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Project Summary

User's Manual for the Integrated Air Pollution Control System Design and Cost-Estimating Model (Version II)

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The Integrated Air Pollution Control System (IAPCS) is a computerized simulation model used to estimate the costs and predict the performance of sulfur dioxide (SO_2), nitrogen oxides (NO_x), and particulate matter (PM) emission control systems for coal-fired utility boilers. The model includes conventional and emerging technologies that effect pre-, in situ, and post-combustion emission control. The model can accept any combination of the technology modules built into the system. Interactions are reflected in a material balance tabulation of the exit of each module. Alterations in the material balance are used to account for integrated performance and cost effects. The emission control technologies contained in IAPCS can be selected in either isolated or integrated configurations.

This version of IAPCS (IAPCS-II) was completed in April 1986. It incorporates a number of enhancements to the design premises of the emission control modules as well as the model's user access and versatility. Enhancements to the control modules involved upgrades to five modules: wet flue gas desulfurization (FGD), low-NO_x combustion, limestone injection multistage burner (LIMB), electrostatic precipitator (ESP), and fabric filter (FF). Other important enhancements to IAPCS-II include expanding the solid waste handling and disposal module, housing the model on a microcomputer (personal computer), providing EPRI and TVA economic premises, and expanding the user-activated parameter file.

The User's Manual describes the second version of IAPCS. This manual provides a guide to the user of the model. It presents the design bases of the individual modules comprising the model and the structure of the program itself, as well as the bases for a number of model enhancements now available to the user.

This Project Summary was developed by EPA's Air and Energy Engineering Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Background and Purpose

Costs of installing and operating air emission control equipment to meet sulfur dioxide (SO_2), particulate matter (PM), and nitrogen oxide (NO_x) emission standards have grown significantly and now represent a large portion of the total powerplant costs. The significance of these costs has led to the emergence of the concept of integrated environmental control of utility powerplant air emissions within the last several years.

One logical means of addressing the design and operation of an air emission control system is to consider that sys-

tem as an integral part of the powerplant. By optimizing the interactions of control devices, the integrated control concept can effect the necessary control level at a minimal cost.

The Integrated Air Pollution Control System (IAPCS) is a computerized simulation model developed for the Air and Energy Engineering Research Laboratory (AEERL) of EPA to estimate the costs and predict the performance of SO_2, NO_x, and PM emission control systems for coal-fired utility boilers. The model includes conventional and emerging technologies that effect, pre-, in situ, and post-combustion emission control. The model can accept any combination of the technology modules built into the system. Interactions are reflected in a material balance tabulation of the exit of each module. Alterations in the material balance are used to account for integrated performance and cost effects. The emission control technologies contained in IAPCS can be selected in either isolated or integrated configurations.

The power of IAPCS lies in its ability to reflect integrated effects of various control configurations. This allows the analyst to identify synergistic interactions and thus optimize performance and cost in terms of integrated cost effectiveness. The specific technologies that are contained in IAPCS are presented in Table 1.

The first version of IAPCS (IAPCS-I) was developed in November 1983. This version was a mainframe computer model housed at EPA's National Computer Center (NCC). The second version of IAPCS (IAPCS-II) was completed in April 1986. This version incorporates a number of enhancements to the design premises of the emission control modules as well as the model's user access and versatility. Enhancements to the control modules involved upgrades to five modules: wet flue gas desulfurization (FGD), low-NO_x combustion, limestone injection multistage burner (LIMB), electrostatic precipitator (ESP), and fabric filter (FF). Other important enhancements to IAPCS-II include expanding the solid waste handling and disposal module, housing the model on a microcomputer (personal computer), providing EPRI and TVA economic premises, and expanding the user-activated parameter file.

Capabilities of IAPCS-II

The IAPCS-II design and cost-estimating model was developed to estimate the cost and performance of air emission control equipment for coal-fired utility boilers. The model includes both conventional and emerging control technologies. The control technologies (modules) included are:

- Physical coal cleaning (PCC)
- Low-NO_x combustion (LNC)
- Limestone injection multistage burner (LIMB)
- Electrostatic precipitator (ESP)
- Fabric filter (FF)
- Spray humidification (SH)
- Dry sorbent injection (DSI)
- Lime spray drying (LSD)
- Flue gas desulfurization (FGD)

As designed, the model accepts any combination of these technologies. System interactions are reflected in a material balance tabulation at the exit of each module. The PCC, LNC, and LIMB modules (pre-combustion and in situ technologies) are applicable to the boiler unit; the effects of these devices are accounted for in a material balance column reflecting flue gas conditions at the air heater exit. An uncontrolled material balance column is calculated before the boiler control modules are accounted for so that the net effect of emission control can be calculated on a system basis. Output from the model reports the reduction in SO_2, PM, and NO_x emissions; associated capital and annualized costs of such reductions; and associated cost-effectiveness values (dollars per ton of pollutant removed across the entire emission control system).

A parameter file and a user-prompted optimization routine are important features of this model. As each module was developed, the important design parameters were included in a parameter file. These parameters may be subsequently changed by the user for a given application. The parameter file is designed to permit the user to modify the important values to reflect those of choice.

The first run of the model for a user-specified control configuration makes use of default performance values for each module (i.e., the costs reflect the design-specified maximum performance levels of the control equipment). When the output from the initial run has been completed, the user can exercise the option to enter an optimization routine which permits sequential revision of the performance levels of certain modules for a single pollutant. The user must iterate runs to effect a desired pollutant mass emission rate/overall system removal efficiency.

The model also includes other important design features, including an optional debug output in identifying interim calculated values for each control module in the control system. An input summary for each run ensures that cost and performance data are attached to the specifics and date of that run.

Table 1. *IAPCS Control Modules*

Type	Technology	Pollutant(s) controlled
Pre-combustion	*Physical coal cleaning*	*SO_2/PM/NO_x*[a]
In-situ	*Low-NO_x combustion*	*NO_x*
	LIMB	*SO_2*
Post-combustion	*ESP*	*PM*
	Fabric filter	*PM*
	Spray humidification	*SO_2/PM*[b]
	Dry sorbent injection	*SO_2*
	Wet FGD	*SO_2/PM*[c]
	Lime spray drying FGD	*SO_2/PM*[d]

[a] *The product coal is de-ashed and desulfurized. Some NO_x reduction is reflected due to alteration of the combustion conditions and nitrogen content of the cleaned coal.*
[b] *Spray humidification improves PM collection by conditioning the gas upstream of the ESP. Some SO_2 may be absorbed by the spray water.*
[c] *Some FGD configurations provide supplemental PM control in the scrubbing system.*
[d] *Removal of PM (and the SO_2 reaction solid products) occurs in the spray dryer chamber and downstream PM control system.*

General Model Description

Input Requirements

A typical run entails a number of requests for input from the user. The input questions are presented in Figure 1.

These items either provide basic data for the given run or specifically affect

ENTER FIRING CONFIGURATION OF BOILER:
1. WALL-FIRED
2. TANGENTIALLY FIRED
ENTER BOILER SIZE IN MW>
ENTER BOILER CAPACITY FACTOR (%)>
ENTER CONSTRUCTION STATUS (1=NEW, 2=RETROFIT)>
ENTER DATE AND COMMERCIAL OPERATION OF BOILER>
ENTER TEMPERATURE AT AIR HEATER EXIT>
ENTER ACFM AT THE AIR HEATER EXIT:ENTER 0 TO CALCULATE>
ENTER SELECTION OF TYPICAL COAL(1) OR SPECIFIC CHARACTERISTICS(2)>
ENTER COAL CHOICE:
1. BITUMINOUS - PENNSYLVANIA
2. BITUMINOUS - OHIO
3. BITUMINOUS - WEST VIRGINIA
4. BITUMINOUS - ILLINOIS
5. SUBBITUMINOUS -WYOMING
6. LIGNITE - NORTH DAKOTA>
ENTER COAL CLEANING LEVEL:
1. RUN-OF-MINE SORTED AND SCREENED
2. PHYSICAL COAL CLEANING>
ENTER BOILER BOTTOM ASH CONFIGURATION:
1. DRY-BOTTOM
2. WET-BOTTOM>
SELECT IAPCS CONFIGURATION FROM THE FOLLOWING:

MODULE	POLLUTANTS
1. LOW-NO_x BURNERS, OVERFIRE AIR	NO_x
2. LIMB	NO_x, SO_2
3. COAL CLEANING	PART, SO_2
4. SPRAY HUMIDIFICATION (SH)	PART, SO_2
5. ESP	PART
6. FABRIC FILTER (FF)	PART
7. LIME SPRAY DRYING (LSD)	SO_2
8. LIMESTONE/LIME FGD (FGD)	SO_2
9. DRY SORBENT INJECTION (DSI)	SO_2

THE FOLLOWING RULES APPLY TO SELECTING A CONFIGURATION:
1 - METHOD 4 MAY NOT BE USED WITH METHODS 7 OR 9
2 - METHOD 5 OR 6 MAY NOT PRECEDE (BUT MAY FOLLOW) 7 OR 9
3 - METHODS MUST BE IN ASCENDING NUMERICAL ORDER (EXCEPT AS IN 2 ABOVE)
4 - METHODS MAY NOT BE REPEATED IN THE SAME SYSTEM. (GENERALLY THE POST COMBUSTION MODULES FOLLOW THE GAS PATH)
ENTER OPTION NUMBERS IN ORDER (SEPARATE BY COMMAS)
SELECT OUTPUT OPTION:
1. OUTPUT TO PRINTER
2. OUTPUT TO SCREEN
3. BOTH ABOVE

Figure 1. *IAPCS-II Input requirements.*

the outcome of the run. Input requests include boiler data, fuel characteristics, and the control configuration. The boiler data are used to quantify the unit/system generating performance. The coal characteristics are used to estimate the emissions from firing a given quantity of coal, and the user specifies the controls to be utilized. The firing configuration is used to estimate uncontrolled emissions and to specify the appropriate NO_x control device from the LNC module.

Cost Formats

Emission control cost estimates must be comparable in terms of base year dollars, cost categories, and overall content (i.e., cost components). To facilitate comparisons, IAPCS-II has adopted the bases and format of cost estimation used by the Tennessee Valley Authority (TVA) and the Electric Power Research Institute (EPRI), which are generally accepted as industry standards.

Output Format and Options

The model provides the user with eight outputs: (1) user input summary, (2) module-specific output, (3) boiler performance, (4) material balance, (5) emission reduction, (6) capital cost estimate, (7) annual cost estimate, and (8) cost-effectiveness (or unit cost) of SO_2 removal.

Computer Program Structure

IAPCS-II has been converted to Microsoft FORTRAN 77 (Version 3.2) for use on the IBM PC AT or XT microcomputer.* The model cannot be used on a floppy-disk-based system. The model is available as a computer program through NTIS in the form of MS-DOS formatted microcomputer diskettes (5.25-in. double-sided floppy disks). The system must include at least 512 kilobytes of random access memory and run under the DOS 2.1 (XT) or 3.1 (AT) (or higher) operating system. The user should have at least 1.5 megabytes available on the hard disk.

The executable program files and all supporting data files are provided on floppy disks in the PC DOS BACKUP format. Table 2 describes these files.

The original version of IAPCS was designed as an interactive system; IAPCS-II allows input via a batch file created with a word processor or spreadsheet program. Output reports can be transmitted to either the console screen or the printer, or to both, at the user's option.

(*)IBM PC AT and IBM PC XT are trademark names of the IBM Corporation.

Table 2. *IAPCS-II Disk Files*[a]

File Name	Description
MODULES.EXE	Program executable file to size and cost control modules.
INPUT.EXE	Program executable file to gather input data and perform initial gas stream and coal-cleaning calculations.
OUTPUT.EXE	Program executable file to site and cost system fans and waste disposal. Also makes economic calculations and prints output reports.
IAPCS.BAT	DOS batch command file to run executables sequentially.
PARMFILE.TVA	TVA default parameter file.
PARMFILE.EPR	EPRI default parameter file.
LOSTHELP.DOC	Help information for escalation.
OPTHELP.DAT	Help information for optimization.
PARMHELP.DAT	Help information for parameter editor.

[a]Other temporary files are created by the program.

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The complete report consists of three parts, entitled "User's Manual for the Integrated Air Pollution Control System Design and Cost-Estimating Model (Version II):"

"Volume I.," (Order No. PB 87-127 767/AS; Cost $18.95)

"Volume II. Appendix C," (Order No. PB 87-127 759/AS; Cost: $30.95)

"Volume III. IAPCS2 (Floppy diskette)," (Order No. PB 87-127 775; Cost: $75.00)

The above items will be available only from: (costs subject to change)

National Technical Information Service
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