CHAPTER 3

Environmental Law and Regulations: from End-of-Pipe to Pollution Prevention

By the end of this section you should:

- **Be aware of the primary federal statutes on environmental regulations.**

- **Be familiar with the background for the basic provisions of pollution prevention concepts and terminology.**

Provisions: 규정

Contents

statute [stǽtʃuːt] *n.*
법령, 성문법, 법규; 정관(定款), 규칙

Why you need to be aware of environmental regulations?

Chemical engineers practice a profession and are required to obey specific laws governing their professional conduct.

Environmental laws require engineers to perform affirmative duties, and if those duties are not performed, chemical engineers and the firms may be held civilly and criminally liable.

civilly and criminally liable : 민형법상 책임

Why you need to be aware of environmental regulations?

These laws are designed to

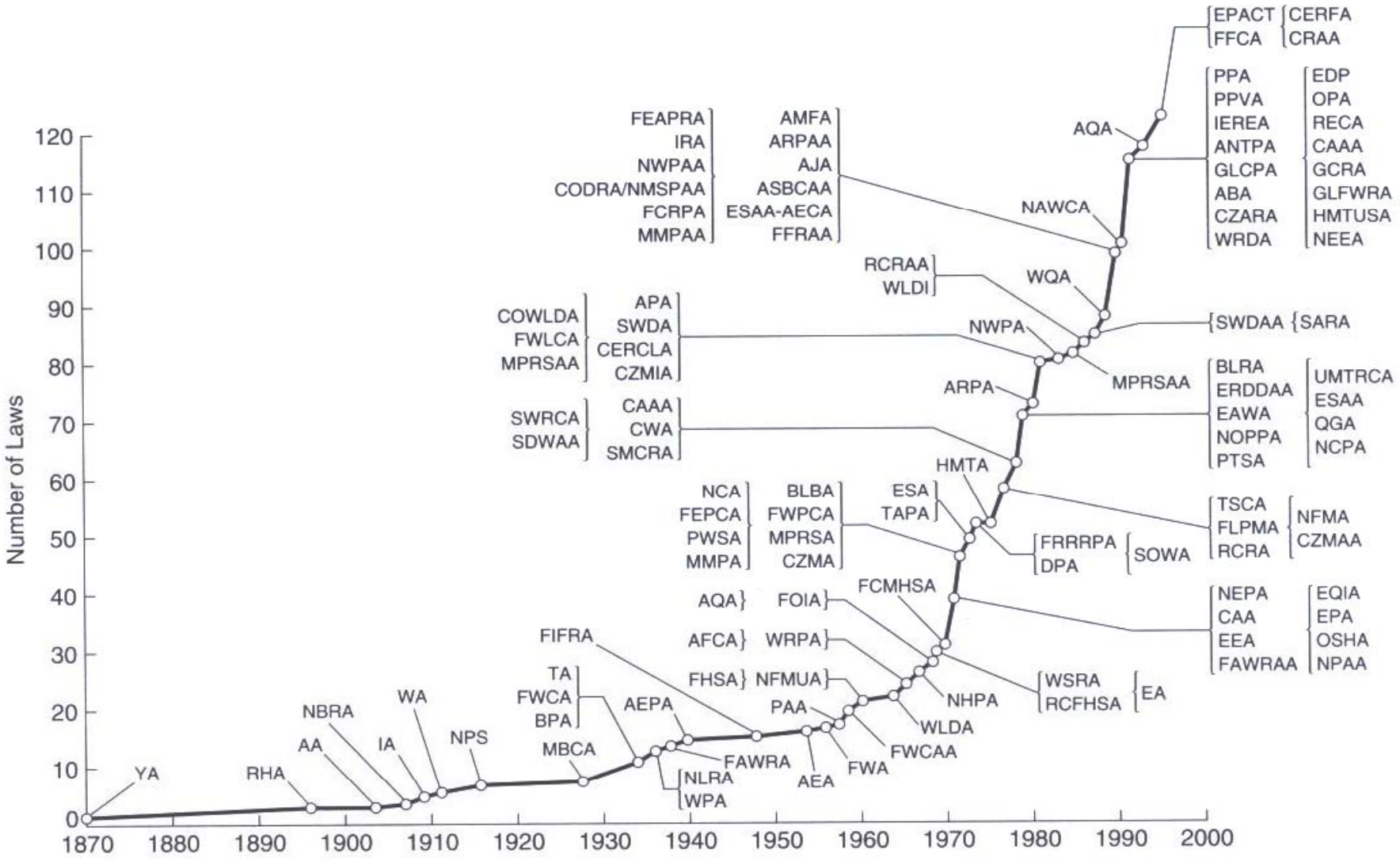
protect human health and protect the environment

These laws limit

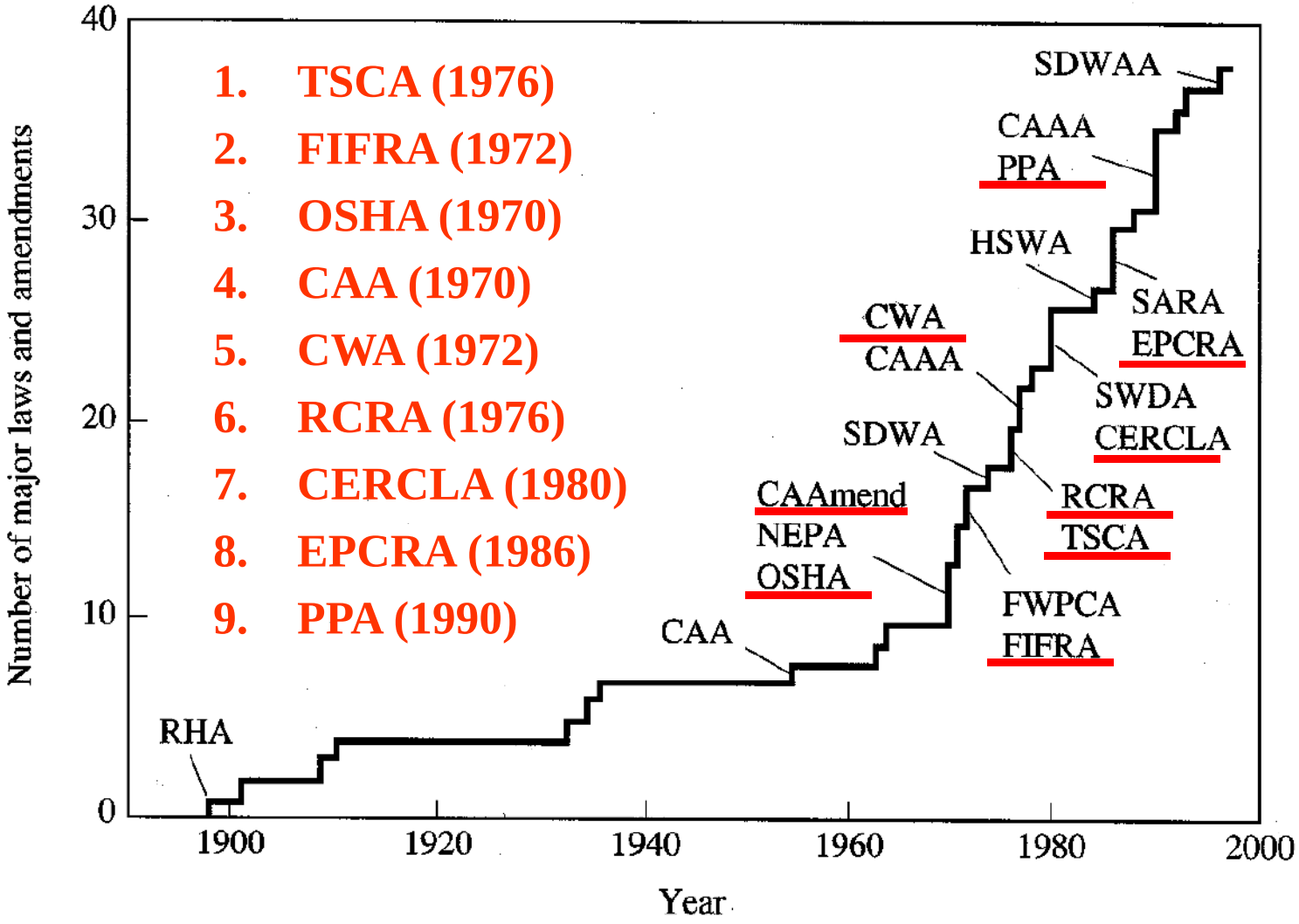
waste stream quantity and chemical make-up of waste streams that are released from manufacturing processes.

One statute places restrictions on how hazardous waste from industry is stored, transport, treated. Another statute places strict liability on the generators of hazardous waste, requiring responsible parties to clean up disposal sites that fail to protect the environment. For manufacturers of new chemicals, there are regulatory requirements that require filing of a premanufacture notice (PMN) before introducing a new chemical into the marketplace.

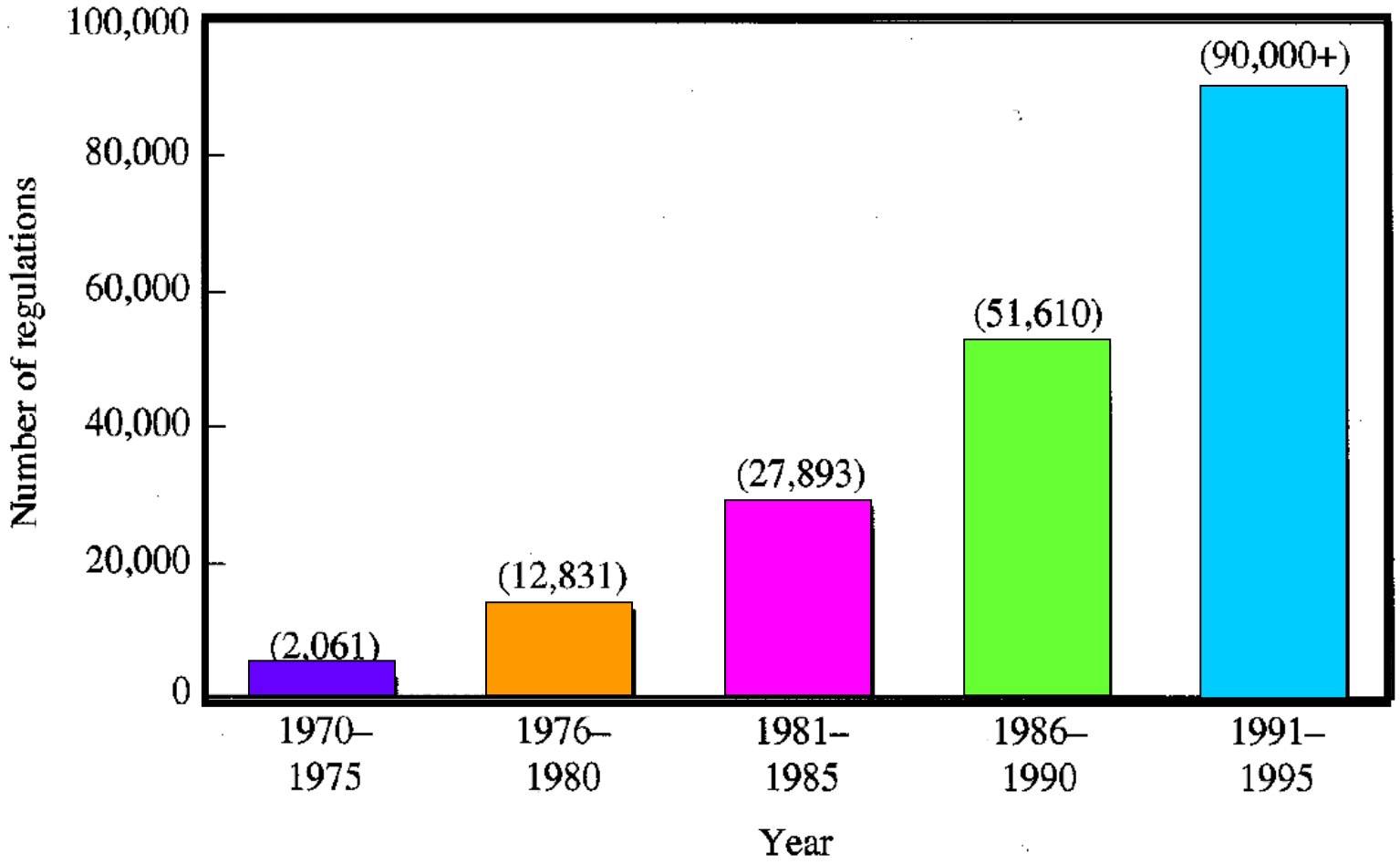
Cumulative growth in federal environmental laws and amendments



Cumulative growth in federal environmental laws and amendments



Cumulative growth in federal environmental laws and amendments

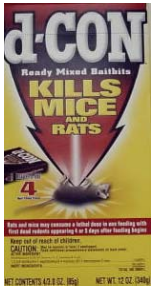


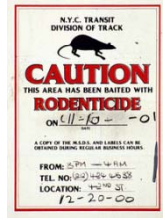
The duties of a chemical engineer may be:

- *To revise plant design to minimize pollution*
- *To secure permits*
- *To report releases*
- *To submit notifications*
- *To advise management*
- *To work with legal staff*
- *To work with regulatory agencies – EPA, TCEQ, Cities*

Chemical engineers need to be aware of their legal liability in order to protect themselves and their company from legal action.

3.2 Nine Prominent Federal Environmental Statutes





1. **TSCA** ***(1976, Toxic Substances Control Act)*** **: test and restrictions**
2. **FIFRA** ***(1972, Federal Insecticide, Fungicide, and Rodenticide Acts)*****:**
3. **OSHA** ***(1970, Occupational Safety and Health Act)*****: in workplace**
4. **CAA** ***(1970, The Clean Air Act)*****: quality of air resource**
5. **CWA** ***(1972, Clean Water Act)*****: restore and maintain water**
6. **RCRA** ***(1976, Resource Conservation and Recovery Act)*****: waste treatment, storage and disposal**
7. **CERCRA** ***(1980, Comprehensive Environmental Response, Compensation, and Liability Act) :*** **clean-up waste abandon sites**
8. **EPCRA** ***(1986, Emergency Planning and Community Right-to-Know Act)*****: responding to chemical emergencies and reporting of toxic chemical usage**
9. **PPA** ***(1990, Pollution Prevention Act)*****: reduce environmental impact**

Table 3.2-1 : *Summary Table of U.S. Environmental Laws*

Environmental Statute	Background	Key Provisions
Regulation of Chemical Manufacturing		
The Toxic Substances Control Act (TSCA) 1976	Highly toxic substances, such as polychlorinated biphenyls (PCBs), began appearing in the environment and in food supplies. This prompted the federal government to create a program to assess the risks of chemicals before they are introduced into commerce and to test existing chemical substances.	Chemical manufacturers, importers, or processors must submit a report detailing chemical and processing information for each chemical. Extensive testing by companies may be required for chemicals of concern. For newly created chemicals, a Premanufacturing Notice must be submitted.
The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) Enacted, 1947 Amended, 1972	Because all pesticides are toxic to some plants and animals, they may pose an unacceptable risk to human health and the environment. FIFRA is a federal statute whose purpose is to assess the risks of pesticides and to control their usage so that any exposure that may result poses an acceptable level of risk.	Before any pesticide can be distributed or sold in the US, it must be registered with the EPA. The registration data are difficult and expensive to develop and must prove that the chemical is effective and safe to humans and the environment. Labels must be placed on pesticide products that indicate approved uses and restrictions.
The Occupational Safety and Health Act (OSH Act) 1970	The agency that oversees the implementation of the OSH Act is the Occupational Safety and Health Administration (OSHA). All private facilities having more than 10 employees must comply with the OSH Act requirements.	Companies must adhere to all OSHA health standards (exposure limits to chemicals) and safety standards (physical hazards from equipment). The OSH Act's Hazard Communication Standard requires companies to develop hazard assessment data (material safety data sheets (MSDS)), label chemical substances, and inform and train employees in the safe use of chemicals.
Regulation of Discharges to the Air, Water, and Soil		
Clean Air Act (CAA) Enacted 1970, Amended 1990	The CAA is intended to control the discharge of air pollution by establishing uniform ambient air quality standards that are in some instances health-based and in others, technology-based. The CAA also addresses specific air pollution problems such as hazardous air pollutants, stratospheric ozone depletion, and acid rain.	The CAA established the National Ambient Air Quality Standards (NAAQS) for maximum concentrations in ambient air of CO, Pb, NO_2, O_3, particulate matter, and SO_2. States must develop source-specific emission limits to achieve the NAAQS. States issue air emission permits to facilities. Stricter requirements are often established for hazardous air pollutants (HAPs) and for new sources.

Table 3.2-1 *(continued)*

Clean Water Act (CWA) Enacted, 1972	The Clean Water Act (CWA) is the first comprehensive federal program designed to reduce pollutant discharges into the nation's waterways ("zero discharge" goal). Another goal of the CWA is to make water bodies safe for swimming, fishing, and other forms of recreation ("swimmable" goal). This act has resulted in significant improvements in the quality of the nation's waterways since its enactment.	The CWA established the National Pollutant Discharge Elimination System (NPDES) permit program that requires any point source of pollution to obtain a permit. Permits contain either effluent limits or require the installation of specific pollutant treatment. Permit holders must monitor discharges, collect data, and keep records of the pollutant levels of their effluents. Industrial sources that discharge into sewers must comply with EPA pretreatment standards by applying the best available control technology (BACT).
Resource Conservation and Recovery Act (RCRA) Enacted 1976	The Resource Conservation and Recovery Act was enacted to regulate the "cradle-to-grave" generation, transport, and disposal of both non-hazardous and hazardous wastes to land; encourage recycling; and promote the development of alternative energy sources based on solid waste materials.	Generators must maintain records of the quantity of hazardous waste generated and where the waste was sent for treatment, storage, or disposal, and file this data in biennial reports to the EPA. Transporters and disposal facilities must adhere to similar requirements for record keeping as well as for monitoring the environment.
Clean-Up, Emergency Planning, and Pollution Prevention		
The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) 1980	CERCLA began a process of identifying and remediating uncontrolled hazardous waste at abandoned sites, industrial complexes, and federal facilities. EPA is responsible for creating a list of sites ranked by level of risk, which is termed the National Priority List (NPL). CERCLA was amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986.	After a site is listed in the NPL, EPA identifies potentially responsible parties (PRPs) and notifies them of their potential CERCLA liability, which is strict, joint and several, and retroactive. PRPs are 1) present or 2) past owners of hazardous waste disposal facilities, 3) generators of hazardous waste, and 4) transporters of hazardous waste.
The Emergency Planning and Community Right to Know Act (EPCRA) 1986	Title III of SARA contains a separate piece of legislation called EPCRA. There are two main goals of EPCRA: 1) to have states create local emergency units that must develop plans to respond to chemical release emergencies, and 2) to require EPA to compile an inventory of toxic chemical releases to the air, water, and soil from manufacturing facilities.	Facilities must work with state and local entities to develop emergency response plans in case of an accidental release. Affected facilities must report annually to EPA data on the maximum amount of the toxic substance on-site in the previous year, the treatment and disposal methods used, and the amounts released to the environment or transferred off-site for treatment and/or disposal.
Pollution Prevention Act (PPA) 1990	The Pollution Prevention Act established pollution prevention as the nation's primary pollution management strategy with emphasis on source reduction and established a Pollution Prevention Information Clearinghouse whose goal is to compile source reduction information and make it available to the public.	The PPA requires owners and operators of facilities that are required to file a Form R under the SARA Title III to report to the EPA information regarding the source reduction and recycling efforts that the facility has undertaken during the previous year.

The 9 essential environmental regulations:
the manufacture of chemicals

Environmental Statute	Date Enacted	Purpose of Legislation	Key Provisions
Regulation of Chemical Manufacturing **The Toxic Substances Control Act (TSCA)**	1976	Assess the risks of chemicals before they are introduced into commerce.	Chemical manufacturers, importers, or processors, must test new chemicals and submit a Premanufacturing Notice.
The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)	Enacted, 1947 Amended, 1972	Assess the risks of pesticides and to control their usage to minimize exposure.	Before any pesticide can be distributed or sold in the U.S., it must be registered with the EPA.
The Occupational Safety and Health Act (OSH Act)	1970	Control exposure to chemicals in the workplace	Companies must adhere to all OSHA health standards (exposure limits to chemicals) and safety standards (physical hazards from equipment). Requires companies to develop material safety data sheet (MSDS).

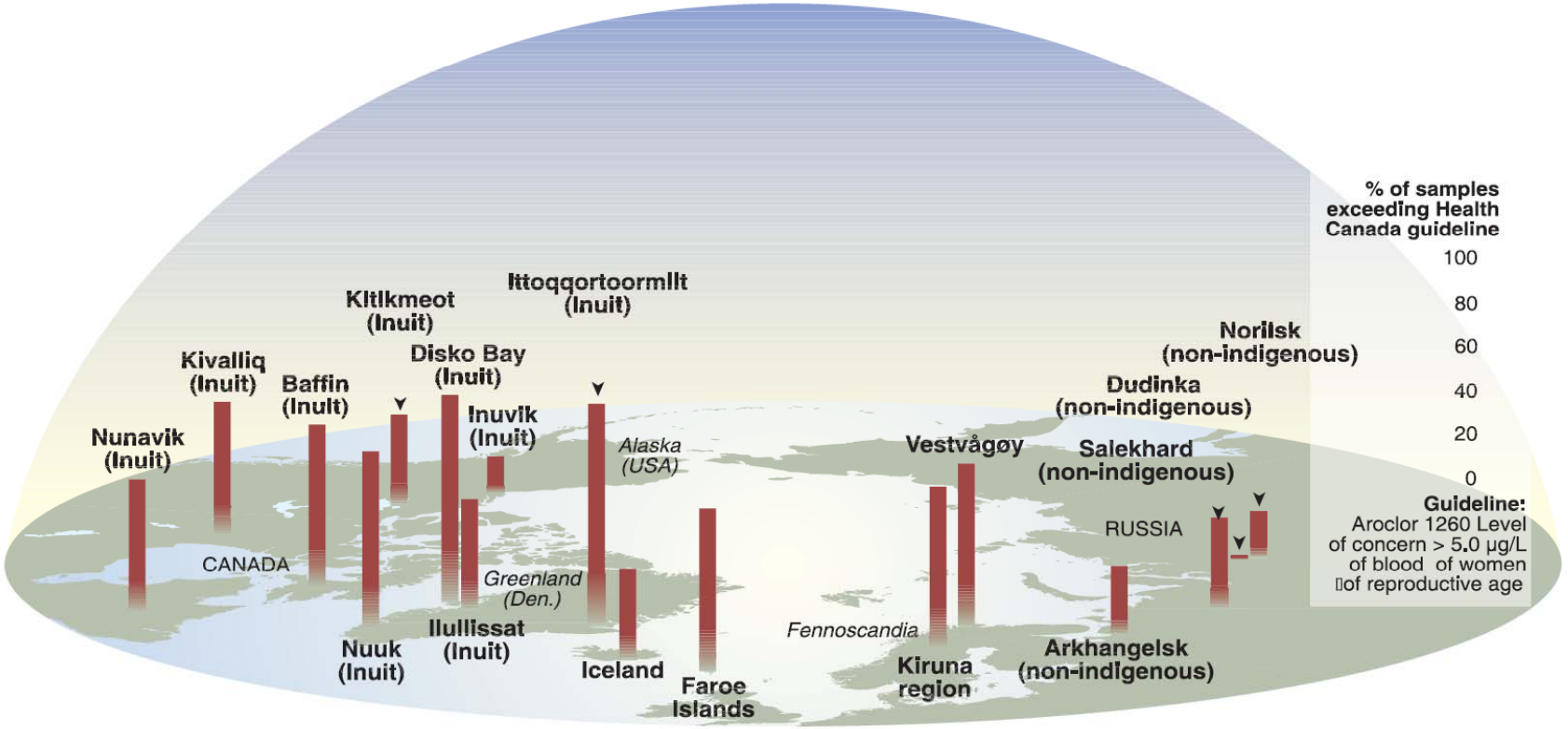
The 9 essential environmental regulations:
Discharges to air, water, and soil

Environmental Statute	Date Enacted	Purpose of Legislation	Key Provisions
Regulation of Discharges to the Air, Water, and Soil **Clean Air Act (CAA)**	1955/1970	Establish uniform ambient air quality standards / control air pollution discharge. Address specific air pollution problems (hazardous air pollutants, stratospheric ozone depletion, and acid rain).	**National Ambient Air Quality Standards (NAAQS) for CO, Pb, NO_2, O_3, particulate matter, and SO_2. States must develop source-specific emission limits to achieve the NAAQS.**
Clean Water Act (CWA)	1972	Reduce pollutant discharges into the nation's waterways ("zero discharge" goal). Make water bodies safe for swimming, fishing, and other forms of recreation ("swimmable" goal).	**National Pollutant Discharge Elimination System (NPDES) permit program. Permit holders must monitor discharges, collect data, and keep records of the pollutant levels of their effluents.**
Resource Conservation and Recovery Act (RCRA)	1976	**Regulate the "cradle-to-grave" generation, transport, and disposal of both non-hazardous and hazardous wastes to land, encourage recycling, and promote the development of alternative energy sources based on solid waste materials.**	**Generators must maintain records of hazardous waste generation and transportation, and file this data in biennial reports to the EPA. Transporters and disposal facilities must adhere to similar requirements for record keeping and monitoring the environment.**

The 9 essential environmental regulations:
clean-up, disclosure, and pollution prevention

Environmental Statute	Date Enacted	Purpose of Legislation	Key Provisions
Clean-Up, Emergency Panning, and Pollution Prevention **The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)**	1980	Identify and clean up hazardous waste sites at industrial complexes, and federal facilities. EPA is responsible for creating the National Priority List (NPL). Amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986.	**EPA identifies potentially responsible parties (PRPs) and notifies them of their potential CERCLA liability, which is strict, joint and several, and retroactive.**
The Emergency Planning and Community Right to Know Act (EPCRA – part of SARA)	1986	1) to respond to chemical release emergencies, and 2) compile an inventory of toxic chemical releases to the air, water, and soil from manufacturing facilities.	**Facilities must help state and local entities to develop emergency response plans, and report annually to EPA data on toxic substances .**
Pollution Prevention Act (PPA)	1990	Establish pollution prevention as the nation's primary pollution management strategy with emphasis on source reduction. Established a Pollution Prevention Information Clearinghouse.	**Owners and operators of facilities that are required to file a Form R under the SARA Title III to report to the EPA information regarding the source reduction and recycling efforts that the facility has undertaken during the previous year.**

PCBs in the blood of Arctic residents.



Source: Arctic monitoring and Assessment Programme (AMAP), 2003. AMAP Assessment 2002: Human Health in the Arctic.

Many POPs (persistent organic pollutants) and heavy metals from emissions further south are accumulated in Arctic food chains and ultimately in indigenous peoples. While fear of these compounds sometimes has resulted in abandonment of traditional foods, this has also led to more unhealthy food habits acquired from non-indigenous peoples. Most indigenous peoples in smaller communities still supply a large share of their household foods from natural resources.

Toxic Substances Control Act (TSCA)

Background: In the 1970s, it became clear that the manufacture and use of certain chemical products needed to be regulated; these included:

PCBs (polychlorinated biphenyls) heat transfer fluid in electrical transformers, capacitors, hydraulic equipment; accumulates in the food chain and causes skin disease and cancer

CFCs (chlorofluorocarbons) spray-can propellants and refrigerants; in the stratosphere solar radiation decomposes CFCs; resulting free chlorine destroys ozone

Lack of regulatory structure to control PCBs, CFCs, and other similar compounds

Toxic Substances Control Act (TSCA)

Coverage:

- Passed in *1976* by Congress,
- Deals with compounds used in commerce
- Empowers EPA to screen new and existing chemicals to assure that their production and use does not cause "*unreasonable risk*" to human health and the environment
- System to evaluate all new chemical substances entering the US market for effects on human health, other living organisms, and the environment.

Toxic Substances Control Act (TSCA)

Basic Elements

1. **Gather information on existing chemicals**
   Chemicals not on list of existing compounds are considered new and subject to Premanufacture Notice
2. **Testing of existing chemicals identified as possible risks**
   Based on use of high volumes, unreasonable risk to health or environment
   Could be required for an existing chemical with new uses
3. **Screen new chemicals for risk**
   Balance between economic and social benefits against purported risks
   EPA has 90 days to review; EPA can require additional testing
4. **Control chemicals proven to pose a risk**
   Limit production or use; ban use
   Warning labels at point of sale

Toxic Substances Control Act (TSCA)

Basic Elements

About *55,000* **chemicals in use**

About *2,000* **new chemicals each year**

To support TSCA, the Chemical Engineering Branch of the Office of Pollution Prevention and Toxics at EPA has developed a set of screening tools that we will use in this course (see Chapter 5)

Clean Air Act (CAA)

Background:

Air Pollution Act of 1955 amended eight times;

1970, 1977 and 1990 Clean Air Act Amendments most important

1. EPA may act to prevent harm
2. Health protection extends to both healthy and susceptible people
3. Standards based on public health and welfare

Coverage

National ambient air quality standards (NAAQS)

National emission limits and standards

Many elements delegated to states

States may set tighter standards

Clean Air Act (CAA)

Basic Elements

A. National ambient air quality standards (NAAQS) for criteria pollutants

1. Announce that a substance is to be listed as a criteria pollutant
2. Issue air quality criteria document, which forms the basis for setting the standard
3. Issue proposed NAAQS for the substance
4. Periodic review
5. States must perform monitoring to evaluate air quality compared to NAAQS. Areas not complying are identified as nonattainment areas
6. States must submit to EPA a state implementation plan that documents procedures to attain and maintain the NAAQS

Clean Air Act (CAA)

Basic Elements

B. Hazardous air pollutants (HAP)

1. EPA can set national emission standards for specific air pollutants (**NESHAPS**) that are hazardous to health
2. These national emission standards for hazardous air pollutants standards (NESHAPS) are technology based.
3. Maximum achievable degree of control (**MACT**) standards are source specific
4. Before 1990 there were about *10 HAPs*
5. 1990 amendments listed *189 HAPs*

Clean Air Act (CAA)

Basic Elements

C. New source review

1. New source performance standards (**NSPS**) National NSPS set by EPA; each standard specific for a given industry based on emissions, control technologies available, and cost of controls; permit review delegated to states with EPA oversight
2. Prevention of Significant Deterioration (PSD) Sets limit on source growth for criteria pollutants; new sources above a trigger level have to show compliance with NAAQS; new sources must meet best available control technology (BACT); Permit review delegated to states with EPA oversight
3. Nonattainment areas: New sources must off set new emissions
   New sources must meet lowest achievable emission rates (LAER)
   Permit review delegated to states with EPA oversight

Clean Air Act (CAA)

Basic Elements

D. Transportation

1. EPA sets national standards for mobile sources
2. Transportation projects must conform to pollution levels defined in the State Implementation Plan

CERCLA

Comprehensive Environmental Response, Compensation and Liability Act

Background Triggered by Love Canal; passed in 1980; established superfund for site cleanup

Coverage

System for identifying and cleaning up chemical and hazardous substances released to any part of the environment. Collects in one place all provisions for responding to releases of hazardous substances into the environment. Authority to collect the cost of cleaning up a release from responsible Parties; established $1.6 billion fund to pay for clean up where no responsible party can be found.

$1.6 billion~1.6조원

CERCLA

Comprehensive Environmental Response, Compensation and Liability Act

Basic Elements

A. EPA identifies sites

1. In 1994 1,232 facilities on superfund list

B. EPA identifies potentially responsible parties (PRP)

1. PRPs responsible for paying their share of clean up
2. PRP are present owners of hazardous waste disposal facilities, past owners of hazardous waste disposal facilities, generators of hazardous waste who arrange for treatment or disposal at any facility, transporters of hazardous waste to any disposal facility

C. Liability for PRPs is strict, joint, several

EPCRA

Emergency Planning and Community Right to Know Act

Background: **Triggered by Bhopal release; passed in 1986; part of SARA Title III**

Coverage

States create local emergency units to develop plans to respond to chemical release emergencies. EPA to compile an inventory of toxic chemical releases from manufacturing facilities

Triggered: 자극이 되어

EPCRA

Emergency Planning and Community Right to Know Act

Basic Elements

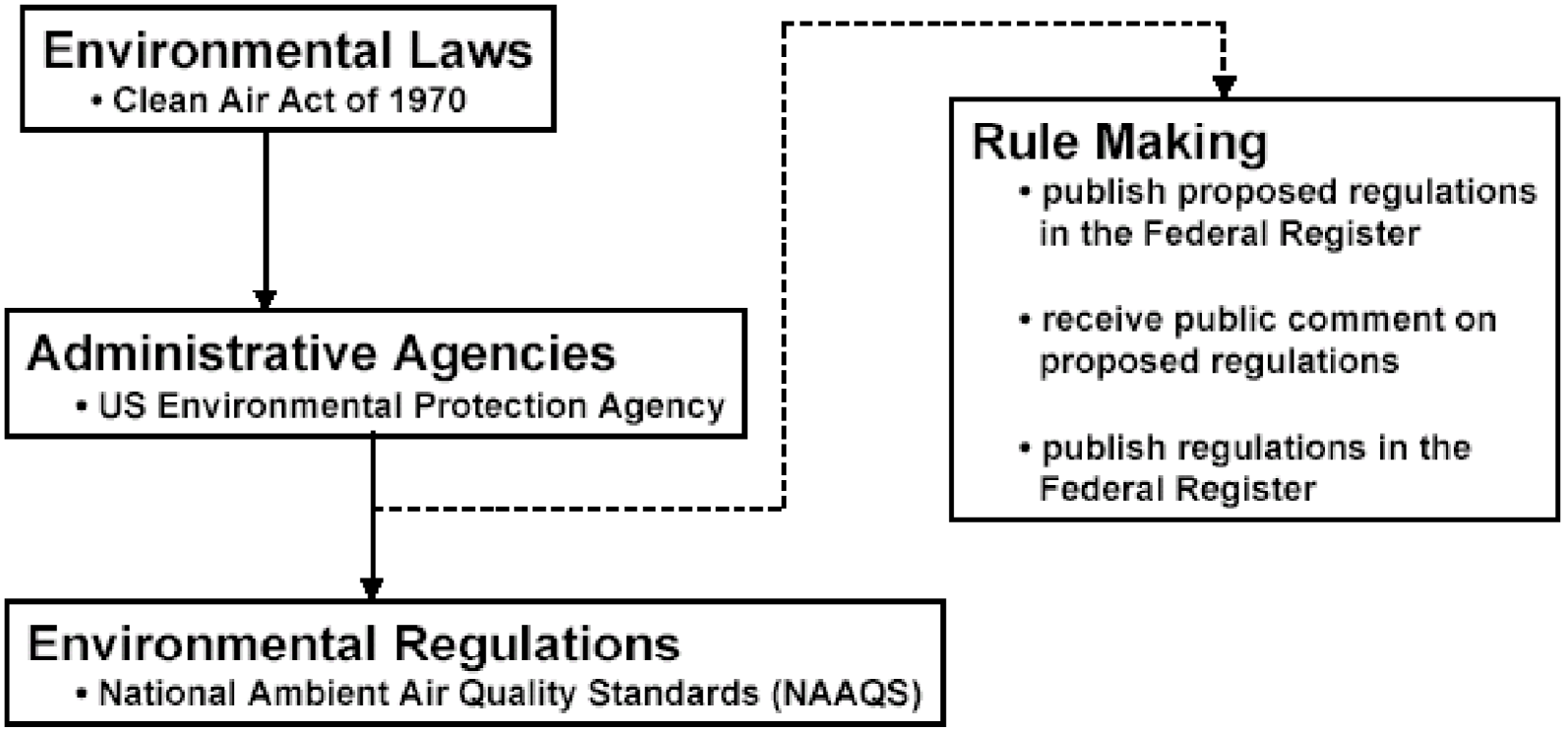
A. Toxic Release Inventory (TRI)

1. Annual report to EPA
2. Facilities with more than *10* employees, use more than *10,000* pounds/year of listed chemicals or categories of chemicals, or manufacture more than *25,000* pounds/year of listed chemicals or categories of chemicals. More than 600 chemicals covered
3. Data in TRI: For each toxic substance, maximum amount on site treatment and disposal methods used, amounts released to environment or transferred off site for treatment or disposal. Includes routine and accidental releases

Structure of environmental law:

the role of legislatures, administrative agencies and the courts

Understanding how environmental laws and regulations are enacted, promulgated, and structured will allow chemical engineers to have a role in crafting more effective laws and regulations in the future.



Structure of environmental law:

the role of legislatures, administrative agencies and the courts

Example for the Clean Air Act, criteria pollutants

Legislative bodies – Federal level - Congress enacts laws (CAAA, 1990); states can enact stricter laws

Federal Administrative Agencies *EPA sets National Ambient Air Quality Standards (concentration based); delegates most implementation to states*

State Administrative Agencies (e.g., Texas Commission on Environmental Quality) can either set regulations or further delegate to local areas

Courts adjudicate disputes, review administrative activities (standards and rules adopted)

Evolution of Regulatory & Voluntary Programs:
from End-to-Pipe to Pollution Prevention

- Despite individual Act has been extremely effective, volumes and hazards of toxic chemicals release to environment continue to grow *(1970s~1980s)*
- Began to decrease absolute amounts of toxic release to environment in many categories *(mid-1980s~)*
- amount of energy used/$ of GNP has been decreased *(last 10 yrs)*
- concentration of pollutants in environment are going down *(VOCs, CO, ozone, lead, etc.)*

Moving Pollutants

- ***air, water, and moving of pollutants*** can be reduced when pollutants are destroyed or transformed into less harmful forms in any media of environment

Complementary Strategy

- to reduce amounts and the hazardous characteristics of wastes released into all media of the environment

Pollution Prevention Concepts and Terminology

Waste Management Hierarchy established in Pollution Prevention Act of 1990 (U.S.C.§§13101-13109):

- ‘pollution should be prevented or reduced at the source whenever possible’
- ‘pollution that cannot be prevented should be recycled in safe manner’
- ‘pollution that cannot be prevented or recycled should be treated in safe manner’
- ‘disposal or other release into environment be employed only as a last resort’

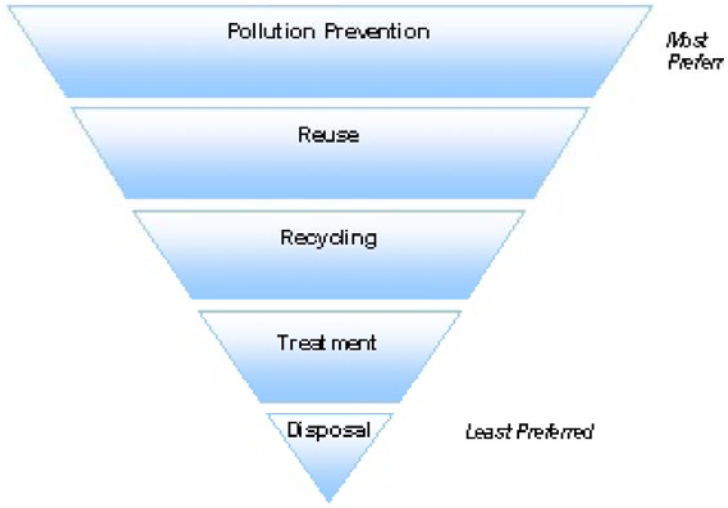
Hierarchy: (분류)체계
only as a last resort : 오직 최후의 수단으로서

Waste Management Hierarchy

폐기물처리체계

Based on definition and distinctions between recycle options, we can place the waste management hierarchy in the following descending order, from most to the least preferable.

http://www.epa.gov/ttnmain1/fera/data/risk/vol_1/chapter_28.pdf



1. Source reduction
2. In-process recycle
3. On-site recycle
4. Off-site recycle
5. Waste treatment
6. Secure disposal
7. Direct release to the environment

Original Process

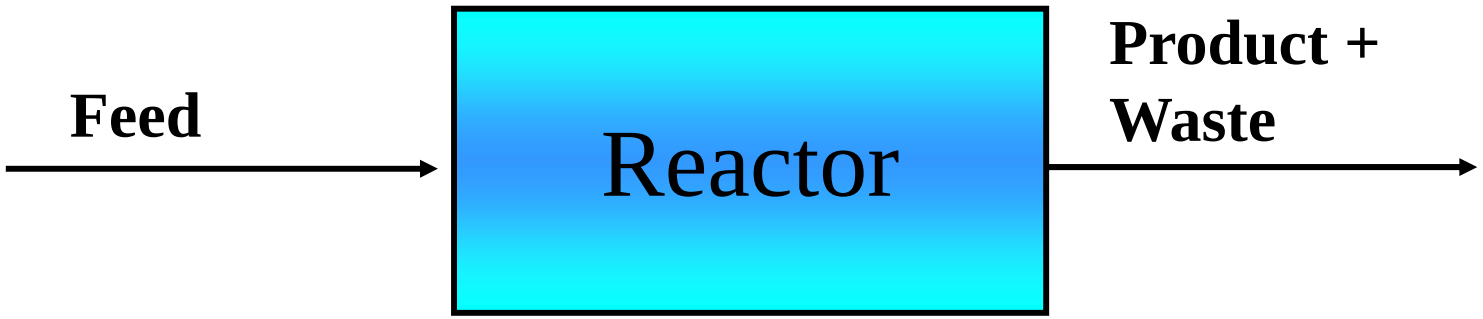


Fig 3.4-1 *: Waste management modifications for a simple reactor/separator process Classified according to the waste management hierarchy*

1. Source Reduction

The reactor is modified so that less waste is generated or so that waste is less hazardous.

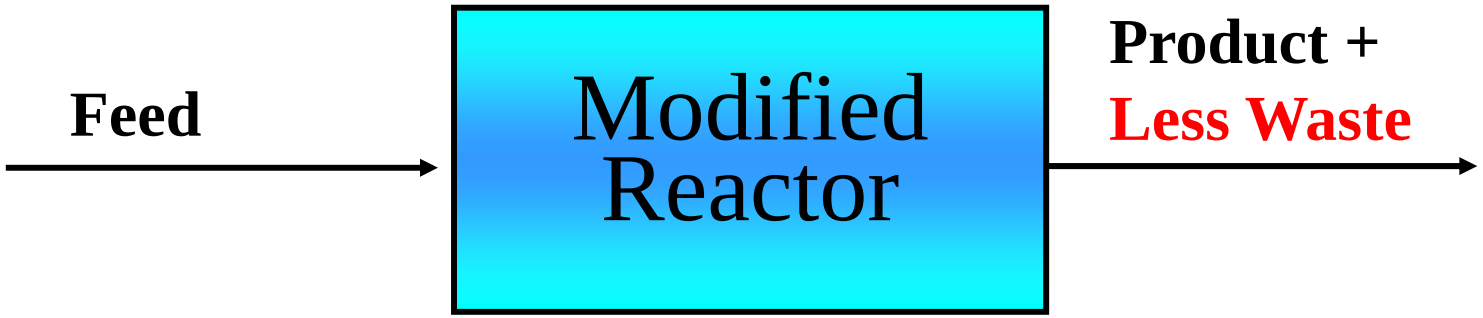


Fig 3.4-1 *: Waste management modifications for a simple reactor/separator process Classified according to the waste management hierarchy*

2. In-Process Recycle

unreacted feed is separated and

recycle back to the reactor

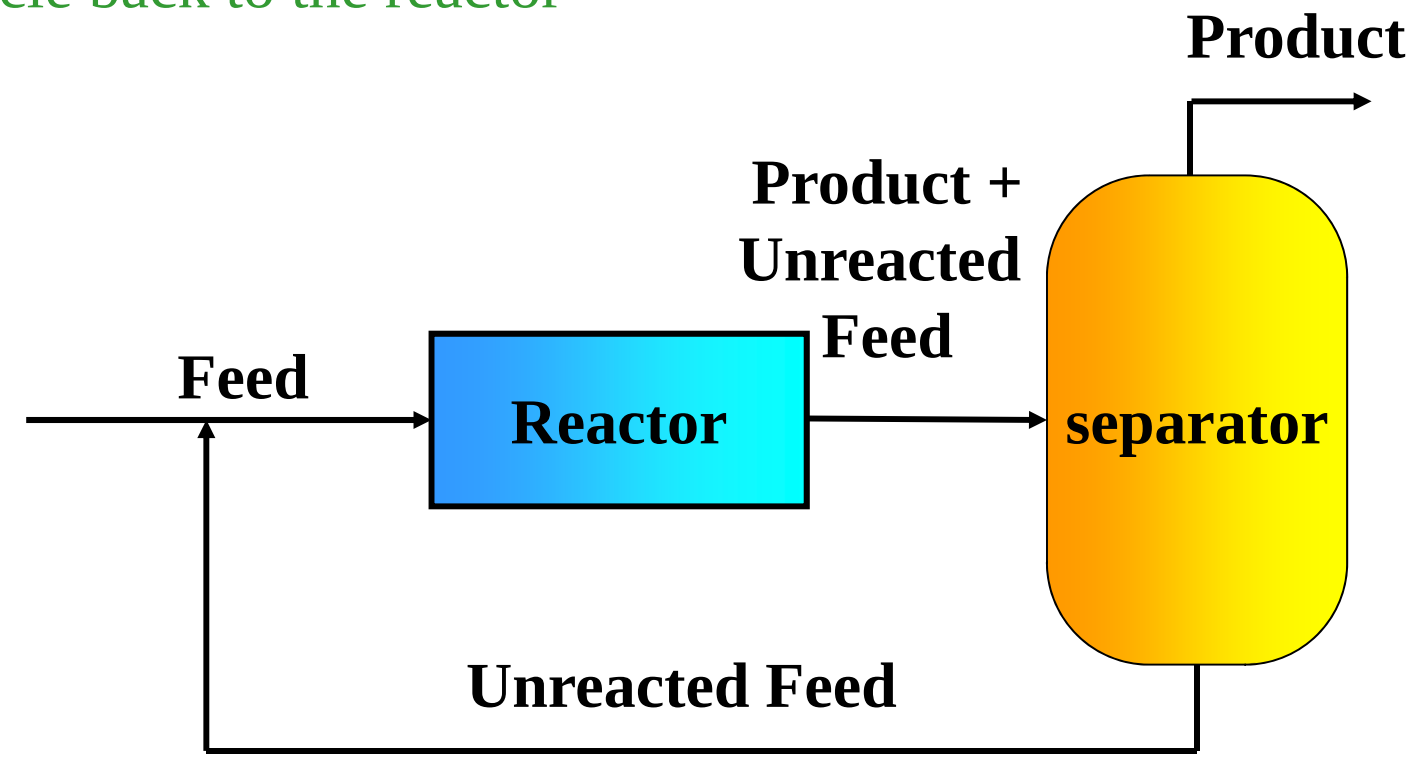


Fig 3.4-1 *: Waste management modifications for a simple reactor/separator process Classified according to the waste management hierarchy*

3. On-Site Recycle

waste from the reactor is converted to a commercial product by a second reactor within the facility

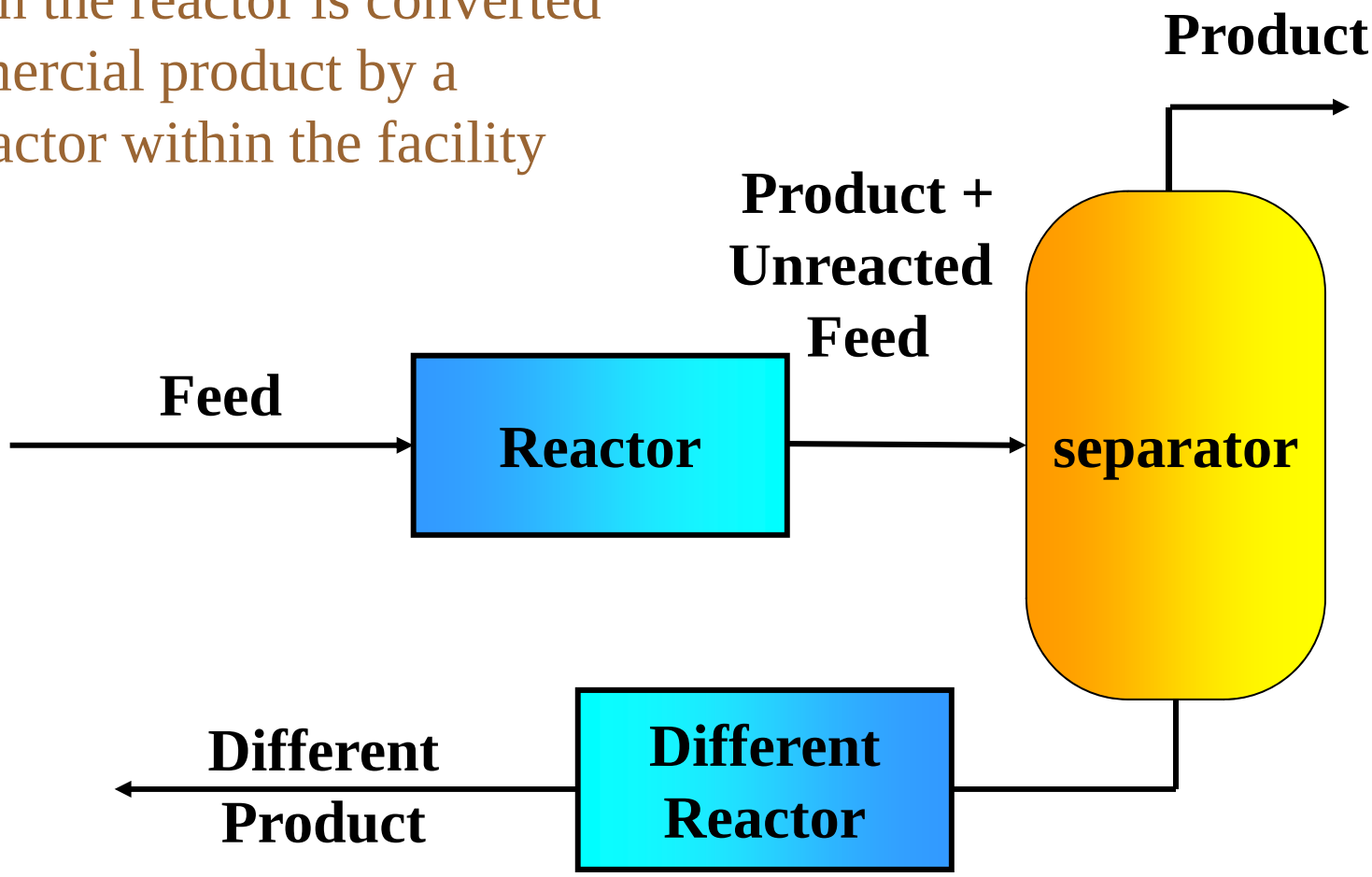


Fig 3.4-1 *: Waste management modifications for a simple reactor/separator process Classified according to the waste management hierarchy*

4. Off-Site Recycle

waste from reactor is separated and transferred off-site where it is converted to a commercial product within another facility

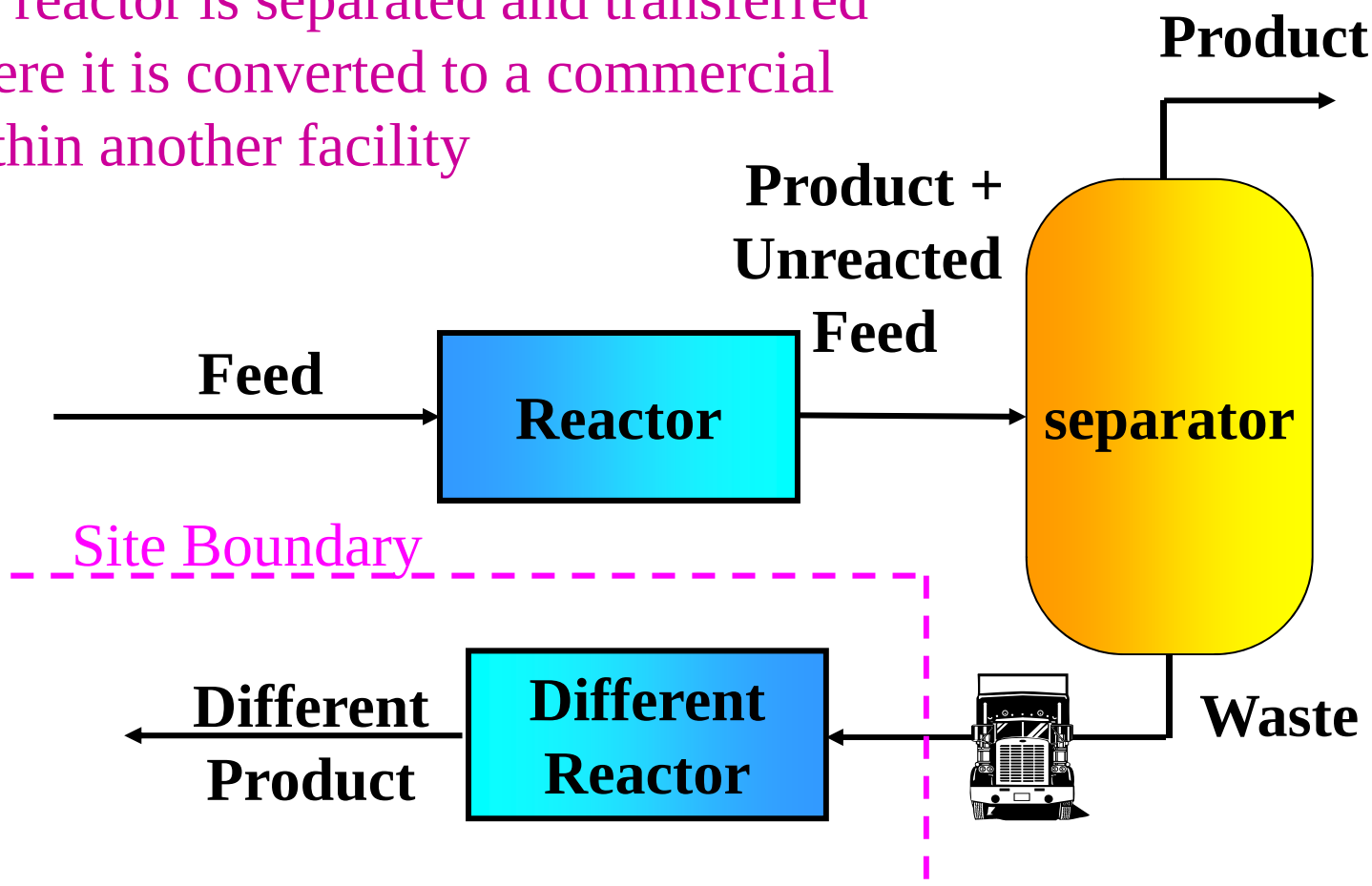


Fig 3.4-1 *: Waste management modifications for a simple reactor/separator process Classified according to the waste management hierarchy*

5. Waste Treatment

waste from reactor is separated and

treated to render it less hazardous

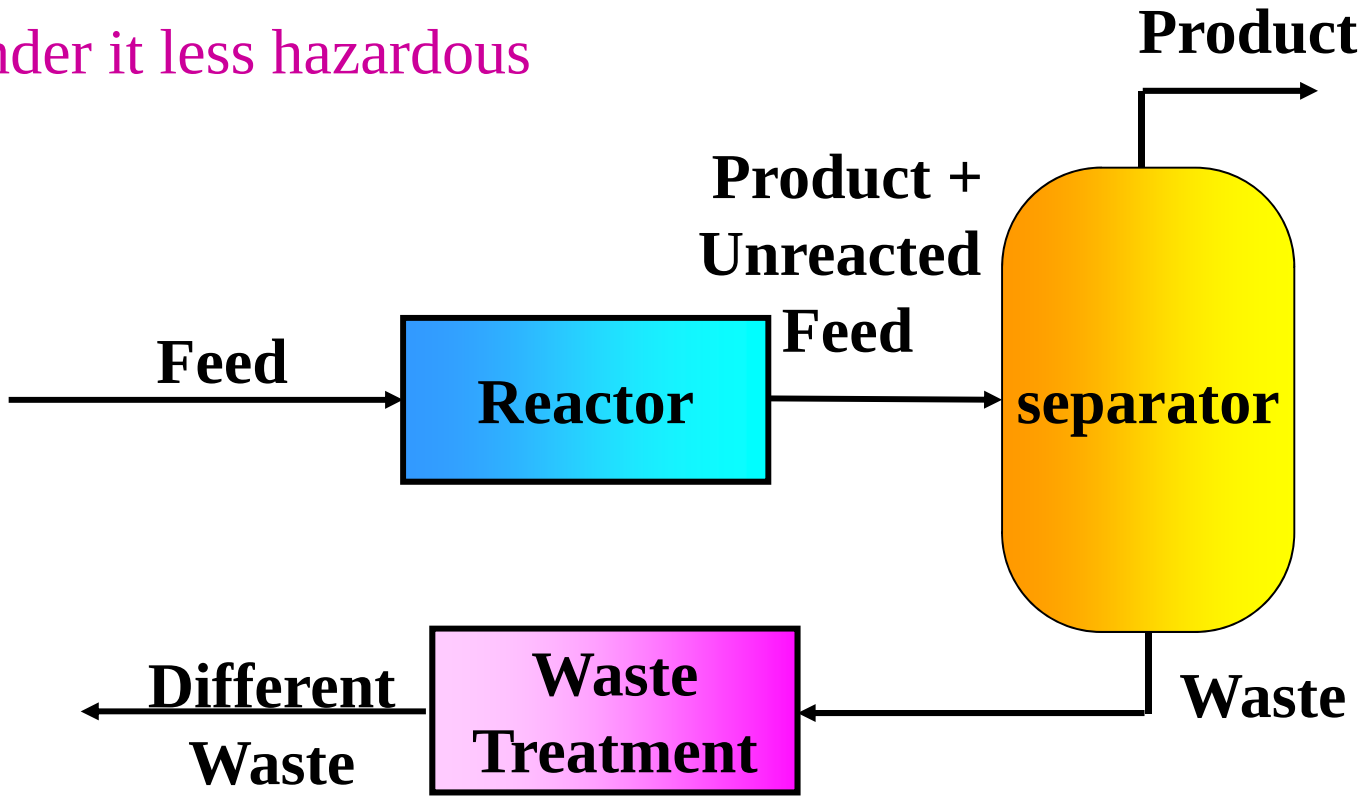


Fig 3.4-1 *: Waste management modifications for a simple reactor/separator process Classified according to the waste management hierarchy*

6. Secure Disposal

waste from reactor is separated and sent to a secure disposal facility, landfill

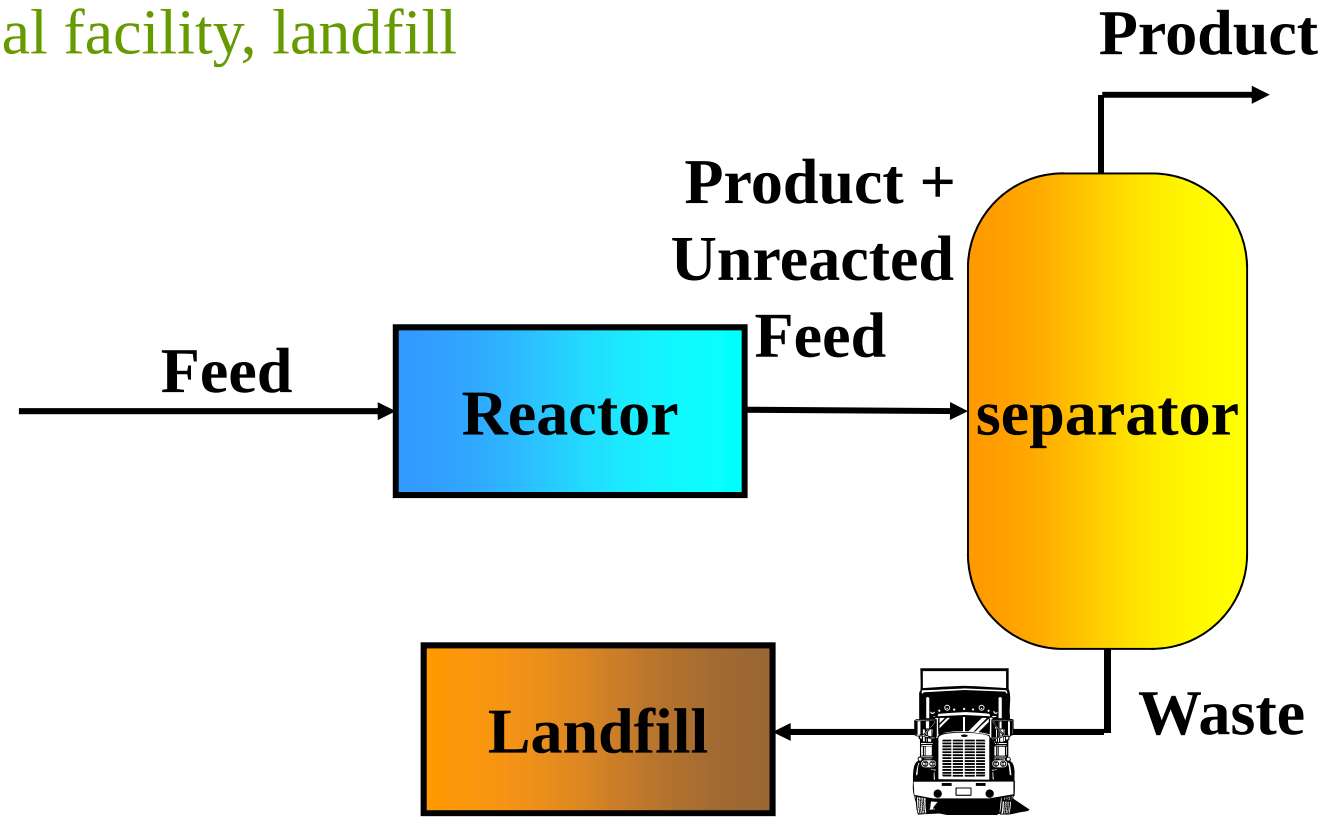


Fig 3.4-1 *: Waste management modifications for a simple reactor/separator process Classified according to the waste management hierarchy*

7. Direct Release

waste is separated from product and released to the environment

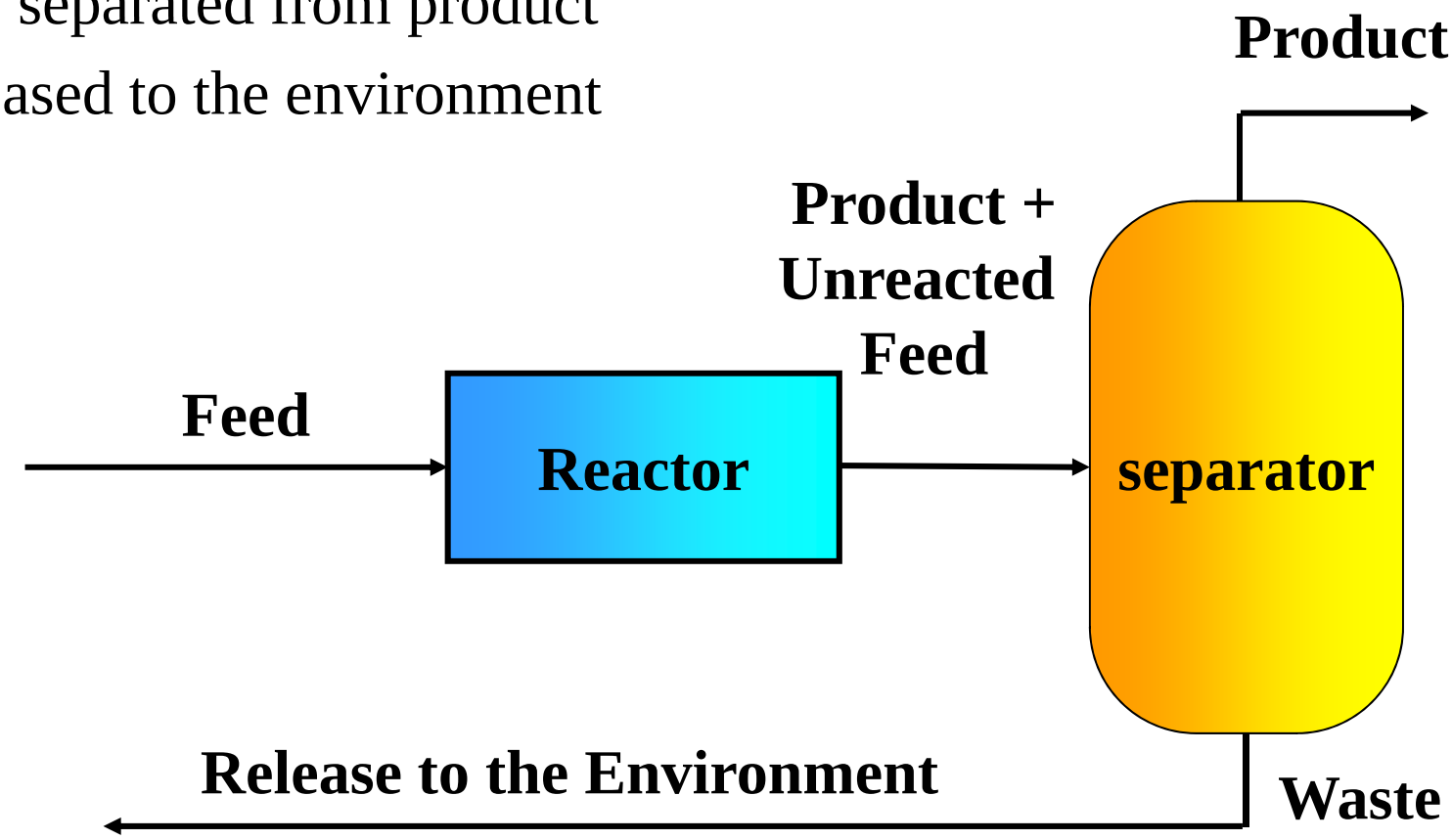


Fig 3.4-1 *: Waste management modifications for a simple reactor/separator process Classified according to the waste management hierarchy*

Waste Management Hierarchy

1. Source reduction	The reactor is modified so that less waste is generated or so that waste is less hazardous
2. In-process recycle	unreacted feed is separated and recycle back to the reactor
3. On-site recycle	waste from the reactor is converted to a commercial product by a second reactor within the facility
4. Off-site recycle	waste from reactor is separated and transferred off-site where it is converted to a commercial product within another facility

Waste Management Hierarchy

5. Waste treatment	waste from reactor is separated and treated to render it less hazardous
6. Secure disposal	waste from reactor is separated and sent to a secure disposal facility, landfill
7. Direct release to the environment	waste is separated from product and released to the environment

Source Reduction

(definition by federal Pollution Prevention Act, 1990)

A. The term ‘source reduction’ means any practice that,

1. ***Reduce the amount of any hazardous substance, pollutant, or contaminant entering any waste stream or otherwise released into the environment prior to recycling, treatment, or disposal***

2. ***Reduces the hazards to public health and the environment associated with the release of such pollutants, or contaminants***

The term includes equipment or technology modifications, process or procedure modifications, reformation or redesign of products, substitution of raw materials, and improvements in house keeping, maintenance, training, or inventory control

Inventory Control

재고품관리

▶ Inventory control aims to reduce waste generation resulting from "out-of-date" or "off-spec" raw materials or final products.

▶ Effective techniques for inventory control might include ordering only the amount of raw material needed for one production run or reviewing purchasing procedures to eliminate hazardous chemicals and substitute environmentally-friendly alternatives.

▶ Other techniques for inventory control might be more challenging, such as adopting just-in-time manufacturing techniques.

▶ Modifying production procedures can lead to waste reduction and increased profits.

DuPont/EPA pollution prevention study

US EPA, "DuPont Chambers Works Waste Minimization Project," United States Environmental Protection Agency, Office of Research and Development, EPA/600/R-93/203, pg. 86-91, November 1993.

▶ A cleaning solvent waste from a specialty chemical multiple batch process could be completely eliminated

▶ A source reduction project installed drains at low points in the process to recover chemicals from the prior campaign, yielding a Net Present Value of $2,212,000.

Source Reduction

B. The term ‘source reduction’ does not include

any practice which alters the physical, chemical or biological characteristics or the volume of a hazardous pollutant, or contaminant through a process or activity which itself is not integral to and necessary for the production of a product or the providing of a service.

Source Reduction

PPA(1990) Clarification of 'Source Reduction' or 'not'

Pollution prevention means '*source reduction*' as defined under PPA, and other practices that reduce or eliminate the creation of pollutants through

- *Increased efficiency in the use of raw materials, energy, water, or other resources*, or,
- *Protection of natural resources by conservation*

Source Reduction

Recycling activities are included within Pollution Prevention Activities.

1. *Drawing an absolute line between prevention and recycling can be difficult. "Prevention" includes what is commonly called **"in-process-recycling"**, but not **"out-of-process recycling"**.*
2. *Recycling conducted in an environmentally sound manner shares many of the advantages of prevention, such as energy and resource conservation, and reducing the need for end-of-pipe treatment or waste contaminant, ... ,*
3. *Some practices commonly described as "**in-process-recycling**" may qualify as pollution prevention*

In-Process, On-Site Recycling, or Waste Treatment ?

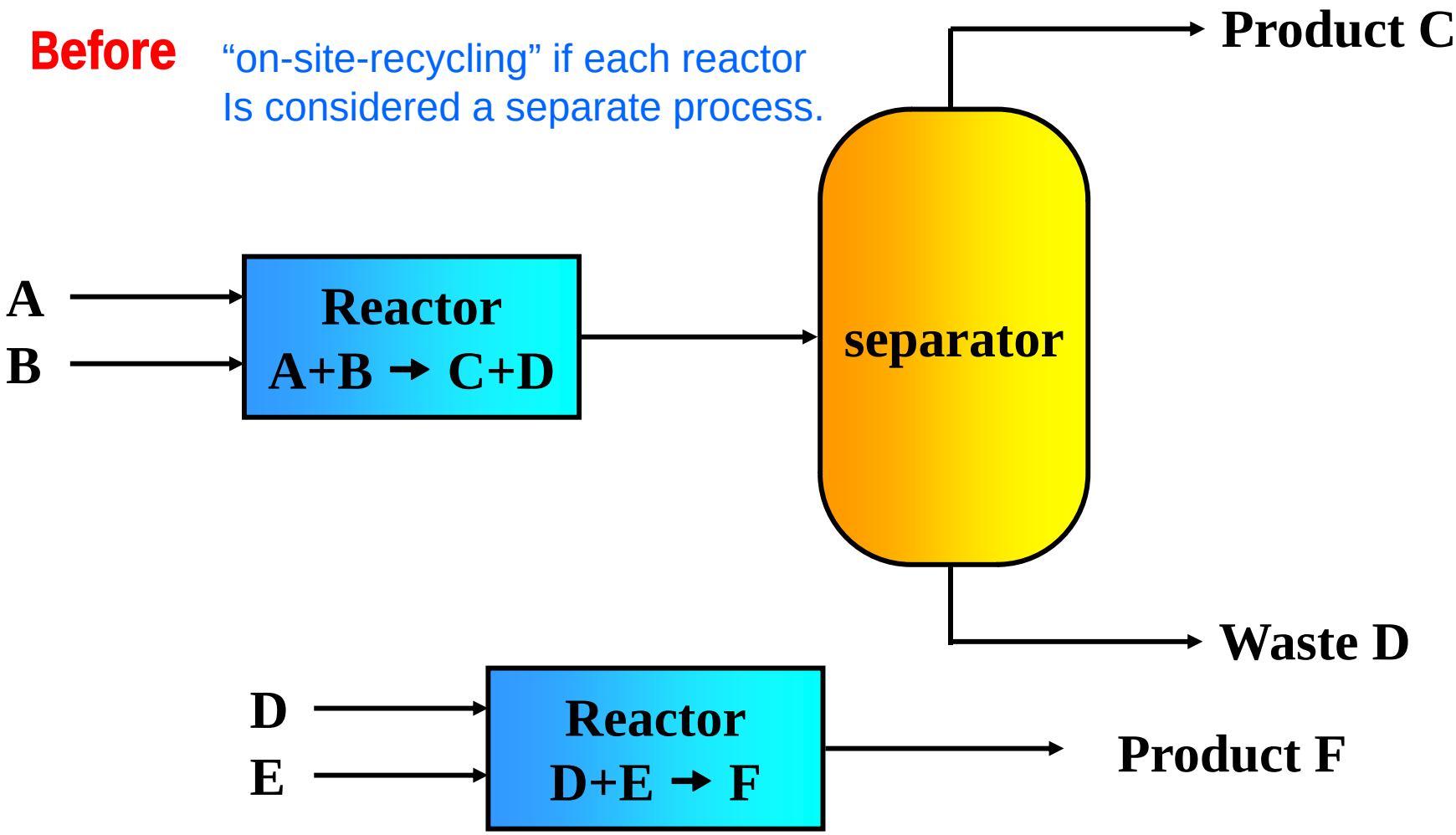


Fig 3.4-2 : *A process modification involving two reactors that are part of the same Industrial facility. It is in-process recycling or on-site recycling ?*

In-Process, On-Site Recycling, or Waste Treatment ?

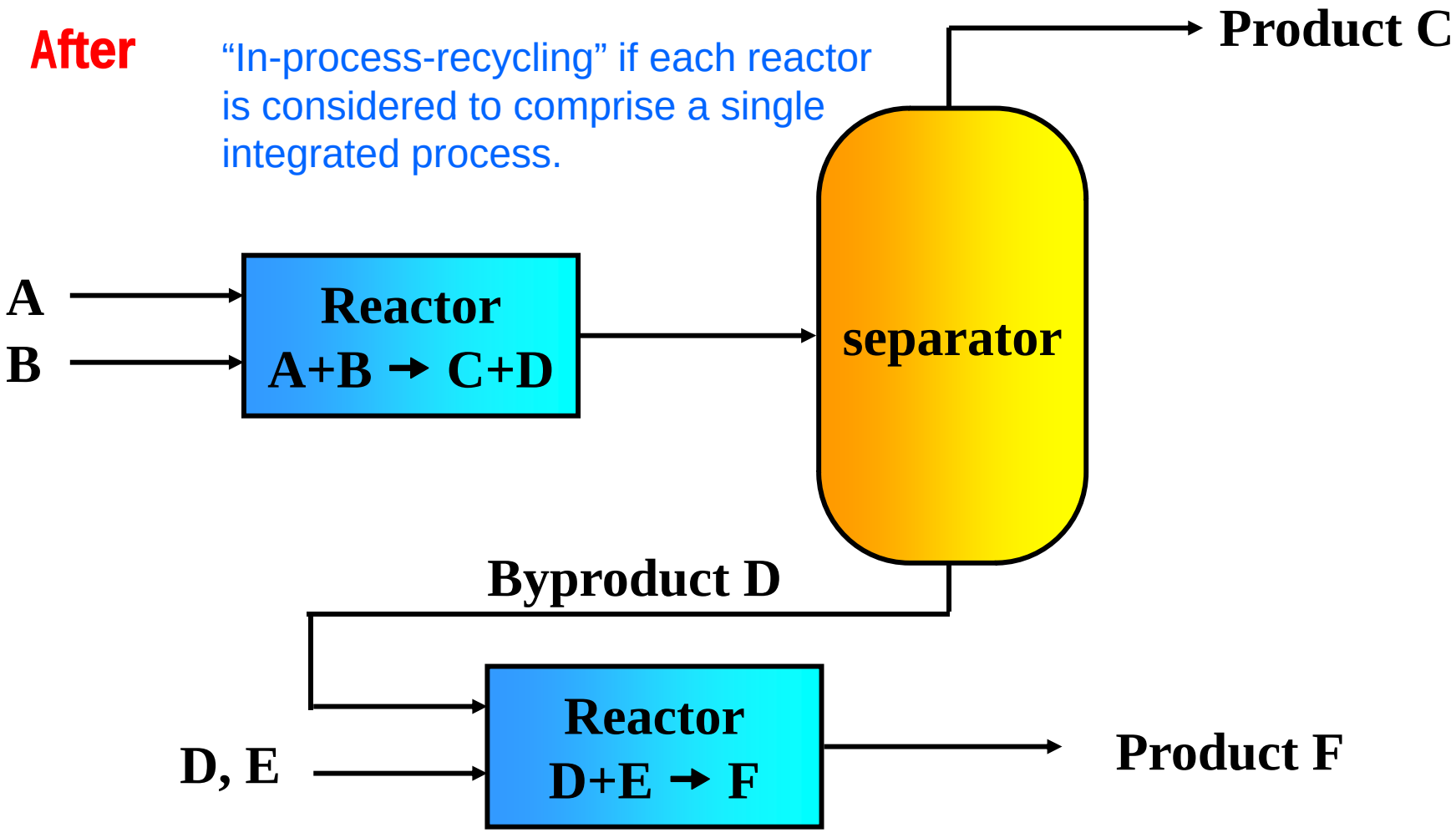


Fig 3.4-2 : *A process modification involving two reactors that are part of the same Industrial facility. It is in-process recycling or on-site recycling ?*

Is it waste treatment or recycling ?

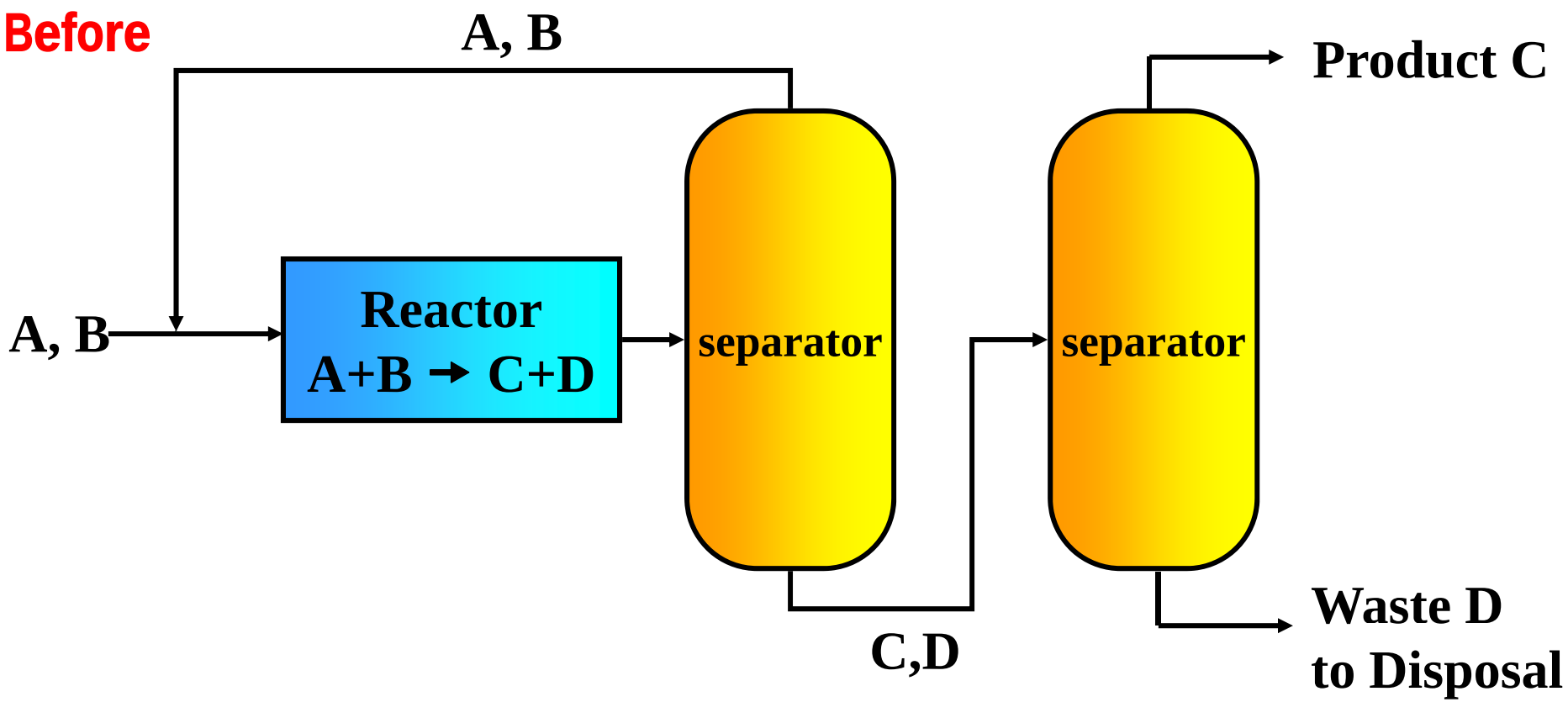


Fig 3.4-3 *: A process modification. Is it waste treatment or recycling ?*

Is it waste treatment or recycling ?

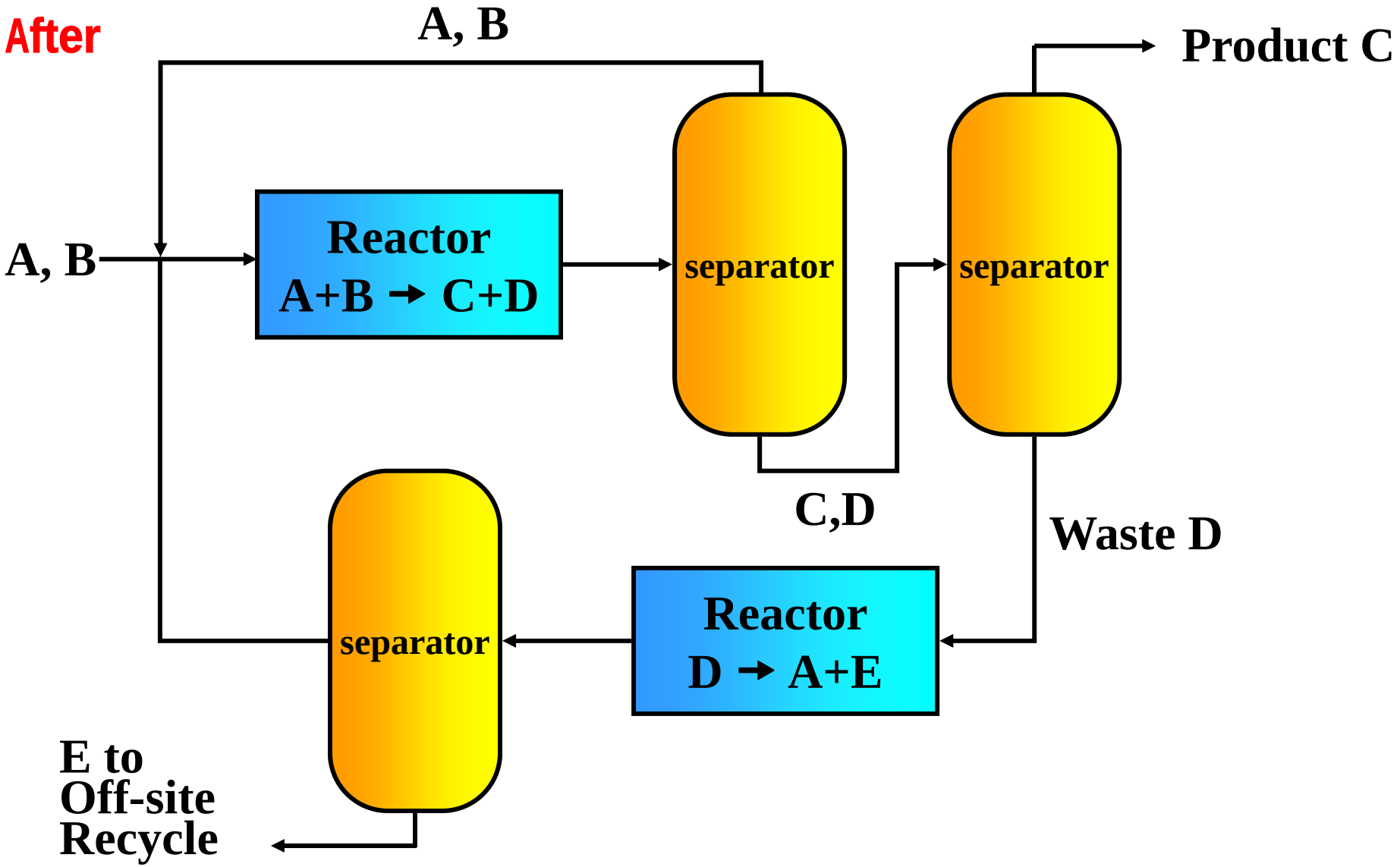


Fig 3.4-3 : *A process modification. Is it waste treatment or recycling ?*

Homework #3

Problem

1. Provide definitions for the following terms

   a) pollution prevention

   b) source reduction

   c) in-process versus on-site versus off-site recycling

   d) waste treatment

   e) disposal

   f) direct release