IBM's ECOL - Environmental Management

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ABSTRACT

IBM's Environmental Control of the Line (ECOL) management system is used to track the air, water and waste emissions for all of the manufacturing tools used at the East Fishkill facility. Recent additions to the ECOL system have added the ability for Title V real-time continuous compliance with State and Federal air quality regulations.

IBM Inc. has enhanced the Windows-based ECOL system to meet the ongoing TitleV compliance and certification process. In order to achieve this requirement, additions were made to the ECOL system to track and report Title V air quality data. The Title V air quality additions to ECOL are as follows:

- Incorporate the various Title V air calculation methodologies as modules in ECOL

- Provide printouts documenting the step by step calculation methodology of air emissions

- Incorporation of Stack Test information for actual emissions for tools from a stack

- Prepare and print the Title V certification documents

- Prepare and print the Title V air emission reports

- Add graphical mass balance reports for tools, systems or buildings

Data from the ECOL environmental system is also shared with other manufacturing and corporate data management systems to provide IBM with a complete business system.

INTRODUCTION

The IBM Plant, located in East Fishkill New York, manufactures semiconductor devices (chips) and substrate packaging. The substrate packaging is used to mount the "chips" for installation into the computers. The semiconductor and substrate packaging manufacturing processes consists of hundreds of chemical steps. In order to manage environmental issues related to the manufacturing of semiconductor and substrate packaging, IBM created the Environmental Control of the Line System (ECOL).

The ECOL management system is a Windows-based system used to track and report material/chemical usage at a production tool and the emissions to air, water and solid waste. The ECOL system has evolved at IBM East Fishkill from a mainframe program in use from the 1970's to its current version as a Windows-based Title V continuous compliance tool. Recent enhancements to ECOL have added the Title V compliance capability to reflect IBM's final Title V permit 11/2001. In addition to maintaining Title V reporting and compliance, ECOL interacts with other existing IBM systems to provide an overall mass balance of materials entering and leaving the site.

The other systems that ECOL interacts with are:

IBM Chemical Authorization System to track chemical usage limits at each building/tool

Chemical receiving and distribution with the plant

Chemical/Waste storage from the on-site tanks

Waste tracking system of material manifested off-site

Essentially ECOL is a cradle to grave tracking system with the following capabilities:

- pull in information about chemicals delivered to a tool,
- check the authorization for chemical usage limits,
- track chemical usage amounts,
- determine the emission fates of the chemicals used at a tool

The ECOL system is also able to produce a graphical mass balance from the tool level, building level or site-wide for a chemical.

This ability to provide checks and balances on chemical usage and disposal insures site-wide compliance with all applicable regulations and is used to quickly spot any potential environmental or regulatory problem.

ECOL SYSTEM

The ECOL system is a Windows-based program written in Microsoft's Visual Basic. The modules in the system consist of data entry for tool information, reports and support databases. The Support Tables contain information that is used throughout the system in drop-lists for the following:

- Exhaust Fans
- Chemicals
- Buildings

- Controls
- Disposal Codes
- Fan Types
- Supply Codes

An example of the Support Tables for Exhaust Fans are shown in Figures 1-2. The exhaust fans table includes information on fan type, manufacturer, location and physical parameters.

Figure 1. Support Table – Exhaust Fans

Figure 2. Support Table – Exhaust Fan Table specifications.

Each tool used at the facility is given a specific number (Brass Tag Number). Note that the term tool is used to describe all equipment on-site. This can be a production tool, boiler, chemical hood, etc. ECOL contains records for all tools on-site and tracks if they are in-service or if the record is for a new tool that is pending and not yet in operation. Figure 3 shows the specific information stored for each tool.
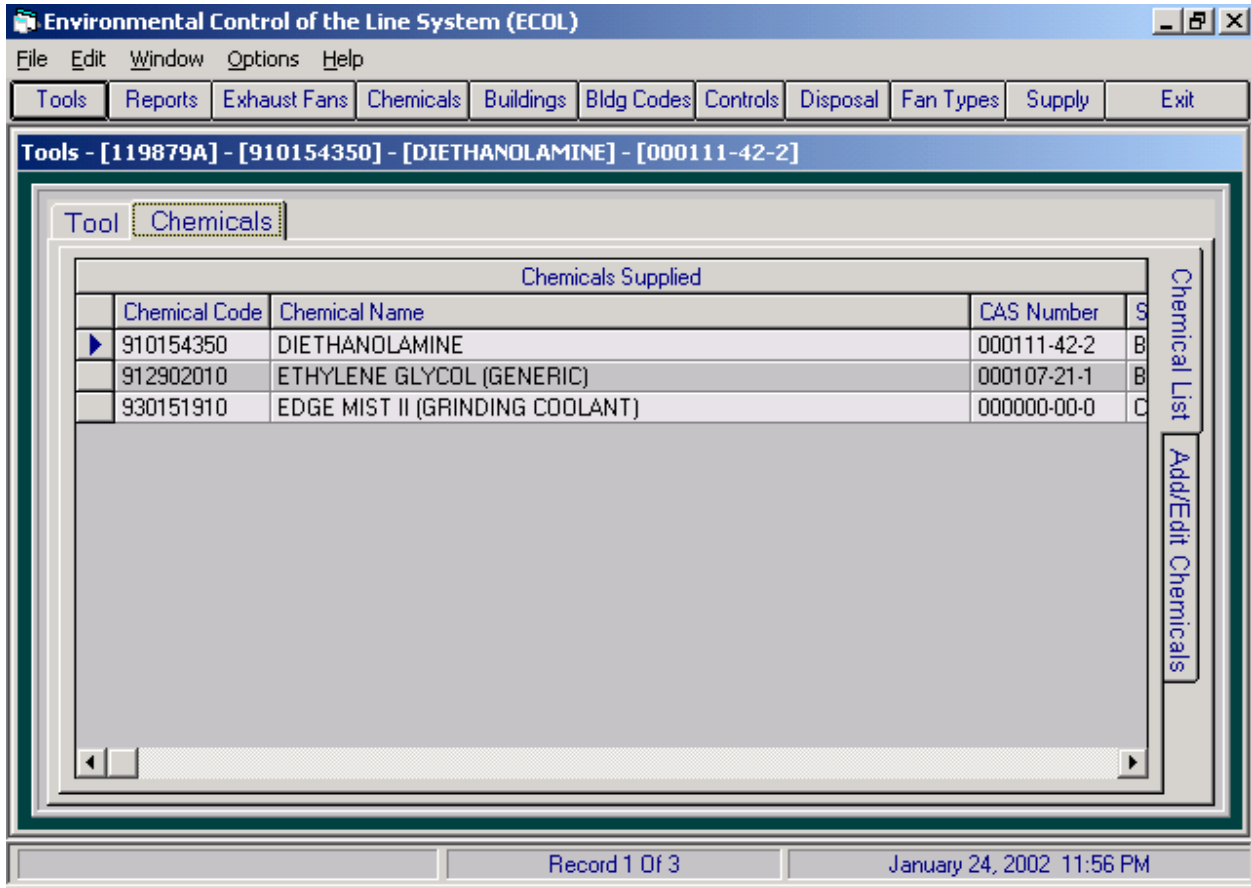
Figure 3. Tool input screen

The main screen provides location information about a tool as well as any exhaust fans associated with the tool. The Chemical flipcard contains information on the chemicals used by the tool (Figure 4). Each chemical used is identified by a specific IBM chemical code and the common chemical name.

Figure 4.   Chemicals used at a tool.

The Add/Edit Chemicals flipcard on the right side of the screen gives the amount of each chemical used at a tool as well as the disposal fate of this chemical (Figure 5). This screen gives information on the amount of chemical supplied to the tool as well as the method of arrival to the tool – Supply System. The grid at the bottom of the screen details the pathway and amount of chemical that is disposed. This chemical can become part of a product, be disposed down a drain, become solid waste or be emitted as an air emission.

Figure 5. Chemical usage and disposal for a tool.

If the disposal code indicates an air emission from the tool, the emission rate may have been calculated using various methodologies built into ECOL to achieve the final emission rate.

Air Emissions for semiconductor, substrate packaging manufacturing and supporting activities are estimated using a variety of methods. The methods selected include the following:

Materials Balance is typically employed for tools using gases to perform processes like chemical vapor deposition and etching. For these processes the stoichiometry is known and defines the output chemicals. Any input chemicals used in excess of the "limiting factor", will be discharged with the reactants. Therefore, by "programming" the recipe and the designed flow rates for each tool, the ECOL system calculates the emission.

Wet tools operation include three types of installations: chemical baths, spray cleaning and application of organic slurries (including photoresist). Emissions from chemical bath operations are estimated using the Ideal Gas Law. For each installation, data is recorded for bath dimensions, temperature, sparging, volume of exhaust, and total number of product cycles the tool sees in an hour. Emissions of spray tools are estimated using empirical data collected on similar applications and scaling for chamber size, and adjusting for vapor pressure of the chemical at the temperature used in the tool. Emission for slurry/resist applications are

calculated by determining the total volume of slurry/resist applied and assuming that all volatile compounds evaporate.

Supporting activities at the plant include chemical /waste handling, waste water treatment and fuel combustion for generating high temperature hot water. Calculation methods for these activities are readily available from USEPA and include:

Combustion source emissions are calculated by inputting the appropriate fuel use into the ECOL system. ECOL using AP-42 calculates the appropriate emission data.

Emissions from Storage Tanks are calculated by entering dimensional and turnover data into the ECOL system. ECOL using Tanks4 calculates the emission.

The option exists for the air emissions calculated in ECOL to printout a step by step calculation record of the methodologies used with references back to EPA and State source documents for the equations used.

REPORTS

The tool information in the ECOL system is used to provide compliance information for the Title V permit as well as general information about each tool. The various reports in the ECOL system are shown in Figure 6.   Many of the reports in ECOL have a filtering capability to allow the user to produce a report using all of the data in ECOL or based on specific criteria (Figure 7).

Figure 6. ECOL report types.

Figure 7.   Example of Report Filters.
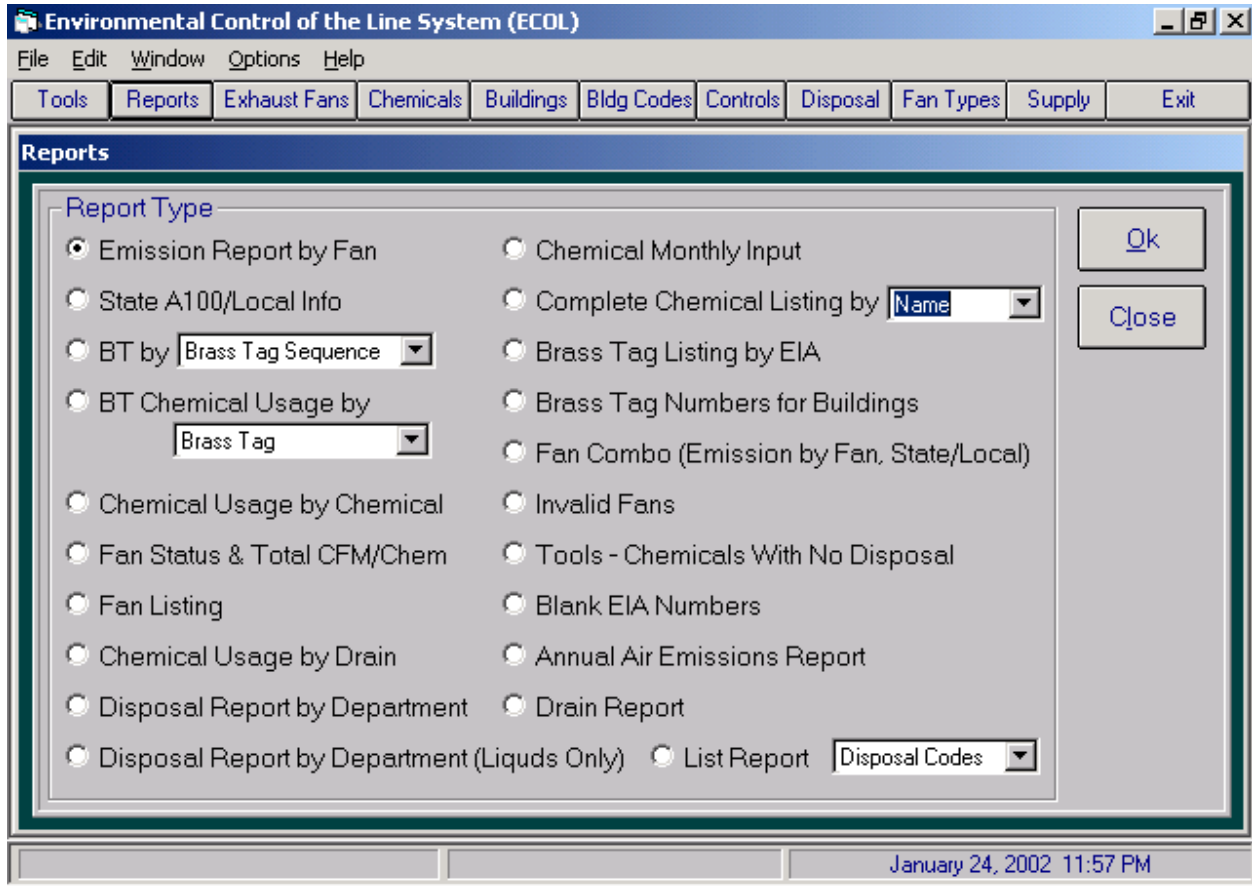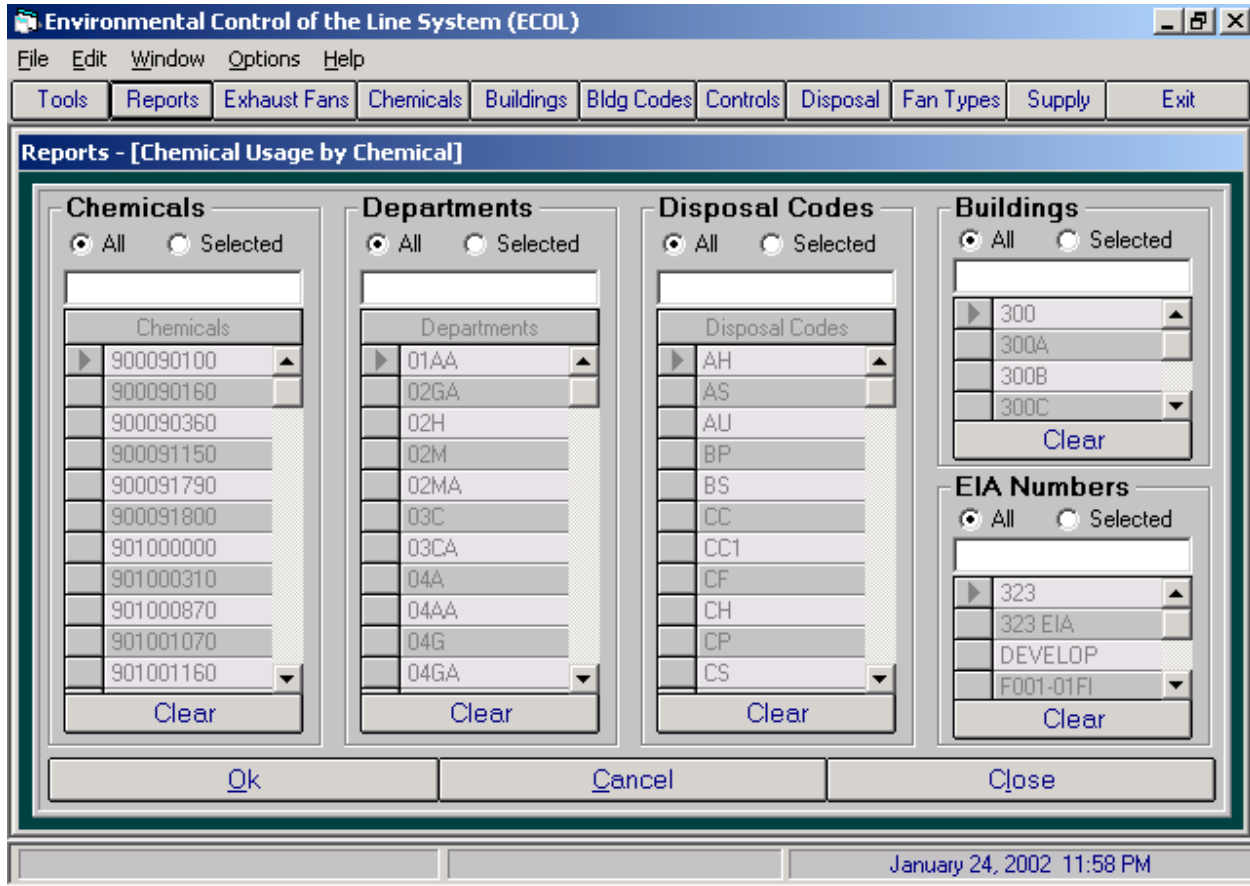

Figures 8-9 show examples of general reports from the ECOL system. Figures 10–11 show specific compliance reports. The flexibility of the reporting module allows ECOL users to produce reports to meet all of the regulatory reporting needs. ECOL is also used as a checks and balance system to insure chemical usage restrictions and emission limits are met around the facility.

Figure 8. Example of a screen preview of an emission report.

Figure 9. Example of a chemical usage by tool.

Figure 10. Example of an air quality compliance report.

Section 3.1 - Industrial Process Emissions Summary

Owner: IBM Corp
New Orchard Rd
Armonk, NY 10504

Facility: IBM East Fishkill Facility
Rt 52
Hopewell Junction, Ny 12533

DARID: 1328000095

Primary SIC: 3679   **DECID:** 3132800025

Total Industrial Process Emissions by Contaminant

Enter the 2000 emissions total of each contaminant from this facility

CHEM FAMILY	CAS NO.	CONTAMINANT NAME	ACTUAL (LBS/YR)
9	000050-00-0	FORMALDEHYDE	<10
4	000056-81-5	GLYCEROL	230
9	000057-12-5	CYANIDE	<10
4	000057-55-6	METHYLETHYL GLYCOL	900
1	000064-02-8	ETHYLENEDIAMINETETRAACETIC ACID, SODIUM SALT	20
4	000064-17-5	ETHYL ALCOHOL	100
4	000064-19-7	ACETIC ACID	40
9	000067-56-1	METHYL ALCOHOL	2320
4	000067-63-0	ISOPROPYL ALCOHOL	49700
6	000067-64-1	DIMETHYL KETONE	1900
9	000067-66-3	CHLOROFORM	20
10	000071-55-6	ETHANE, 1,1,1-TRICHLORO-	<10
6	000074-82-8	METHANE	130
4	000074-86-2	ACETYLENE	190
6	000074-94-2	BORON, TRIHYDRO(N-METHYLMETHANAMINE)-,	<10
4	000074-98-6	PROPANE	80
4	000075-10-5	DIFLUOROMETHANE	20
4	000075-28-5	ISOBUTANE	<10
4	000075-37-6	ETHANE, 1,1-DIFLUORO-	280
6	000075-45-6	CHLORODIFLUOROMETHANE	120
6	000075-46-7	TRIFLUOROMETHANE	1280
4	000075-59-2	TETRAMETHYL AMMONIUM HYDROXIDE	540
6	000075-71-8	DICHLORODIFLUOROMETHANE	60
6	000075-73-0	TETRAFLUOROMETHANE	1380
6	000075-75-2	METHANESULFONIC ACID	<10
6	000076-15-3	CFC-115	30
6	000076-16-4	ETHANE, HEXAFLUORO-	22680
4	000078-10-4	SILICIC ACID, TETRAETHEYL ESTER	1080
4	000078-40-0	PHOSPHORIC ACID, TRIETHYL ESTER	60
9	000078-93-3	METHYL ETHYL KETONE	<10
4	000090-72-2	PHENOL, 2,4,6-TRIS ((DIMETHYLAMINO)METHYL)-	<10
4	000095-14-7	1H-BENZOTRIAZOLE	<10
4	000096-48-0	DIHYDRO 2(3H)-FURANONE	1570
4	000097-64-3	PROPANOIC ACID, 2-METHYL-1,2-ETHANEDIYL ESTER	2400
9	000100-41-4	ETHYLBENZENE	20
4	000100-66-3	ANISOLE	<10
4	000102-71-6	2,2,2-NITRILOTRIS ETHANOL	<10

Figure 11. Example of an air quality compliance report.

New York State Department of Environmental Conservation
Division of Air Resources
2000 Emission Statement
Section 3.2 - Industrial Process Emissions

Owner: IBM Corp
New Orchard Rd
Armonk, NY 10504

Facility: IBM East Fishkill Facility
Rt 52
Hopewell Junction, Ny 12533

DARID: 1328000095

Primary SIC: 3679   **DECID:** 3132800025

Process Data: Emission Unit: C-00001

SCC: 3-13-065-01 SMICNDR MFG-CLEAN-WET-SPECIFY   Process ID: 0J3

SCC Desc: ELECTRICAL EQUIPMENT
ELECTRICAL EQUIPMENT-SEMICONDUCTOR MANUFACTURING
SEMICONDUCTOR MFG-CLEANING PROCESSES-WET CHEMICAL-SPECIFY AQ SOLUTION

Annual Thruput: 401   Thruput units: TONS PROCESSED

Process Description:

SCREENING AND AQUEOUS MASK CLEANING

Control Equipment Description:
Provide control efficiency below with emissions summary

Emission Point Identifiers:
List all Emission Point(s) associated with the Emission Unit listed above:

| JBG38 | JBD34 | HX27 | HAB25 | HE26 | JBB44 | JAZ34 | JBA33 | HA23 | JBA42 | JBD28 |
| HD28A | HEF1 | JEF3 | HH27 | | | | | | | |

Operational Data:

	Annual Average			Percent Operation by Season			June thru August		
Hours/Day	Days/Week	Weeks/Year	Dec-Feb	Mar-May	Jun-Aug	Sep-Nov	Hours/Day	Days/Week	Total Days
24	7	52	25	25	25	25	24	7	92

Process Contaminant Summary:
Provide actual emissions for the process listed above

CHEMICAL FAMILY	CAS NO.	CONTAMINANT NAME	CONTROL EFFICIENCY (%)	ACTUAL (LBS/YR)	HD	EMISSION FACTOR	SOURCE
4	000064-17-5	ETHANOL	NA	10	2.4	NA	NA
4	000064-19-7	ACETIC ACID	NA	≤10	2.4	NA	NA
4	000067-63-0	ISOPROPANOL	NA	90	2.4	NA	NA
6	000067-64-1	ACETONE	NA	≤10	2.4	NA	NA
4	000075-59-2	TETRAMETHYL AMMONIUM HYDROXIDE	NA	100	2.4	NA	NA
6	000075-73-0	CARBON TETRAFLUORIDE	NA	20	2.4	NA	NA
4	000090-72-2	2.4.6-TRIS(DIMETHYLAMINOMETHYL)PHENOL	NA	≤10	2.4	NA	NA
4	000110-25-8	SARCOSYL OIL	NA	≤10	2.4	NA	NA
4	000110-82-7	CYCLOHEXANE	NA	≤10	2.4	NA	NA
4	000124-17-4	BUTYL CARBITOL ACETATE	NA	700	2.4	NA	NA
1	001344-28-1	ALUMINUM OXIDE	NA	≤10	2.4	NA	NA

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CONCLUSION

IBM's Environmental Control of the Line (ECOL) management system is used to track the air, water and waste emissions for all of the manufacturing tools used at the facility. Recent additions to the ECOL system have added the ability for Title V real-time continuous compliance with State and Federal air quality regulations.

Data from the ECOL environmental system is also shared with other manufacturing and corporate data management systems to provide IBM with a complete business system.

The ECOL system is modular and easily modified as regulatory data tracking and reporting requirements change.