Rayon processing	metric ton of rayon	42	30	55		
Acetate processing	metric ton of acetate	75	45	40		
Nylon processing	metric ton of mylon	125	45	30		
Acrylic processing	metric ton of acrylic	210	125	87		
Polyester processing	metric ton of polyester	100	185	95		

[a] The pH varies widely, from 1.9 to 10.4.
[b] The average compounded load factors listed are based on the assumption that only 20% of the product is mercerized (only non-woolen components are mercerized) and 10% is bleached.
[c] The average compounded load factors listed are based on the assumption that only 35% of the product is mercerized, 50% of the product is dyed and 14% of the product is printed.
Source: World Health Organization, 1993.

- Substitute non-degradable spin finish and sizes with degradable alternatives.
- Use biodegradable textile preservation chemicals. Do not use polybrominated diphenylethers, dieldrin, arsenic, mercury, and pentachlorophenol in moth proofing, carpet backing, and other finishing processes. Where feasible, use permethrin for moth proofing instead.
- Control the quantity and temperature of water used.
- Use counter current rinsing.
- Improve cleaning and housekeeping measures (may reduce water usage to less than 150 m^3/t of textiles produced).
- Recover heat from wash water (reduces steam consumption).

Target Pollution Loads

Implementation of cleaner production processes and pollution prevention measures can provide both economic and environmental benefits. The following production-related waste load figures can be achieved by implementing measures such as those detailed in the previous section. The figures are the waste loads arising from the production processes before the addition of pollution control measures.

Air Emissions

VOC emissions should be less than 1 kg carbon/t of fabric.

Wastewater

Wastewater load levels should preferably be less than 100 m^3 per ton of fabric up to 150 m^3 considered acceptable.

Treatment Technologies

VOC abatement measures include the use of scrubbers, adsorbers using activated carbon, and routing the vapors through a combustion system. A common approach to treatment of wastewaters is screening, flow equalization, and then settling to remove suspended solids, followed by biological treatment. Physical-chemical treatment is also practiced. In this treatment careful control of pH followed by the addition, coagulant (such as alum) before settling can achieve good first-stage treatment. If further treatment to reduce BOD_5 is required, it can be provided in oxidation ponds if space permits (or another aerobic process, with up to 95% removal of BOD_5). Average effluent levels of 30 to 50 mg/L BOD_5 will be obtained. Anaerobic treatment systems are not widely used for textile wastes. Carbon adorption is sometimes used to enhance removal. In some cases, precipitation and filtration may also be required. Up to 90% recovery of size is feasible by partial recycling of prewash and additional ultrafiltration of diluted wash water. Disinfection of wastewaters from wool processing may be required to reduce coliform levels.

Residues and sludges often contain toxic organic chemicals and metals. These should be properly managed, with final disposal in an approved secure landfill. Sludges containing halogenated organics and other toxic organics should be effectively treated (such as by incineration) before disposal of the residue in a secure landfill.

Emission Guidelines

Emission levels for the design and operation of each project must be established through the Environmental Assessment (EA) process, based on country legislation and the *Pollution Prevention and Abatement Handbook* as applied to local conditions. The emission levels selected must be justified in the EA and acceptable to MIGA.

The following guidelines present emission levels normally acceptable to the World Bank Group in making decisions regarding provision of World Bank Group assistance, including

MIGA guarantees; any deviations from these levels must be described in the project documentation.

The guidelines are expressed as concentrations to facilitate monitoring. Dilution of air emissions or effluents to achieve these guidelines is unacceptable.

All of the maximum levels should be achieved for at least 95% of the time that the plant or unit is operating, to be calculated as a proportion of annual operating hours.

Air Emissions

VOC emissions should be reduced to less than 1 kg carbon per metric ton of fabric (or 20 milligrams per normal cubic meter (mg/Nm^3)) by implementing measures such as routing the extracted air from the solvent usage areas through a combustion system (such as a boiler).

Liquid Effluents

The following effluent levels should be achieved:

Effluents from the Textiles Industry*

Parameter	*Maximum value milligrams per liter (mg/L)*
pH	6 - 9
BOD_5	50
COD	250
AOX	8
Total suspended solids	50
Oil and grease	10
Pesticides (each)	0.05
Chromium (total)	0.5
Cobalt	0.5
Copper	0.5
Nickel	0.5
Zinc	2
Phenol	0.5
Sulfide	1
Temperature increase	less than 3°C[1]
Coliform	400 Most Probable Number/100 mL

* Mercury should not be used in the process.

[1]The effluent should result in a temperature increase of no more than 3 degrees Celsius at the edge of the zone where initial mixing and dilution take place. Where the zone is not defined, use 100 meters from the point of discharge.

The liquid effluent should not be colored.

Note: Effluent requirements are for direct discharge to surface waters.

Sludges

Sludges containing chromium or other toxics should be treated and disposed in a secure landfill. Incineration of toxic organics should effectively destroy/remove over 99.99% of toxic organics.

Ambient Noise

Noise abatement measures should achieve either the following levels or a maximum increase in background levels of 3 dB(A). Measurements are to be taken at noise receptors located outside the project property boundary.

Ambient Noise

	Maximum Allowable L_{eq} (hourly), in dB(A)	
Receptor	Daytime 07:00 - 22:00	Nighttime 22:00 - 07:00
Residential; institutional; educational	55	45
Industrial; commercial	70	70

The emission requirements given here can be consistently achieved by well-designed, well-operated and well-maintained pollution control systems.

Monitoring and Reporting

Frequent sampling may be required during start-up conditions. Once a record of consistent performance has been established, sampling for the parameters listed above should be at least on a weekly basis. Only those metals should be monitored which are either detected or suspected to be present. If other heavy metals such as arsenic, cadmium, lead, mercury, and nickel are suspected to be present, then those should be included in the monitoring program and treated to levels mentioned in the General Industry Guidelines.

Monitoring data should be analyzed and reviewed at regular intervals and compared with the operating standards so that any necessary corrective actions can be taken. Records of monitoring results should be kept in an acceptable format. These should be reported to the responsible authorities and relevant parties, as required, and provided to MIGA if requested.

Key Issues

The following box summarizes the key production and control practices that will lead to compliance with emissions guidelines:

- Avoid the use of less-degradable surfactants (in washing and scouring operations) and spinning oils.
- Consider the use of transfer printing for synthetics. Use water-based printing pastes, where feasible.
- Consider the use of pad batch-dyeing.
- Use jet dyers instead of winch dyers where feasible.
- Avoid the use of benzidine-based azo dyes and dyes containing cadmium and other heavy metals. Chlorine based dyes should not be used.
- Do not use mercury, arsenic, and banned pesticides in the process.
- Control the makeup of chemicals and match process variables to type and weight of fabric.
- Recover and reuse process chemicals and dye solution.
- Substitute less toxic dye carriers wherever possible. Avoid carriers containing chlorine.
- Use peroxide-based bleaches instead of sulfur and chlorine based, where feasible.
- Adopt counter current rinsing and improved cleaning and housekeeping.

Further Information

The following are suggested as sources of additional information (these sources are provided for guidance and are not intended to be comprehensive):

Gherzi Textile Organization, 1990. The Spinning, Weaving, Knitting, and Processing Sectors to 2000 AD: A Period of Further Dynamic Global Changes. Report prepared for International Finance Corporation Under Contract No. 3090.

International Finance Corporation, 1994. Textile Waste Treatment Seminar, June 21, Presentation by Piedmond Olsen Hensley.

Modak. 1991. *Environmental Aspects of the Textile Industry: A Technical Guide*. Prepared for United Nations Environment Programme Industry and Environment Office.

Paris Convention for the Prevention of Marine Pollution, Sixth Meeting of the Working Group on Industrial Sectors, Oslo: 17-21 January, 1994. INDSEC 6/12/2-E. Agenda Item 12. Draft Report on Best Available Techniques and Best Environmental Practice for Wet Processes in the Textile Processing Industry, Presented by Belgium

United Nations Environment Programme (UNEP). 1994. *The Textile Industry and the Environment*. Technical Report No. 16. Paris: UNEP/IE.

World Bank, Environment Department. 1996. "Pollution Prevention and Abatement: Textiles Industry." Technical Background Document.

World Health Organization. 1993. Assessment of Sources of Air, Water, and Land Pollution. A Guide to Rapid Source Inventory Techniques and their Use in Formulating Environmental Control Strategies. Part One: Rapid Inventory Techniques in Environmental Pollution by Alexander P. Economopoulos. Publication No. WHO/PEP/GETNET/93.1-A.