EPA   United States
Environmental
Protection
Agency

Environmental Management Systems

Process Mapping Approach—DRAFT

For a company that manufactures a product, process mapping is an effective tool for systematically identifying its environmental aspects (p. 3). Identification of environmental aspects is fundamental to environmental management, so if your company already has an EMS, probably you have some way of doing this. The value of process mapping is that it is *systematic and comprehensive* — you may well identify important environmental aspects that a more informal process would have missed.

> **Process mapping** is an approach to systematically analyzing a particular process. It involves mapping each individual step, or unit operation, undertaken in that process in chronological sequence. Once individual steps are identified, they can be analyzed in more detail. For example, the environmental aspects of a given step can be identified by analyzing its inputs and outputs.

Because it is best done in small teams, process mapping is an important focal point for employee involvement in the EMS. The act of defining each unit operation of a given process, and the environmental aspects of each unit operation, gives a much deeper understanding of the process to team members — sometimes leading to ideas for immediate operational and environmental improvements.

The following six steps will help you apply process mapping to your company's production processes. All of these steps are illustrated by using the screen printing (p. 2) process as an example; the DfE Program has collaborated closely with screen printers in the past. Although process mapping is most clearly applicable to the manufacturing context (e.g., screen printing), you can easily adapt it to the operations of most service providers.

Step 1: Understanding the basic process mapping tool (p. 4)

Step 2: Creating a flow chart of your product's life-cycle (p. 8)

Step 3: Using the flow chart to define the boundaries of your EMS (p. 9)

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Step 4: Identifying the processes within the boundaries you've set (p. 12)

Step 5: Applying the basic process mapping tool to each process (p. 13)

Step 6: Compiling your results (p. 15)

Environmental Aspects

The following definitions and example illustrate the concept of environmental aspects and their relationship to environmental impacts and ecological and human health risks.

Environmental Aspect: Element of an activity, product, or service of a company that *is causing or can cause* an environmental impact.

Environmental Impact: Actual interaction with or impact on the environment.

Aspect   **Aspect and Impact**
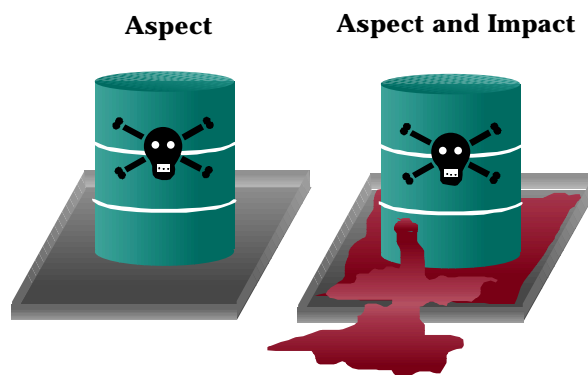
Not all environmental aspects cause environmental impacts. For example, take the storage of a cleaning solvent. If the container leaks, the leaking solvent will impact the environment. Because there is the *potential* for an impact, storage of the solvent is an environmental aspect. But if the container does not leak, then there is no impact on the environment from storing the solvent.

Screen Printing

There are about 20,000 graphic art screen printing shops in the United States. These mostly small- and medium-sized businesses perform diverse functions ranging from the printing of billboard advertisements and posters to printing onto electronic equipment. Screen printing involves stretching a porous mesh material over a frame to form a screen. Then a rubber-type blade (squeegee) is swept across the screen surface, pressing ink through a stencil and onto the print material.

For more information about screen printing, you can visit DfE's Screen Printing project page at www.epa.gov/opptintr/dfe/screenprinting/screenprinting.html.

Step 1:   Understanding the Basic Process Mapping Tool

There are two basic components to process mapping:

!   Developing a process map
!   Analyzing each unit operation

Developing a process map: breaking a process down into unit operations

The first basic step in process mapping is to break down a process into its component steps, or unit operations. The process map depicts these steps and the relationship between them.

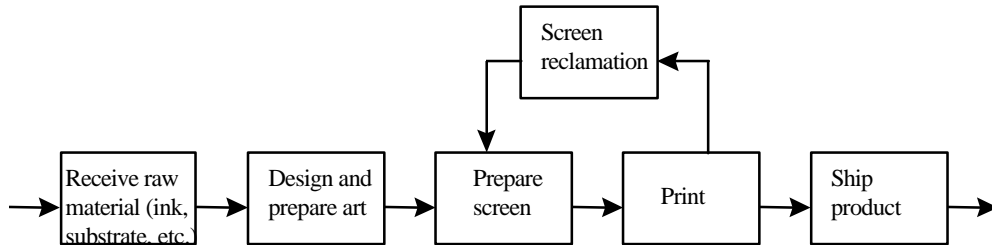*Analyzing each unit operation*

The second basic step in process mapping is to analyze each unit operation in the form of a diagram that answers the following questions:

!   What is the *product input* to each unit operation? (The product input to a given unit operation is generally the product output of the preceding unit operation. For the first unit operation of a process, there may not be any "product input.")

!   What are the *non-product inputs* to the unit operation? (These include raw materials and components as well as energy, water, and other resource inputs.)

!   What is the *product output* of the unit operation?

!   What are the *non-product outputs* of the unit operation? (These include solid waste, water discharge, air emissions, noise, etc.)

!   What are the *environmental aspects* of the unit operation? (These may have been designated as inputs or outputs.)
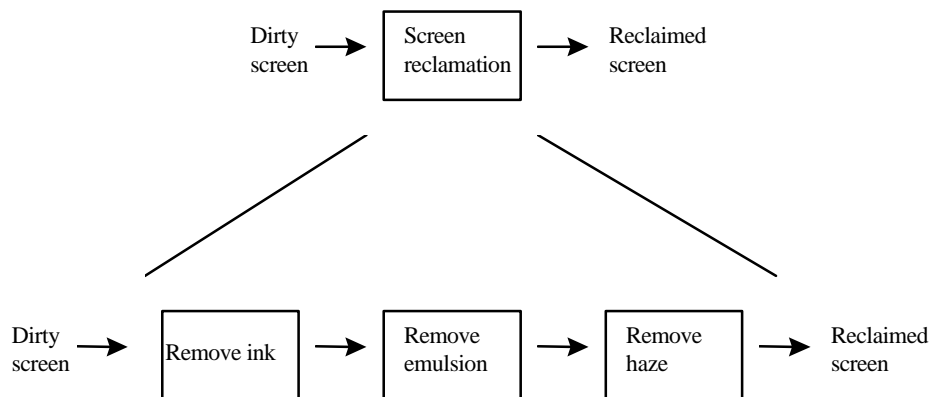
See p. 6 for a generic unit operation diagram.

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Process Map for a Screen Printing Shop

```
                                    ┌──────────────┐
                                    │   Screen     │
                                    │ reclamation  │
                                    └──────────────┘
                                    ▲              ▲
┌───────────┐   ┌──────────┐   ┌──────────┐   ┌────────┐   ┌──────────┐
│Receive raw│   │Design and│   │ Prepare  │   │        │   │  Ship    │
│material   │──▶│prepare   │──▶│ screen   │──▶│ Print  │──▶│ product  │──▶
│(ink,      │   │art       │   │          │   │        │   │          │
│substrate, │   └──────────┘   └──────────┘   └────────┘   └──────────┘
│etc.)      │
└───────────┘
```
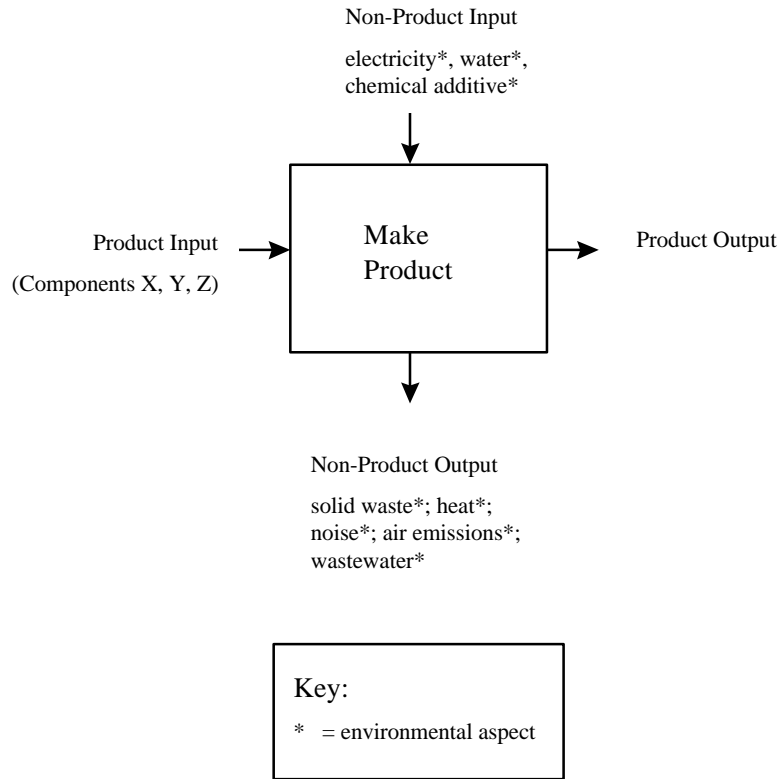
These are the basic processes carried out in a screen printing shop. Of course, many of these processes have separate steps to them. These steps are called unit operations. For example, in some screen printing shops the "screen reclamation" process can be divided into the following separate steps. Different chemicals are applied, and then rinsed off, at each step.

```
Dirty      ┌────────────┐    Reclaimed
screen ──▶ │   Screen   │ ──▶ screen
           │reclamation │
           └────────────┘

Dirty   ┌─────────┐   ┌─────────┐   ┌─────────┐   Reclaimed
screen ▶│Remove   │──▶│Remove   │──▶│Remove   │──▶ screen
        │ink      │   │emulsion │   │haze     │
        └─────────┘   └─────────┘   └─────────┘
```
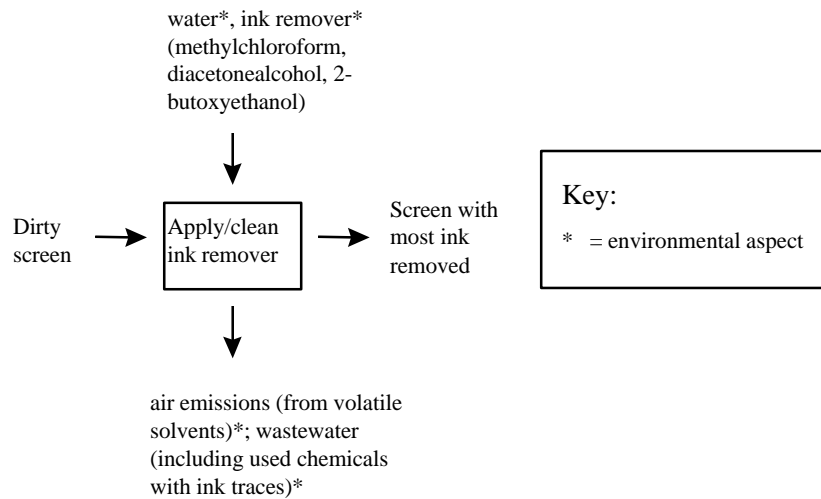
Additional examples of process mapping can be found in other DfE program projects. For example, through its work with the Printed Wiring Board industry, the DfE program has generated process maps for specific manufacturing processes in that industry. For more information, you can download DfE's Printed Wiring Board Industry and Use Cluster Profile at www.epa.gov/opptintr/dfe/pwb/pubs.htm#cas studies.

Generic Unit Operation Diagram

Non-Product Input

electricity*, water*,
chemical additive*

Product Input →   **Make Product**   → Product Output

(Components X, Y, Z)

Non-Product Output

solid waste*; heat*;
noise*; air emissions*;
wastewater*

Key:

* = environmental aspect
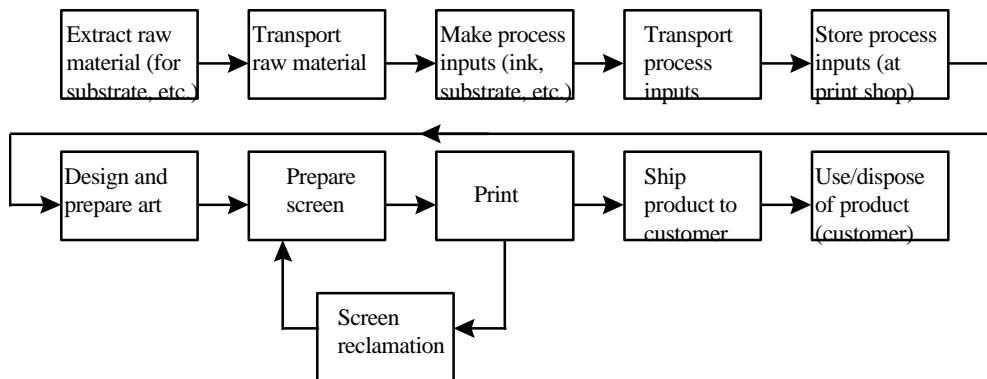
Unit Operation Diagram for Screen Reclamation

This diagram shows the inputs, outputs, and environmental aspects of a unit operation (applying and washing off ink remover) within the screen reclamation process.

water*, ink remover*
(methylchloroform,
diacetonealcohol, 2-
butoxyethanol)

↓

Dirty
screen → | Apply/clean
ink remover | → Screen with
most ink
removed

Key:

* = environmental aspect

↓

air emissions (from volatile
solvents)*; wastewater
(including used chemicals
with ink traces)*

Step 2:   Creating a Process Map of Your Product's Life-cycle

The first application of the basic process mapping approach is to create a simple flow chart or process map showing the main stages of the life-cycle of your product, from raw material extraction to end-of-life disposal (or reuse or recycling). Follow the process mapping guidelines given in Step 1 (p. 4), using the entire life cycle of the product.

Life-cycle Process Map for a Screen Printing Shop

```
┌──────────┐   ┌──────────┐   ┌──────────┐   ┌──────────┐   ┌──────────┐
│Extract raw│   │Transport │   │Make process│  │Transport │   │Store process│
│material(for│→ │raw material│→│inputs(ink,│ → │process   │ → │inputs(at   │
│substrate,  │   │          │   │substrate, │   │inputs    │   │print shop) │
│etc.)       │   │          │   │etc.)      │   │          │   │            │
└──────────┘   └──────────┘   └──────────┘   └──────────┘   └──────────┘

┌──────────┐   ┌──────────┐   ┌──────────┐   ┌──────────┐   ┌──────────┐
│Design and│   │Prepare   │   │  Print   │   │Ship      │   │Use/dispose│
│prepare art│→ │screen    │ → │          │ → │product to│ → │of product │
│          │   │          │   │          │   │customer  │   │(customer) │
└──────────┘   └──────────┘   └──────────┘   └──────────┘   └──────────┘
                   ↑              │
               ┌──────────┐       │
               │Screen    │←──────┘
               │reclamation│
               └──────────┘
```

Note: Many more raw materials are used by screen printers than can be indicated in this diagram, which is one reason that making a complete life-cycle process map is very difficult. In addition to ink and substrate, for example, screen printers use screens, stencils, photographic films, film developers and fixers, and screen reclamation solvents.

Step 3:   Using the Flow Chart to Define the Boundaries of Your EMS

On the simple process map that you made in Step 2 (p. 8) , draw a dotted line around the processes that you want to include in your analysis of environmental aspects. In effect, you are indicating the boundaries of your aspects identification process. Your choice of aspects identification boundaries is a strategic decision, which should be reflected in your environmental policy. You should include, at the least, the environmental aspects of your internal activities and operations.

See p. 10 for a life-cycle process map for a screen printing process with boundaries defined.

Some companies choose to examine environmental aspects associated with end-of-life disposal (or recycling or reuse), raw materials extraction, and/or the operations conducted by component suppliers. Companies that take responsibility for all environmental aspects associated with the life cycle of their products are practicing what is known as extended producer responsibility (EPR). For example, a paper manufacturer might decide that its customers' failure to recycle paper and its suppliers' failure to practice sustainable forestry are two important environmental aspects within the life cycle of its product.

There are good reasons for and against practicing EPR that you should consider when setting your company's aspects identification boundaries:

!   Sometimes the largest environmental impacts that occur within the life cycle of your product may not be directly attributable to your operations. If one of your goals is supplying a product with the lowest overall environmental impact, you may get the best "bang for your buck" by focusing on environmental impacts outside of your own operations.

!   Especially for small businesses, however, it is difficult to analyze and influence actions that your company does not directly control and to take credit for initiatives you pursue outside of your day-to-day operations.

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Life-cycle Process Map for Screen Printing With Boundaries Defined
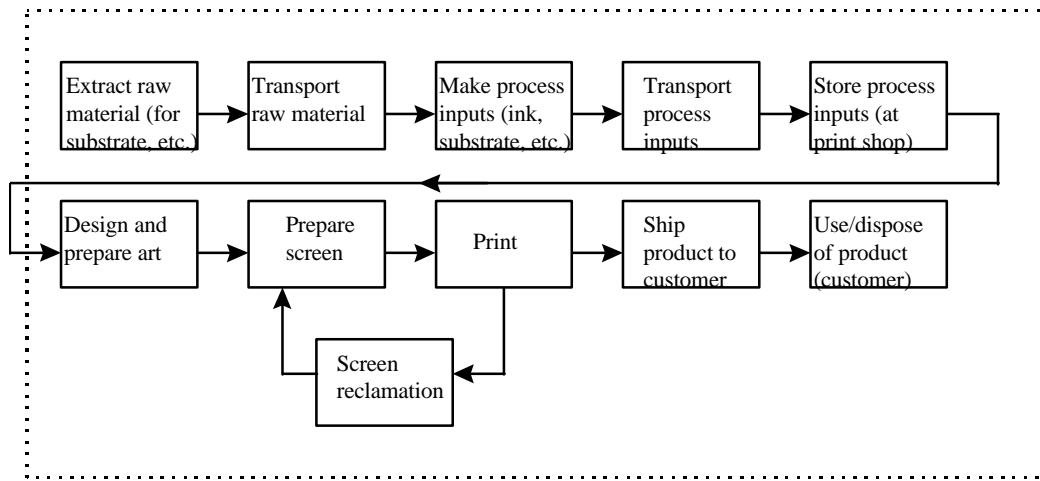

⋮....⋮ = Aspects identification boundary
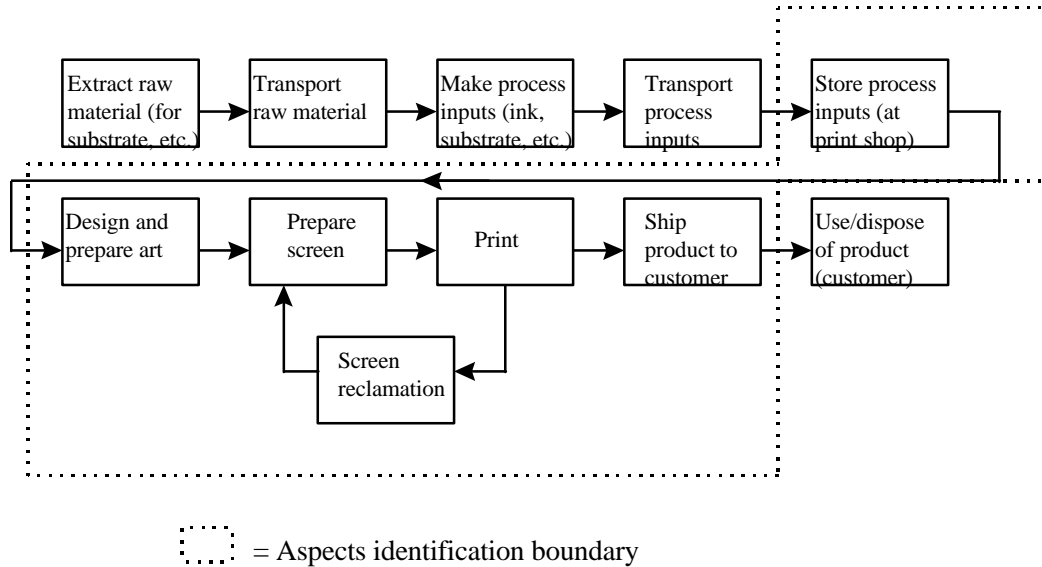
Two points about this diagram:

! In this case, the screen printing shop has chosen to concentrate its aspects identification process on the processes that it directly controls or influences (i.e., "in-house" process and shipping). A company that wanted to take responsibility for the environmental impacts of its product throughout the product's life cycle might expand its aspect identification boundaries.

! Regardless of where the aspects identification boundary is drawn, the *causes* of "in-house" environmental aspects can sometimes be found outside of a company's fenceline. For example, if a supplier applies oil to a part before shipping it for preservation purposes, that might force the receiving company to wash the part with a toxic solvent, thus creating an environmental impact. In this case, the company would have to work with its supplier to solve the problem.

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Life-cycle Process Map for Screen Printing With Boundaries Expanded

.... = Aspects identification boundary

A company that has chosen to practice extended producer responsibility might extend its aspects identification boundary to include upstream and downstream processes. For example, this screen printing shop would consider the environmental aspects associated with making the substrates it uses and with the disposition of its product as within the scope of its EMS.

Step 4:   Identifying the Processes Within the Boundaries You've Set

Your next step is to identify the processes included in the scope of your EMS. As you look at your life-cycle process map, most of your basic processes will be obvious. Any production lines, or major steps, that your product goes through are processes that have environmental aspects. For example, storage and internal transportation (of raw materials and products) are separate processes, as are production lines themselves.

However, there may be some processes or operations within your EMS boundary that are not central to making your product but which have environmental aspects. For example, maintenance is often a separate department, and the environmental aspects associated with maintenance may not be taken into account unless you do a separate analysis of that function. Another example might be the office area, your landscaping, or the cafeteria (if you have one).

Using your life-cycle process map, make a list of all the processes and operations that fall within your EMS boundary.

List of Processes in Screen Printing

Processes basic to screen printing

Receive and store process inputs (such as ink, paper, chemicals)
Design and prepare art
Prepare screen
Print
Reclaim screen
Ship product to customer
Use and disposal of product (customer)

Additional processes/operations to consider

Building management and maintenance
Front office
Employee transportation
Landscaping
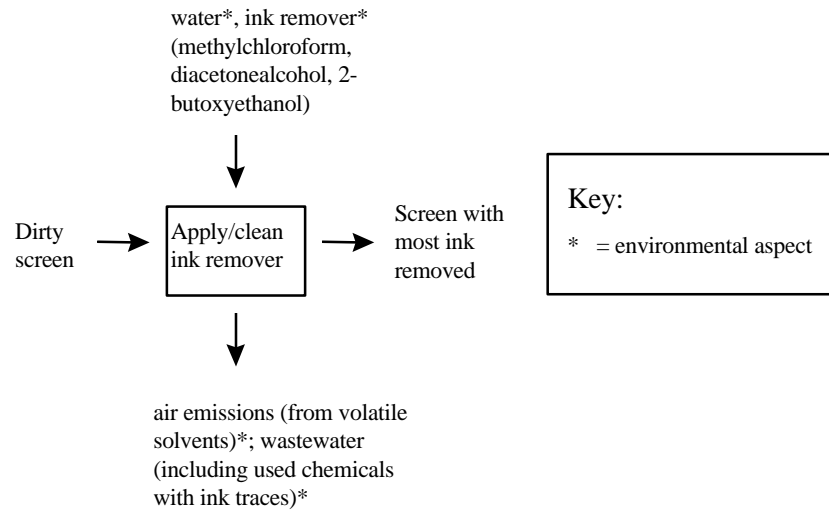#   Cafeteria

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Step 5:   Applying the Basic Process Mapping Tool to Each Process

From Step 4 (p. 12) you have a list of processes that fall under the scope of your EMS. Now you need to apply the process mapping tool to each of these processes to generate a process map showing the unit operations for each process. You can then use a unit operation diagram to identify the environmental aspects of each unit operation. Be sure to include employees familiar with the operation in question on the team that identifies the aspects.

Process Map for Screen Reclamation

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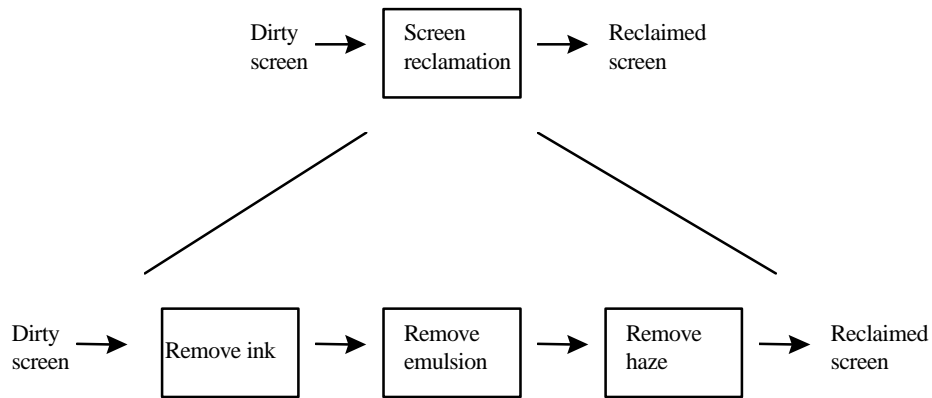
Unit Operation Diagram for Screen Reclamation

Note: The unit operation diagram is only shown for "Apply/clean ink remover." The unit operation diagrams for the remaining two operations would be similar.

water*, ink remover*
(methylchloroform,
diacetonealcohol, 2-
butoxyethanol)

Dirty screen → Apply/clean ink remover → Screen with most ink removed

Key:

* = environmental aspect

air emissions (from volatile solvents)*; wastewater (including used chemicals with ink traces)*

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Step 6: Compiling Your Results

If you have completed the previous five steps, you have identified unit operations for all of your organization's processes and identified the environmental aspects for each unit operation. What next?

In order to incorporate these data into your EMS, you should enter them into a spreadsheet, following the example below. You will then use these data to evaluate which of your environmental aspects are significant.

Results: Screen Printing Operation

Environmental Aspect	Corresponding Unit Operation(s)
Use of ink remover (contains diacetonealcohol, methylchloroform, 2-butoxyethanol)	Apply/clean ink remover
Use of water	Apply/clean ink remover
Generation of wastewater effluent (contains ink remover, ink traces)	Apply/clean ink remover
Emission of air contaminants	Apply/clean ink remover
etc.	etc.

Note: Because the unit operation diagram was only developed for the unit operation "apply/clean ink remover," only associated environmental aspects are listed in this spreadsheet simulation. As you are implementing the process mapping tool in your organization, you can include the environmental aspects from all unit operations and processes in the same spreadsheet. If the same environmental aspect is present in more than one unit operation, you only need to list the aspect once—just list all the corresponding unit operations. A good example is the use of water or electricity, which could be an environmental aspect of many unit operations.

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