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THE DEVELOPMENT OF WIPPVENT, A WINDOWS BASED INTERACTIVE MINE VENTILATION SIMULATION SOFTWARE PROGRAM AT THE WASTE ISOLATION PILOT PLANT.

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ABSTRACT

An interactive mine ventilation simulation software program (WIPPVENT) was developed at the Waste Isolation Pilot Plant (WIPP). The WIPP is a U.S. Department of Energy (DOE) research and development project located near Carlsbad, New Mexico. The facility is designed to provide a permanent, safe underground disposal of U.S. defense generated transuranic waste in bedded salt. In addition to it's regular functions, the underground ventilation system is engineered to prevent the uncontrolled spread of radioactive materials in the unlikely event of a release. To enhance the operability system, Westinghouse Electric Corporation has developed an interactive mine ventilation simulation software program (WIPPVENT). While WIPPVENT includes most of the functions of the commercially available simulation program VNETPC (copyright (c) 1991 Mine Ventilation Services, Inc.), the user interface has been completely rewritten as a Windows ® application and screen graphics have been added. WIPPVENT is designed to interact with the WIPP ventilation monitoring systems through the site wide Central Monitoring System.

Ventilation data can be continuously collected from the Underground Ventilation Remote Monitoring and Control System (which includes airflow, differential pressure, fan static pressure,

and regulator settings) and the Mine Weather Stations (psychrometric data). WIPPVENT also incorporates regulator characteristic curves specific to the site. The program utilizes this data to create and continuously update a real time ventilation model. This paper will discuss the design, key features, and interactive capabilities of WIPPVENT.

INTRODUCTION

The ventilation system at the Waste Isolation Pilot Plant (WIPP) outside Carlsbad, New Mexico, is designed to perform two distinct functions. First, it fulfills normal mine ventilation requirements complying with all state and federal mine regulations. Second, it prevents the uncontrolled release of radioactive contaminants from the facility. Although a nuclear radiation release in the facility is considered unlikely, the ventilation system incorporates many special features to prevent the possible spread of contamination.

The underground facility at the WIPP contains four main ventilation splits. These air splits service the experimental area, mining area, waste storage area, and the waste shaft station. The facility was designed and constructed to keep occupational exposures to radiation and radioactive materials "As Low As Reasonably Achievable" (ALARA). This concept led to a design which separates the nuclear waste handling and storage areas from the mining and non-radioactive experimental areas. The ventilation system is designed so that air leakage is from the mining and experimental areas to the waste storage areas. Furthermore, radiation detectors are strategically located throughout the underground, and an exhaust filtration building is installed on the surface to prevent the possible accidental release of radiation to the environment.

OVERVIEW OF THE WASTE ISOLATION PILOT PLANT

The U.S. Department of Energy (DOE) has determined that the plastic nature of bedded salt will provide the best feasible permanent solution to isolate transuranic (TRU) waste from the biosphere. TRU waste is waste that contains radioactive isotopes heavier than uranium. The TRU waste that is to be stored at the WIPP site is stored in drums. Initial evaluations of the WIPP began in 1974. In 1979, the U.S. Congress enacted Public Law 96-164 authorizing construction and development of the WIPP Project. The mission of the WIPP is to provide the safe, long-term disposal of TRU waste generated by the national defense programs of the U.S.

The WIPP site is located approximately 47 km (29 miles) east of Carlsbad, New Mexico in the Chihuahuan Desert. The repository is located in the 630 m (2000 ft) thick Salado Formation. This Permian Basin salt deposit is about 250 million years old and appears to have been stable and secure from earthquake, faulting, and groundwater activity since it was deposited. The underground facility is 660 m (2,150 ft) below surface, approximately halfway through the Salado Formation. Since 1984 underground non-radioactive experiments have been performed at the WIPP for site characterization and to determine it's performance as a nuclear waste repository.

DESCRIPTION OF THE VENTILATION SYSTEM

The repository is accessed by three intake shafts and one return shaft. The three intake shafts at the WIPP are the Salt Handling Shaft, Waste Handling Shaft, and Air Intake Shaft. The Exhaust Shaft is the only return airway for the facility. During normal operation most of the intake air enters the underground through the Air Intake Shaft. The Salt Handling Shaft, which provides personnel and material access, is used for the removal of the mined salt and is a secondary intake shaft. The Waste Handling Shaft is equipped with an enclosed headframe, and will be used for lowering nuclear waste to the repository horizon. This shaft also provides access for personnel and materials to the repository horizon. A limited amount of intake air enters this shaft. The Waste Handling Shaft air is routed to the Exhaust Shaft after ventilating the shaft station area.

Ventilation through the facility is achieved by running one or both of the 450 kW (600 hp) centrifugal main fans. During concurrent mining and waste handling operations, both parallel fans operate to provide 230 m^3/s (490,000 cfm). This airflow quantity is required for maintaining proper ventilation for the operation of diesel equipment throughout the facility. When either mining or waste emplacement is not active, the ventilation demand can be satisfied with only one main fan in operation. This results in an airflow of 140 m^3/s (300,000 cfm). In the unlikely event of an underground radioactive material release, the ventilation system is either automatically or manually shifted to a filtration mode. The airflow during filtration mode is reduced to 28 m^3/s (60,000 cfm). This shift consists of the main fans being turned off, and one of three 175 kW (235 hp) centrifugal stand-by filtration fans being started. A series of isolation dampers diverts the air through the filtration system. The air is routed through a series of filters including High Efficiency Particulate Air (HEPA) filters.

The WIPP ventilation system includes an Underground Ventilation Remote Monitoring and Control System (UVRMCS). It consists of 15 air velocity sensors, eight differential pressure sensors (strategically placed throughout the repository), and provides for local or remote control of the position of the air regulators controlling the four main ventilation splits. The sensors send a 4-20 mA signal to one of four Central Monitoring System (CMS) Local Processing Units (LPUs) in the repository. The LPUs digitize and process this signal into predetermined engineering units (air velocity in ft/min, differential pressure in inches water gauge (w.g.), and regulator position in percent open), depending on the nature of the signal being received. Each signal or "point" has a specific identifier that the LPU software recognizes. In turn it performs the calculation(s) necessary to convert the signal to its appropriate engineering unit. The LPU(s) then transmit the signal onto the Data Highway which extends throughout the underground and surface facilities. On the surface is a Central Monitoring Room (CMR). The CMR is equipped with Operator-Machine Interface (OMI) stations. A CMR operator can selectively retrieve the signals from the Data Highway and display them on the OMI CRT in graphical or tabular formats as programmed into the OMI software. The CMR operator has the capability to control the system by remotely opening or closing the main regulators.

In addition, the ventilation system includes eight psychrometric Mine Weather Stations (MWS) to collect data for use in calculating natural ventilation pressures. These monitoring stations measure drybulb temperature (in degrees celsius), pressure (in kPa) and relative humidity (in percent) every five minutes. The MWS are currently being upgraded to interface with the CMS through the LPU's in a manner similar to the operation of the UVRMCS.

Information on the underground ventilation system main fans is also available from the CMR. This data shows which fan(s) are operating, the static pressure, and an indication of the airflow quantity.

A Virtual Address Extension (VAX) interface software program transfers data from the CMS VAX Interface Unit then onto the VAX computer network. The VAX network can then be accessed by the ventilation engineer, giving him access to real-time data on the status and performance of the system. Figure 1 shows the relationship between all system components.

MAJOR FEATURES OF WIPPVENT

To enhance the operability of the system, and to utilize the real time data available an interactive mine ventilation simulation software program called WIPPVENT has been developed. WIPPVENT was developed by Westinghouse Electric Corporation and Mine Ventilation Services Inc. as an interactive mine ventilation simulation software program for exclusive use at the WIPP. It is based on the commercially available VNETPC Version 3.1 (copyright (c) 1991 Mine Ventilation Services, Inc.), however, the user interface has been completely rewritten as a Windows operating system to provide a more user friendly environment. Many of the Windows® features were developed using existing applications and shareware technology. Functions such as screen graphics, pull down menus, zoom, a spreadsheet format and editing features have been added. The use of these features that are similar to other Windows ® based applications will not be discussed in this paper.

The characteristic which makes WIPPVENT unique is that it is designed to interact with the WIPP underground ventilation monitoring systems (the UVRMCS and the MWS) through the site-wide Central Monitoring System. Furthermore, WIPPVENT incorporates characteristic resistance curves specific to the site's four main underground regulators. These features give WIPPVENT the ability to retrieve real time data, and to use these data to create and continuously update a real time ventilation model. The design, key features, and interactive capabilities of WIPPVENT are discussed in the following sections.

THE PI SYSTEM

The real time data WIPPVENT utilizes is retrieved from the CMS through a VAX interface

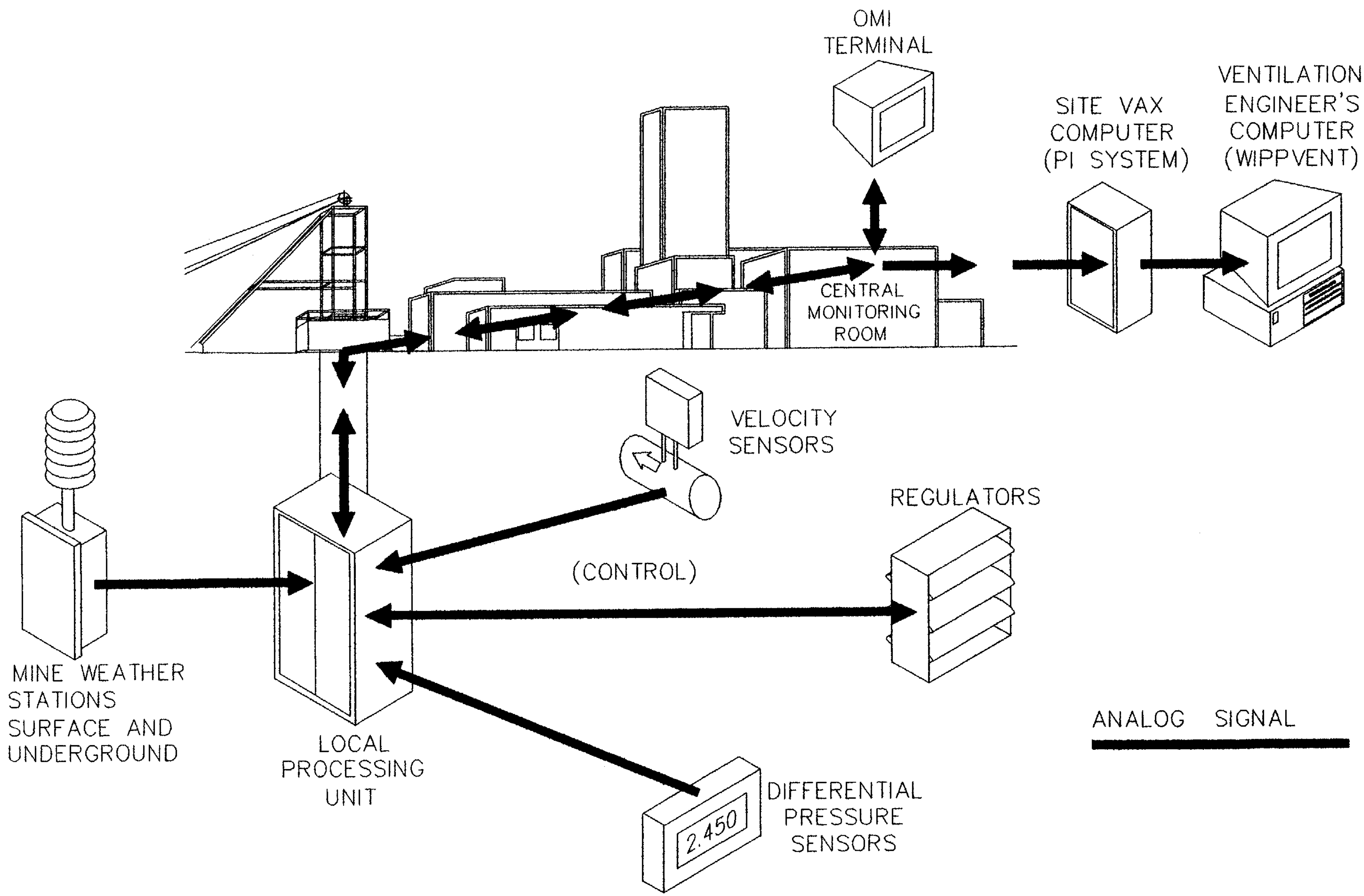


FIGURE 1. RELATIONSHIP BETWEEN UNDERGROUND SENSORS, REGULATOR CONTROLS, LPU CMR, OMI, VAX NETWORK AND THE VENTLATION ENGINEERS COMPUTER

program called PI ®, which is commercially available from Oil Systems Inc. PI is an archival program which collects data, screens it, and archives it to the VAX for final storage. The PI system is connected to the site CMS using computer drivers developed by Oil Systems Inc. WIPPVENT has been written with the ability to connect and "talk" to PI by selecting a series of pull down menu commands. The WIPPVENT user is able to connect to the CMS data through PI, and then retrieve data in either real or historic time.

DATA SUMMARY

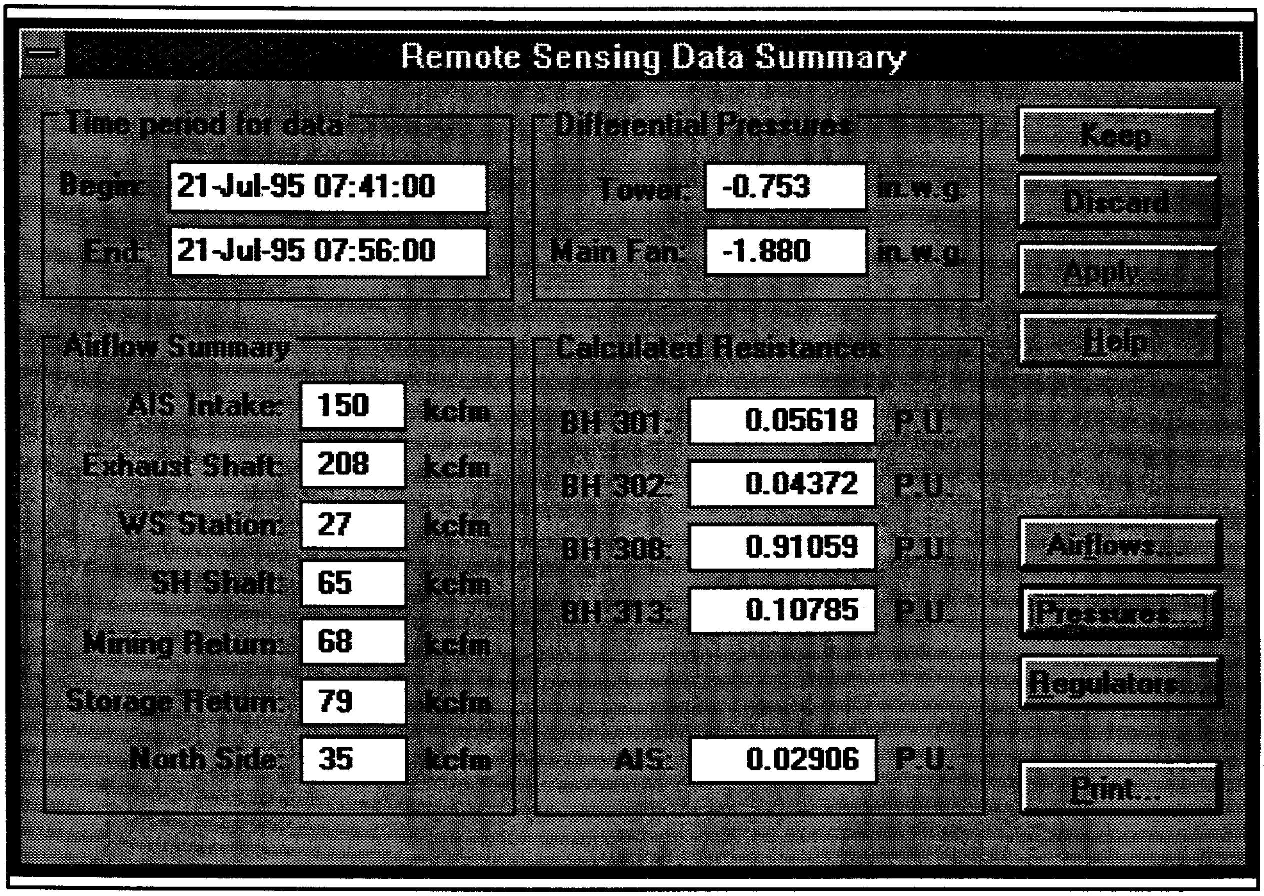
Once the desired data has been imported to WIPPVENT, a remote sensing data summary table provides key information on the ventilation system. Information summarized on the table includes: time period for the data, differential pressures for the Waste Handling Tower and main fans, airflow summary for the shafts and main splits, and the calculated resistances for the Air Intake Shaft and main regulators. Any applicable error signals are displayed in the corresponding field. The summary table also provides buttons to access detailed information on the various types of data available. Once the data has been selected and/or modified, an "apply" button sends the data to WIPPVENT for use in a simulation. Figure 2 shows the Summary Data Information Table for WIPPVENT.

AIRFLOW AND DIFFERENTIAL PRESSURE DATA

Once a connection is established between WIPPVENT and PI, the user is able to retrieve data from the UVRMCS and MWS systems. This data may be accessed from the remote sensing data summary table.

Accessing the "Airflows" or "Pressures" buttons from the summary table provides detailed information on the UVRMCS's fifteen airflow stations and eight differential pressure stations

Figure 2: Remote Sensing Data Summary



located throughout the facility. The additional information provided on each table includes: tag (CMS) number, location, description, status (including applicable errors) , node numbers, and the airflow value in thousands cfm (kcfm) or differential pressure in inches water gauge (in.w.g.) respectively. If desired, the data provided in these tables can be modified using the standard Windows edit features. Altered data will have a "modified" message displayed in the status column of the summary table. This feature allows the user to set up various "what if" ventilation scenarios based on real time data, and at the same time differentiate between real time modified scenarios. Figure 3 shows the Remote Sensing Airflows tables. The Remote Sensing Differential Pressures table is similar.

MAIN REGULATOR DATA

One of the features which makes WIPPVENT a WIPP specific simulator is the ability to utilize data from the underground's four main regulators. Data from these regulators can be accessed directly from the Remote Sensing Data Summary table providing information on the current status of each bank of regulators . The information provided is; airflow through the regulator in kcfm, pressure drop across the regulator in in.w.g., and the calculated resistance of the regulator in Practical Units (P.U.= kcfm/(milli in.w.g.)^2). An optional "louvers" button on the summary table provides access to more detailed information on the individual louvers for each bank of regulators. This additional information includes: Tag (CMS) Number, Louver, Status, Indicated Setting (% open), and the Calculated Setting (degree closed) based on the current airflow/pressure summary data. This data can be applied to WIPPVENT for a mine ventilation simulation.

Additional information on each of the four main regulators can also be accessed through a

Figure 3: Remote Sensing Airflows

Airflows

Tag	Location	Description	Status	From	To	Airflow (kcfm)
AM1001	N215/W500	Intake from AIS	Ok	2	300	149.72
AM1002	N1100/W150	Experimental intake	Ok	303	304	52.98
AM1003	N1400/E400	E. of experimental shop	Ok	320	305	44.66
AM1004	N240/E140	BH 301	Ok	401	288	66.44
AM1005	N150/E100	BH 302	Ok	402	288	67.97
AM1006	N80/E0	N. of SHS	Ok	400	9	78.82
AM1007	S300/W30	S. of SHS	Ok	291	11	143.76
AM1008	S800/W30	N. of BH 313	Ok	12	13	106.74
AM1009	S1100/W30	S of BH 313	modified	13	200	42.65
AM1010	S2050/W170	End of mining circuit	modified	280	281	36.91
AM1011	S600/W170	Mining return	Ok	285	286	37.25
AM1012	S320/E300	N. of exhaust drift	Ok	601	186	102.97
AM1013	S500/E300	S. of exhaust drift	Ok	185	186	78.53
AM1014	S1600/E400	Storage panel return	Ok	114	182	53.51
AM1015	S400/E400	Exhaust drift	Ok	186	5	208.32

OK

Cancel

Help

Figure 4: Typical Regulator Data

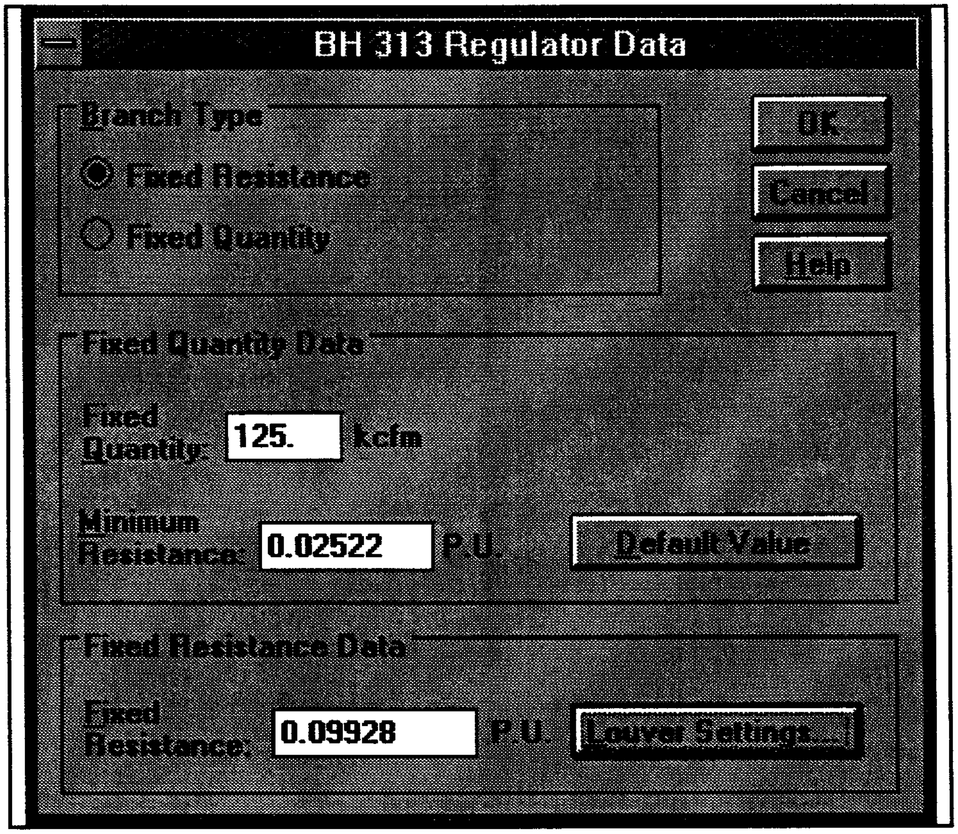
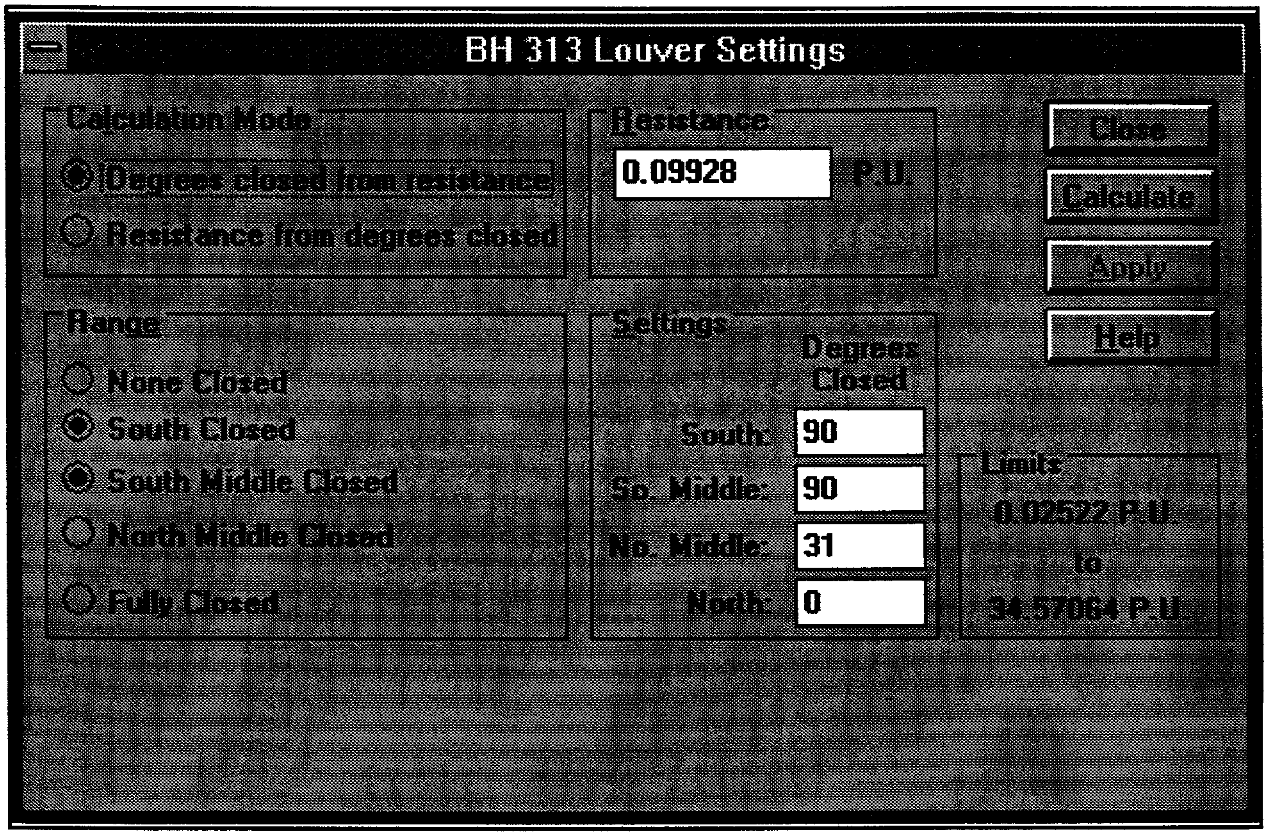


Figure 5: Typical Louver Settings



separate pull down menu. This can either be used in conjunction with data directly from the CMS, or with previously defined ventilation models. Resistance curves for individual louvers in each bank of regulators have been programmed into the simulator. The program shifts from one curve to the next as louvers are adjusted and/or closed in a predefined sequence. This allows the accurate prediction of airflow in any particular split, based on a set of predetermined conditions. Figure 4 shows a typical Regulator Data Table. This table provides the choice between whether the split is to be a Fixed Resistance or a Fixed Quantity branch. If a Fixed Quantity is selected, a corresponding Minimum Resistance can be assigned by the user or defaulted to the resistance of the regulator being wide open. A Fixed Resistance setting can be selected, and any desired fixed resistance assigned to the data box. Once an airflow distribution analysis has been run, selecting the "Louver Settings" in the Fixed Resistance Data box provides additional information on the outcome of the simulation. The user may select a preferred calculation mode. WIPPVENT calculates the settings for each individual louvre in the regulator bank, indicates which (if any) of the louvers needs to be completely closed, and gives the regulator resistance of the scenario. Figure 5 shows a typical Louver Settings summary table. This table enables the user to determine how the underground ventilation system needs to be configured in order to achieve a specific distribution.

WIPPVENT can also be used to determine the airflow distribution for a specific regulator scenario. The "Settings" portion of the Louver Settings box can be used to set the louver(s) in any or all of the regulator banks to any value within the specified limits. When an airflow analysis is performed, this information will be used to determine the airflow in the main ventilation splits for the desired regulator settings. These two features allow for quick and accurate analysis of a variety of airflow quantity and/or regulator configurations depending on changing operational needs.

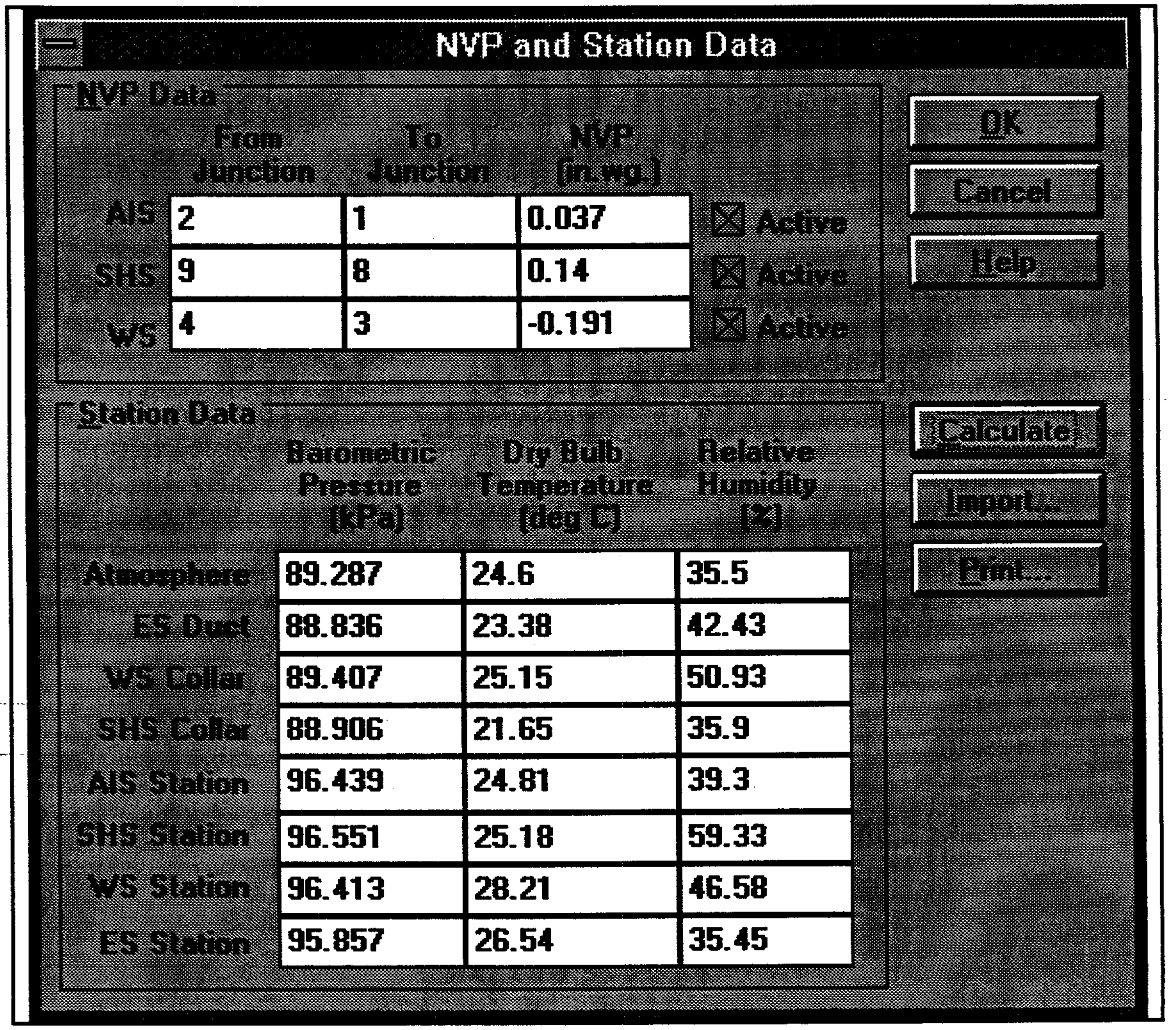
NATURAL VENTILATION PRESSURE DATA

Natural Ventilation Pressure (NVP) can affect the WIPP underground ventilation system. Under winter conditions, the WIPP ventilation system can experience an NVP of up to +2 in.w.g. assisting the fans. In the summer time, an NVP of up to -1.0 in.w.g. opposing the fans is possible. The accurate monitoring and prediction of NVP is desired to maintain the proper underground regulator configuration for correct airflow and pressure distribution throughout the facility.

The WIPP site monitors psychrometric data for the calculation of NVP through eight Mine Weather Stations (MWS). These monitoring stations collect data on drybulb temperature (in degrees celsius), barometric pressure (in kPa) and relative humidity (in percent). The MWS system is currently being upgraded to interface with the CMS through the LPU's in a manner similar to the operation of the UVRMCS. WIPPVENT is designed to access this data, use it in the calculation of NVP, and apply that NVP to a mine ventilation simulation. Figure 6 shows the NVP and Station Data box. NVP summary data for each of the three intake air shafts is provided, as well as the opportunity to indicate whether that data should be used (active) as part of the simulation.

This feature of WIPPVENT enables the NVP's effecting the underground ventilation system to be taken into account on a real time basis. The effect can be modeled, and the proper corrective actions taken in order to maintain the desired differential pressures throughout the ventilation system.

Figure 6: NVP and Station Data



SUMMARY

The development of WIPPVENT Mine Ventilation Simulation Program at the Waste Isolation Pilot Plant represents the final phase of a three phase project to provide real time monitoring, control, and modeling capability to the underground ventilation system. The interactive capabilities of WIPPVENT not only allow for modeling of the current system configuration, but also to accurately predict changes to the system in order to achieve any desired airflow configuration. The real time modeling capability helps insure that the proper airflow quantities and differential pressures are maintained as operational needs and atmospheric conditions change. The use of this program, in conjunction with the UVRMCS and MWS systems, further enhances the safety, flexibility and operability of the underground ventilation system at WIPP.
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