VNET
USER'S MANUAL & TUTORIAL

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1. Introduction

Welcome to VNet. This latest upgrade of the popular ventilation simulation program combines the input of ventilation and mining engineers from around the world to provide an unparalleled engineering tool. This program continues to be designed by practicing ventilation engineers. Credit for many of the new features goes to the hundreds of users in the mining and tunneling industries throughout the world.

The applicability of VNet to subsurface ventilation system design ranges from the initial concept through the system operations phase of a project. Given information that describes the geometry of a ventilation network, airway resistances or dimensions, and the locations and characteristic curves of fans, the code will produce listings and visual graphics of many ventilation parameters. The output includes predicted airflows, frictional pressure drops, air power losses in airways, contaminant flows and concentrations, and fan operating points.

VNet has been developed specifically for computers operating under the Windows environment. The system is supplied on one USB Flash Drive. Data files and fan databases prepared using the previous version of VnetPC Pro can be imported and converted for use with the latest program.

Prior to installing the software, it is recommended that the user become familiar with this User's Manual. This manual provides an overview of the VNet package and software encryption routine that is recommended for both new users, and for users of previous versions. A tutorial section is included with this manual, which provides a quick-start to developing ventilation networks.

If you have any questions or comments regarding VNet, please do not hesitate to contact us. Mine Ventilation Services, Inc. (MVS) maintains a comprehensive web site, which includes up-to-date information on VNet. We also offer free technical support to all users of the latest version of the program. Thank you for choosing the VNet software program, and for supporting the continued development of the code.

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2. Quick Start Guide

This section is intended to be quick start guide for users familiar with VnetPC. A detailed users guide starts in Section 3. VNet is a completely redesigned program built on the basics of VnetPC. The new program was developed with the look and feel of some of the latest professional software to provide the best in user experience.

2.1 Initial Setup

If starting a blank model, first set up some basic parameters by selecting the Model Information button in the Ribbon. It is important to select the units that you will be working in. The default units in VNet are set to SI. Converting between units is easy and can be done in Model Information at any time.

It is helpful to setup a default branch template. Any branch drawn in VNet will take on the characteristics of the active branch template. To set up an initial template open the Templates view by selecting the Templates button in the Ribbon. Select the Edit button and fill in the desired parameters to pass to new branches. Be sure to check all the desired parameters you wish to pass on and select “Ok”. If new templates are created during modeling and saved, the new templates can be set as active and new branches will take on these characteristics.

VNet can also import a VnetPC file by selecting the Backstage button , then selecting “Import VnetPC model”. It is recommended that the model be saved and executed before making any edits to the model.

2.2 Creating Branches

There are three main ways of creating branches: Import centerlines from a DXF, snapping to centerlines of a DXF overlay and free hand. Please note that VNet only supports the import of DXF files that contain only lines and polylines. 3D Poly lines will not import. To convert 3D polylines into poly lines, in AutoCAD, select all of the 3D polylines and use the explode command.

The user can Import a DXF by selecting the Import from DXF button in the Ribbon. This function will turn all of the lines in the drawing to branches. The branches will take on the characteristics of the active branch template. For the best results save the file after import, close and reopen.

New to the program is DXF Reference. This allows the import of a DXF file as lines and not branches. To import a reference, use the Show Resources View button and select the desired file. Branches are drawn using the Draw Branch tool in the Ribbon. There are various display options including an option for newly drawn branches to snap to the DXF overlay lines by selecting the DXF Reference icon located on the icon Tray.

Branches can be drawn freehand using the Draw Branch tool in the XY plane at the active elevation. Active elevation is set by the last selected branch or as specified by the user in the Active Elevation box in the lower left hand corner of the program. When drawing a branch, the junctions will automatically snap to existing branches or junctions.

Branches and junctions are moved using the Move tool in the Ribbon. The tool allows for selected branches and junctions to be moved. Movement is limited to the X-Y plane unless Ctrl key is held down limiting movement to the Z plane. The mode tool also uses a snap feature to connect junctions to other branches and junctions. The move tool can also be used to detach a branch from a junction. To perform this function, use the move tool when no branches are selected and click and hold on a desired branch. The part of the branch closest to the junction that you have selected will detach from the junction and create a new one. This new junction can now be moved.

2.3 Branch Data View

Branch Data dialog box is one of the most important tools in VNet. Branch parameters can be changed from this window as well as adding Fans or Fixed Quantities and Contaminants. Hardy Cross Simulation results of branches can also be shown here. Use the tabs on the right of the box to switch between the data types.

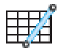
VNet now supports the editing of multiple branches at once. Every branch selected will add to the total number of branches selected until the user hits the Esc key. Once a single branch or multiple branches are selected, editing is done in Branch Data dialog. Parameters that are shared between branches show up as a value. If there is a difference between any of the branches the parameter will display as *Varies*. Changing any of the parameters will change the values for all of the selected branches. For changes to take effect the user must hit “Apply”.

2.4 Display

Use the Tray icons at the bottom of the program widow to quickly change what is displayed in the Model view. VNet supports displaying many types of data and results as text on the Branches. Select the Parameters button on the Ribbon to choose the data to be displayed. Branches can also be colored by range of data. The Color Wheel button in the Tray icons can be pressed to change the color of the branches. If this icon is displayed branches are colored based on branch type. The branch type color can be modified in the Branch Types View. If this icon is displayed branches based on the selected range of parameters for each branch is displayed. This icon turns all colors off.

When rotating and zooming in Model view the viewpoint will be centered around the last selected Branch(es) unless the user pans across the model.

2.5 Results

After executing the model, all of the branch results can be found in branches view by clicking the Branches button  in the Ribbon. Results can be shown on Branches using the parameters button  in the Ribbon. Results for a single branch can be seen in Branch Data dialog.

2.6 Terminology Changes

There have been several terminology changes from the VnetPC to VNet, and they are noted below.

Vnet PC Terminology	VNet Terminology
Visualizer and Schematic View (combined)	Model view (main window showing 3-D computer generation of model)
Branch Code	Branch Type
Branch Groups	Layers
Branch Input View and Branch Results View (combined)	Branches View
The "Parameter" menu under Preferences has been given its own view.	Parameters View
The "Define Colors" menu under Preferences has rearranged in other views.	Parameters View and Branch Types View
Preferences and Tools drop down menus	User Preferences and other views

3. Overview of VNet

Welcome to the newly redesigned VNET, optimized for ease of use. The VNET program is designed to assist the mine ventilation practitioner in the planning and monitoring of underground ventilation layouts. Given data that describes the geometry of the mine network, airway resistances or dimensions, and the location and characteristic curves of fans, the program will provide graphical and tabular representations of various predicted ventilation parameters.

3.1 VNet: Its Applications and Uses

VNET can simulate existing ventilation networks such that fan operating points, airflow quantities, and frictional pressure drops approximate those of the actual system. This is accomplished using data from ventilation surveys together with information determined from known airway dimensions and characteristics. Proposed subsurface facilities may also be designed using VNET. Such simulations are conducted by incorporating physical input data from conceptual plans with documented design parameters used to determine estimated resistances for airways in the network. The range of fan duties required, airflows, pressure drops, operating costs, and the location of ventilation controls may be ascertained for the entire life of a project by conducting time-phase exercises. Options within VNET allow for the display of parameters and manipulation of three-dimensional networks, plots of the model scene, input and output data.

3.2 Background Theory of VNet

The VNet program has been developed with the assumption of incompressible flow and is based on Kirchhoff's Laws. The code utilizes an accelerated form of the Hardy Cross iterative technique to converge to a solution.

3.3 List of Main Program Features

- All new immersive animated 3D network editor
- Enhanced, expandable coordinate system
- Data input and output graphically or through tabular views
- Color coding of branches for airway type (user defined)
- Import DXF files from CAD and mine planning programs to rapidly create new branches
- Attach Reference DXF files for better visualization and to aid in branch creation
- Ability to enter series and parallel arrangements for fans
- Imperial and SI units with full data conversion

- Automatic allocation of surface branches to close meshes among surface nodes
- Notepad to enter detailed description of simulation
- Automatic calculation of branch length from coordinate values
- Regulator orifice sizing tool
- Online support through www.mvsengineering.com
- Export DXF files to CAD and mine planning programs – parameters exported as displayed
- Four input data types for branch resistance
- Steady state contaminant distribution analyses
- Fixed quantity tool
- Color coding of branches for range of parameters (airflow, pressure, etc.)
- Cut/copy/paste features for data exchange within Windows
- Variable frequency drives – fan curve adjustments for density and frequency (RPM)
- Edit branches in multiple views
- Fan curve graphics with current operating point displayed
- Import fan curves created in DuctSIM or VNet
- Transient time calculator based on user-selected path
- Branch templates
- Branch layers (enables user to turn specific layers off/on in display)
- Multiple branch selection and editing
- Editing single or multiple branch properties with templates
- Scroll wheel zooming
- Zoom to cursor
- Pan with center mouse wheel
- Orbit with right mouse button
- Fan stall warnings
- Shock loss calculator with reference material
- Resource attachments allow display of mine plans, ore bodies or topographic maps
- Branch and fan power usage

3.4 Minimum System Requirements of VNet

- IBM Compatible Computer running Windows Vista, Windows 7 or Windows 8
- Intel Pentium class processor or above
- 1 GB RAM Memory
- 100 MB Hard Disk Space for the VNET program (additional for Adobe Acrobat Reader™)
- USB Slot (HASP Key)
- VGA Display

3.5 Software Encryption

The VNet program is protected by a software hardlock (HASP). The hardlock device is installed on a USB port of the computer or server (Net-HASP). After the VNet program is installed, the hardlock device drivers must be installed. If your PC has an active internet connection, Windows may download and install the necessary drivers automatically. For the single user version of VNet, the driver installation routine will be located on the installation Flash Drive, for the multi-user version of the program the driver installation routine will be located in a separate "Net-HASP License Manager" directory.

If any problems are encountered please contact MVS. MVS can be reached at; phone (559) 452-0182, fax (559) 452-0184, or e-mail technical support at **support@mvsengineering.com**.

3.6 Setup Procedure

The VNET program is shipped as a single installation file on an MVS USB Flash Drive (VNET.msi). The following installation instructions will assist you in achieving a trouble-free installation, regardless of what operation system you are running, or whether or not you already have a version of VNET installed on your machine.

1. Insert the MVS USB Flash Drive into any available USB slot and execute the self-installing utility program from VNET.msi.

   The default install directory is C:\Program Files\Mine Ventilation Services, Inc.\ or other as specified by the user. The installation process creates the directory and inserts the associated program and ancillary files. When the installation is complete, a shortcut for VNET will appear on the desktop.

2. Plug the HASP key tag into an available USB port. Windows should automatically install the latest device drivers for the HASP key if your computer has an active internet connection. If Windows does not install the HASP device drivers automatically, the device drivers can be found on the MVS USB Flash Drive, or at our website: www.mvsengineering.com.

   Once the installation of the HASP device drivers is complete, a red light will activate in the end of the HASP key tag. The red light will remain on as long as the HASP key tag is plugged into the machine and is functioning properly.

3. Click on the shortcut to start VNET. Begin modeling by defining the model information, draw a ventilation network, assign airway parameters and define fans. There are four ways to begin a new model.
    1. When the program opens, a tab labeled 'newmodel' opens, which is a blank model.
    2. Select the large blue VNET icon located at the upper left to enter the backstage. Click on the first menu option, New.
    3. Click on the icon in the quick access button strip, in the upper left corner of the program window.
    4. Click the blank tab, to the right of any open model tabs to begin a new model.
4. Select Model Information from the VNET command Ribbon, select model units and enter model specific information, such as Cost of Power and Avg. Air Density plus any revision comments.

Congratulations!! You may now begin using VNET ventilation simulation program.

If you have any further questions with regard to the installation process, or the operation of this or other MVS software, please feel free to contact us by telephone: 1-559-452-0182 or email: support@mvsengineering.com.

3.7 Data Preparation and Input

VNET is structured such that the user moves between the graphical scene and data views, or dialog windows, where input and output data are located. A single database is used for the network input, junction coordinates, and contaminant data. Separate archive files are used to transfer and store different fan curves. Creating, importing, exporting, editing, or viewing fan curves are performed within the VNET program. The VNET program comprises nine views for the input and display of program data. The screens are displayed on the command Ribbon with individual buttons. These views are:

- Branch Data View
- Model Information View
- Branch List View
- Branch Templates View
- Fan List View
- Fixed Quantities View
- Junction List View
- Branch Types View

This section details the content and form of the input data required for the VNET program. The data requirements are presented in eight categories:

1. Ventilation Network (page 15)

2. Descriptive Data (page 16)
3. Branch Data (page 18)
4. Fan Data (page 44)
5. Fixed Quantity Tool (page 49)
6. Contaminant Distribution Data (page 51)
7. Branch Template (page 52)
8. Transient Time Calculator (page 55)

3.8 Program Layout and Functions

The layout of VNet is similar to latest popular windows based programs such as Microsoft Office or AutoCAD. The main file saving and opening functions are found by clicking the Backstage Button. A Quick Access Toolbar is provided at the top of the window for quick saving the file and for undo and redo functions. The Ribbon consists of several buttons that lead to all of the tools to create and edit a model. The Tray icons are provided to quickly change how the model is displayed in Model view. Figure 1 displays the layout of VNet.

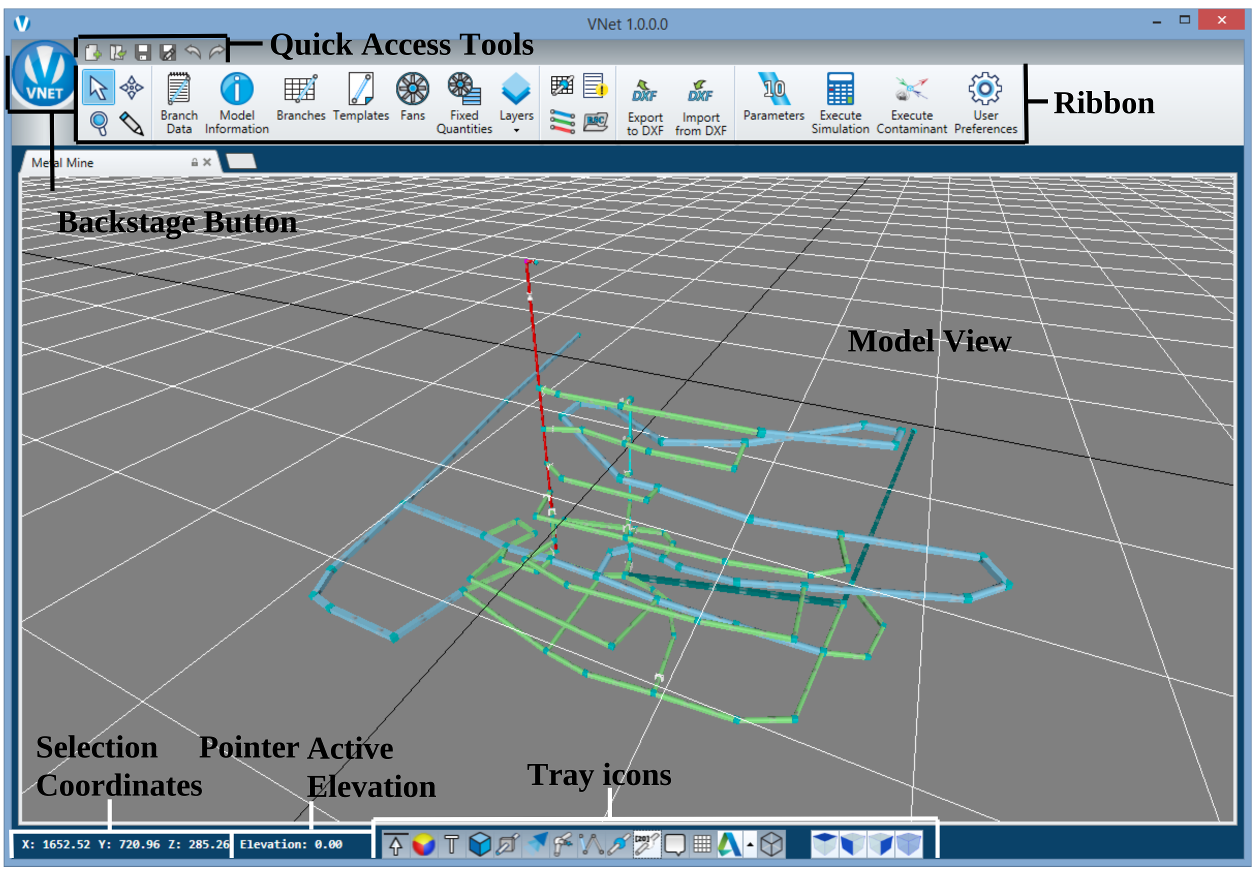


Figure 1: VNet Layout

3.9 Ventilation Network (Model View)

A ventilation network is a graphical representation of a ventilation system that consists of a set of junctions and interconnecting lines (branches) which represent air courses in the underground facility. The following subsections describe the network requirements.

3.9.1 Closed Circuit

The network schematic must consist of interconnected branches that form closed circuits. Each branch should represent a single airway, a group of airways, or leakage paths. VNET will automatically close those branches connected to the surface, as long as the user specifies them as being "In Atmosphere". The option to select the atmospheric connection of the various network branches is located in both the Branch Data View and Branches view.

3.9.2 Junction Numbers

Junction numbers must be assigned to each junction in the schematic. Valid numbers are whole integers. The modeler may select a starting junction number or VNET will automatically allocate junction numbers for new branches drawn in the scene or for data imported from a DXF file.

3.9.3 Schematic Layout

Two methods can be used to enter the schematic into VNET:

1. Draw the schematic in a CAD or mine planning program (established as a unique layer, named by the user) and import to VNET. This method is typically adopted when the user wants to overlay the ventilation network on a mine plan (within a CAD program).
2. Directly plot the network on the screen using the VNET drawing tools (acceptable for smaller networks and where precise geometry is not necessary).

3.10 Descriptive Data

Descriptive data consists of both required and optional information for documentation and program initiation. This information is modified in the Model Information view. The Model Information view allows data to be directly entered into fields as shown in Figure 2.

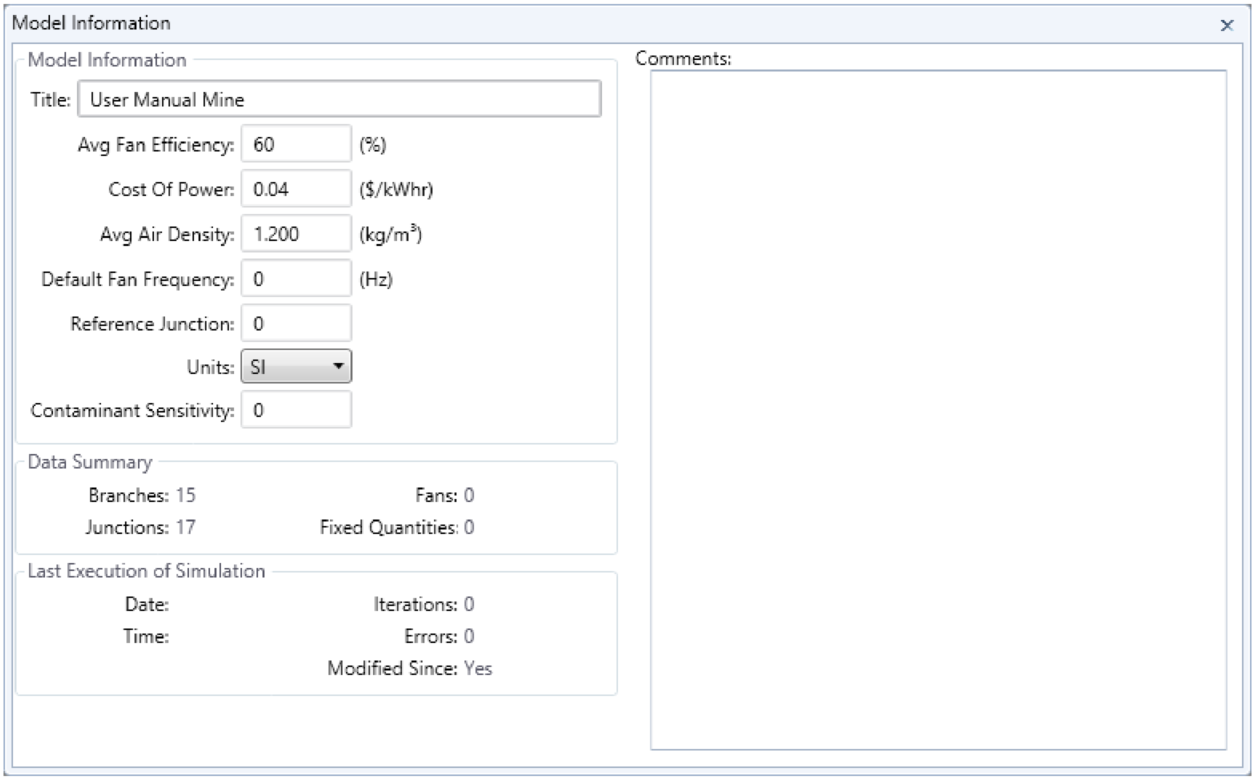


Figure 2: Model Information View

The following subsections describe the input and required format for the data in the Model Information view.

3.10.1 File Name

A file name must be assigned when saving the file for the first time, or when utilizing the “Save As” command under the File menu. When a file is saved, the program automatically prompts for the extension *.vds*.

3.10.2 Units

VNET supports both Imperial and SI units. The user must initially specify one type of engineering unit; however, should the user decide to change units, an automatic conversion feature is available. This conversion feature is available from the Model Information view. In the Model Information view, there is a Units menu button that allows the user to switch between units. The conversion utility converts all the input data including the fan curves. It is important that the user executes the Hardy Cross following unit conversion. In rare cases during conversion, one or more data values may become out of range, and the program will truncate the values. However, this will only occur if the original network contains extremely high input parameters, and the truncated values should still be sufficiently large so that network accuracy is not impacted.

3.10.3 Power Cost

The user should enter an electrical power cost to determine the operating cost for the system fans. Power costs are provided in unit/kWh, where the unit may be any currency.

3.10.4 Air Density and Regulator Sizing and Shock Loss Calculator

The user is required to input an average air density for the underground facility. This value is needed to compute the orifice area for any regulators listed in the Fixed Quantities view. The average air density parameter is also used to calculate shock losses which are added to the total branch resistances.

3.10.5 Notepad (Comments)

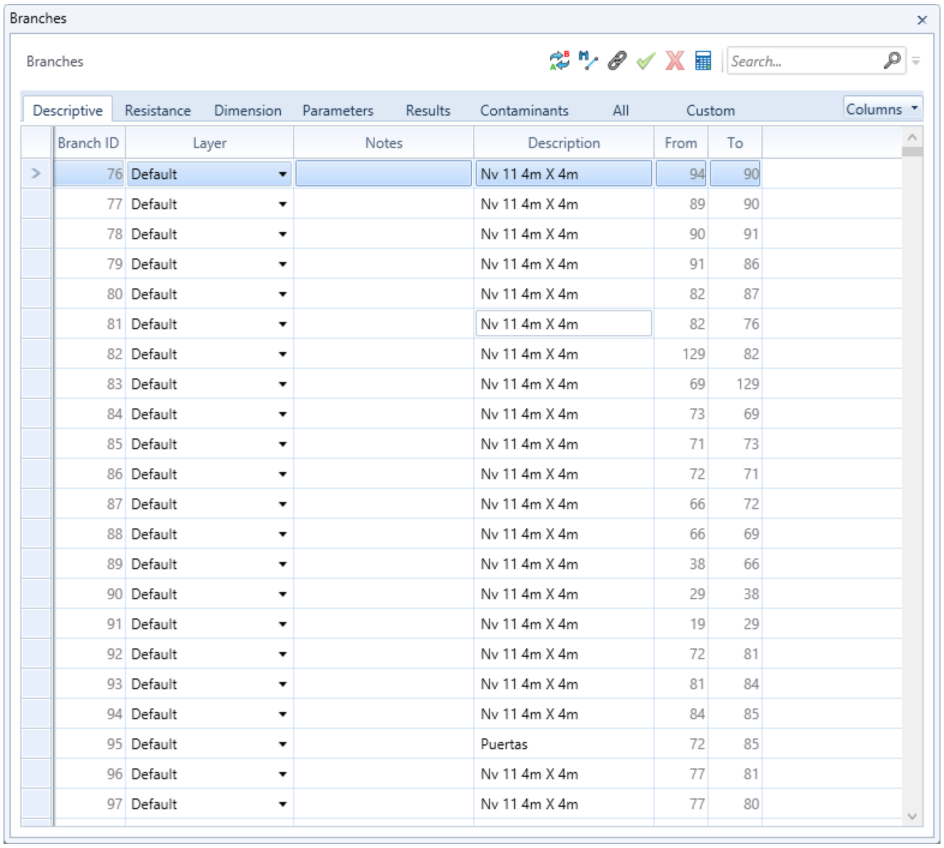
There is a large text field available, in the Model Information view, to enter a detailed description of the particular model. Information may include a title, summary of results, and the specific details associated with that model. Ventilation surveys, revision dates and details of correlation efforts can also be recorded here.

3.11 Branch Data

3.11.1 Branch Data Formats

Each branch is defined by two junctions and by numerical data that indicate the characteristics of the airway. Once data is entered into the program, the data will remain until deleted or overwritten by new data of the same format. If the resistance type is changed to a different data format, original data entered for other formats will be retained and available though inactive.

VNet recognizes four branch data formats: Resistance (R), Pressure Loss and Airflow Quantity (p/Q), Atkinson Friction Factor (k-factor), and Resistance per Branch Length (R/L). A branch data format is chosen for each branch depending on available airway information. The format for each branch is independent of the other branches in the model and can be changed at any time. The available branch types may be accessed in the Branches view, as shown in Figure 3, from selecting the Branches icon . These types can also be set or modified in the Branch Data View from the Model view as shown in Figure 4.



Branch ID	Layer	Notes	Description	From	To
76	Default		Nv 11 4m X 4m	94	90
77	Default		Nv 11 4m X 4m	89	90
78	Default		Nv 11 4m X 4m	90	91
79	Default		Nv 11 4m X 4m	91	86
80	Default		Nv 11 4m X 4m	82	87
81	Default		Nv 11 4m X 4m	82	76
82	Default		Nv 11 4m X 4m	129	82
83	Default		Nv 11 4m X 4m	69	129
84	Default		Nv 11 4m X 4m	73	69
85	Default		Nv 11 4m X 4m	71	73
86	Default		Nv 11 4m X 4m	72	71
87	Default		Nv 11 4m X 4m	66	72
88	Default		Nv 11 4m X 4m	66	69
89	Default		Nv 11 4m X 4m	38	66
90	Default		Nv 11 4m X 4m	29	38
91	Default		Nv 11 4m X 4m	19	29
92	Default		Nv 11 4m X 4m	72	81
93	Default		Nv 11 4m X 4m	81	84
94	Default		Nv 11 4m X 4m	84	85
95	Default		Puertas	72	85
96	Default		Nv 11 4m X 4m	77	81
97	Default		Nv 11 4m X 4m	77	80

Figure 3: Branches View

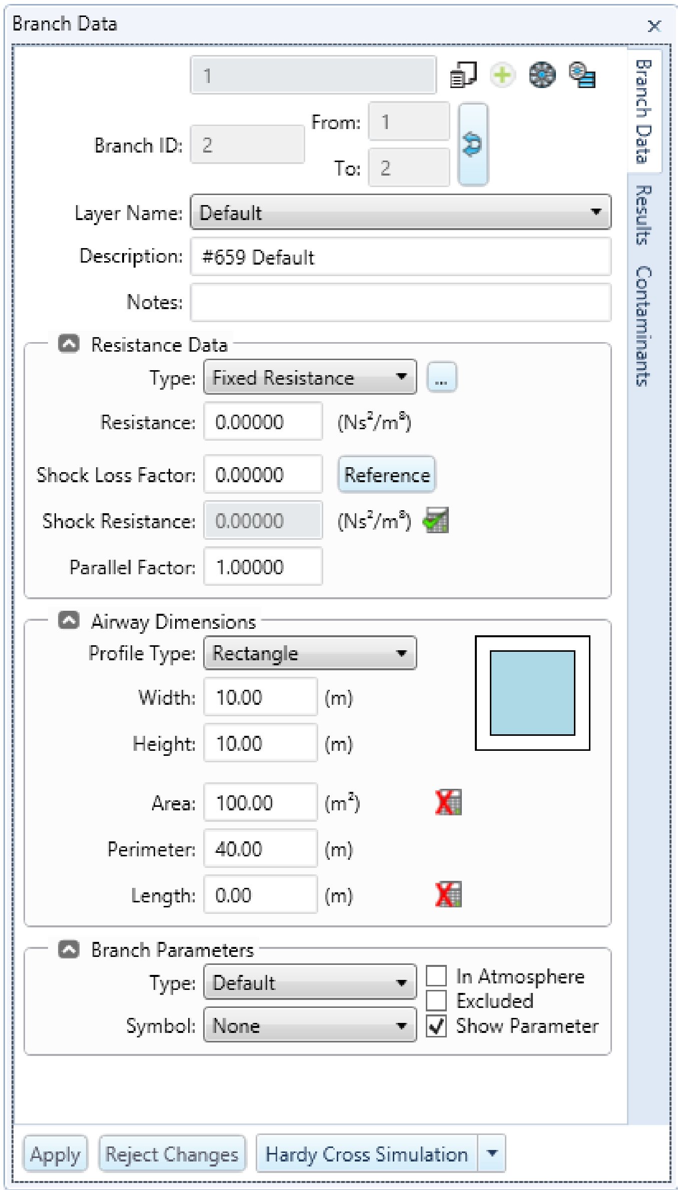


Figure 4: Branch Data View.

The Branch Data View can be accessed from the Model view using the Selection Pointer. It is available by selecting the Selection Pointer icon on the Ribbon, or simply pressing the escape key. Right click the desired branch with the Selection Pointer and choose Branch Data from the drop down menu or double click a branch. Using any of these methods will call up the Branch Data View, illustrated in Figure 4. Branch types and other branch data can be changed in this view. To accept any changes the apply button must be pressed or any changed data will be lost.

3.11.1.1 Resistance Data

The Resistance data type (R) requires that a resistance value be input for the branch. This data type is useful for branches with a known or previously computed resistance. A common example would be adding a stopping or door using an average resistance value calculated from survey data. Typical resistance values for ventilation controls can have the following ranges (shown in Practical Units [P.U.]):

Doors:	5-50 P.U.	(Typical = 25 P.U.)
Seals:	1,000-10,000 P.U.	(Typical = 2500 P.U.)
Curtains or Brattices:	1-5 P.U.	(Typical = 2.5 P.U.)
Bulkheads or Stoppings:	50-5,000 P.U.	(Typical = 1,500 P.U.)

When a new branch is created in model view, the default branch type is designated by the active row in Branch Templates. Please see section 3.15 for more information on Branch Template data entry.

3.11.1.2 Pressure Drop and Quantity Data

The p/Q data input type requires pressure loss and volume flow values to be input. These values are typically obtained from a pressure-quantity survey using the gauge and tube method for pressure loss and vane anemometers for airflow quantity. VNet calculates the resistance, R, on the basis of the Square Law, as given in Equation 1. Directly entering survey data allows the user to bypass a calculation step when preparing data and helps facilitate correlation between measured airflow values and those resulting from the model simulation.

Equation 1:

$$R = \frac{p}{Q^2}$$

Where:
- R = airway resistance (Practical Unit *[P.U.]* or Ns^2/m^8)
- p = pressure drop (milli inch w.g. or Pa)
- Q = flow rate (kcfm *[$\times$ 1000 cfm]* or m^3/s)

3.11.1.3 Atkinson Friction Factor (k-factor)

The k-factor resistance data type requires the physical characteristics of the airway to be input, including: Atkinson Friction Factor (k-factor), length (L), equivalent length of shock loss (L_{eq}, if desired), perimeter (P_{er}), and cross-sectional area (A). This data type computes branch resistance using an empirical formula known as Atkinson's equation, expressed below in Equation 2:

Equation 2:

$$R = \frac{k(L + L_{eq})P_{er}}{cA^3}$$

Where:
- R = airway resistance (Practical Unit or Ns^2/m^8)
- k = friction factor (lbf $min^2/ft^4 \times 10^{-10}$ or kg/m^3)
- L = length of airway (ft or m)
- L_{eq} = equivalent length of shock loss (ft or m)

A = area (ft^2 or m^2)
P_{er} = perimeter of airway (ft or m)
c = constant (Imperial = 52 and SI = 1)

VNet verifies each entry as it is input and, if invalid, requests re-entry. It should be noted when inputting a value for k-factor in Imperial Units into the branch: the 10^{-10} factor must not be included in the entry. Hence, for a typical airway with a k-factor of 65 $\times 10^{-10}$ lbf min^2/ft^4, the user would enter only 65. **Note that VNet uses an Imperial constant of 52 not 5.2 in the Atkinson Equation. This allows the Atkinson friction factor to be entered directly without including the 10^{-10} factor. The resulting unit is termed the Practical Unit (PU).** This same unit is obtained from the Square Law by using milli inch w.g. (thousandths of an inch w.g.) and kcfm (thousand cubic feet of air per minute).

To facilitate input of friction factors, a user-defined list of k-factors may be accessed by clicking the  button on the Branch Data View when k-factor is selected as the Resistance Data Type. The Select Friction Factor dialog box will appear as shown in Figure 5. Use the selection pointer and left mouse click on a cell in the row of the desired k-factor and press 'OK' to apply the k-factor to the branch.

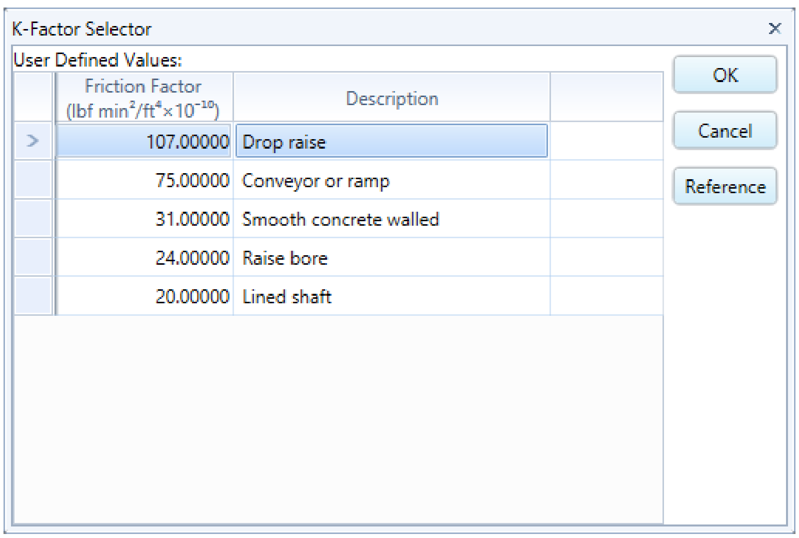


Figure 5: Friction Factor Dialog Box

The 'Select Friction Factor' feature allows the user to enter a k-factor value and description for each variety of airways to be modeled with the k-factor data type. These stored values can then be recalled rapidly to populate resistance data for future branches. Atkinson Friction Factor data type (k-factor) may also be entered by using Branch Templates. Please see Section 3.15 for more information on Branch Template data entry.

3.11.1.4 Resistance per Length Data Format

The resistance per unit length (R/L) data type allows the user to input an empirical resistance per length value for the airway and requires branch length. Equivalent length of shock losses may also be entered if desired. Resistance per unit length values for the airways being modeled are typically obtained from survey results or empirically computed using suitable friction factors and airway geometry.

It is most common to use this data type for extending existing airways without requiring the calculation of k-factors. This is only effective if characteristics such as the dimensions of the opening, roof control methods, and airflow obstructions are consistent along the length of the airway. Resistance per length values are typically calculated as the average of the values of several similar airways. This will eliminate anomalies that commonly occur during ventilation surveys and yield more realistic results than values from a single branch.

The process for entering R/L values is identical to that for entering k-factors in Model view. To facilitate input of R/L values, a user-defined list of R/L values may be accessed by clicking the ... button on the Branch Data View when R\L is selected as the Resistance Data Type. The Select Resistance per Length dialog box will appear as shown in Figure 6. Use the selection pointer and left mouse click on a cell in the row of the desired R/L value and press ‘OK’ to apply the R/L value to the branch. Note: Resistance per length values are input per 1,000 units (ft or m).

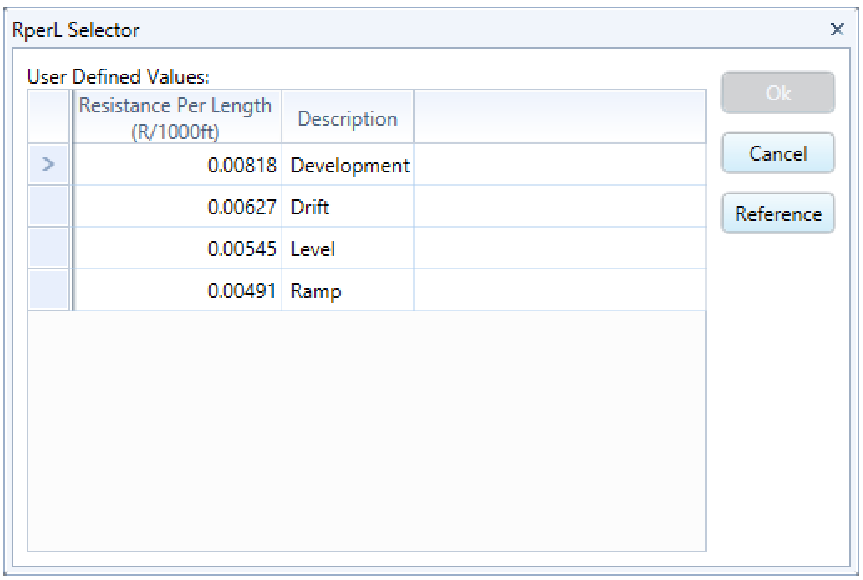


Figure 6: Resistance per Length Values Dialog Box

The ‘Select R per L’ feature allows the user to enter an R/L value and description for each variety of airways to be modeled with the R/L data type. These stored values can then be recalled to populate resistance data for future branches. Resistance per unit length data type (R/L) may also be entered by using Branch Templates. Please see Section 3.15 for more information on Branch Template data entry.

3.11.1.5 Automatic Length Tool

The VNet program incorporates an automatic length tool to provide a length value based on junction coordinates. This feature can be activated for each branch through the appropriate column in the Branches view and through the Branch Data View in the Model view.

If the automatic length feature is enabled, the program will calculate the branch length based on the x, y and z coordinate data of the two junctions that define the branch. This feature is commonly activated when the model is created to scale from a DXF file. It is important to note that VNet assumes that each division (coordinate) in Imperial units is 1 foot and in SI Units is 1 meter. The units of a source DXF file must be identified correctly when imported as this cannot be adjusted afterward.

When Auto Length is enabled, the length field will become “read only” or “grayed out” in both the Branches and Branch Data Views. This is indicated by changing the color of the text and fill of the field. The user will not be able to edit this inactive field while Auto Length is enabled.

Modifying junction locations or creating a not-to-scale model can make viewing and manipulating the model easier. The automatic length tool will update the branch length when there has been a change in the location of one of the junctions. When modifying junction locations with the Auto Length off, care should be taken to enter correct airway lengths by hand in order to achieve realistic branch resistance values when using the k-factor and R/L data formats. This is especially important for branches used to represent shafts and raises.

During unit conversion, the length of branches is converted automatically regardless of Auto Length status. The coordinates in the Model view are also converted, resulting in updated length data from the automatic length feature.

In both Branches view and Branch Data View the symbol for auto length turned on is , and off is .

3.11.1.6 Auto Calculate Area / Perimeter Tool

The VNet program incorporates an automatic area and perimeter calculator tool based on airway dimensions. This feature can be activated for each branch by checking the calculator icon in Branch Data View in the Model view or the appropriate column in the Branches view. When the auto calculate area/perimeter tool is turned on the symbol is , and when it is off the symbol is . In order to calculate the proper area the user must provide the proper Profile Type information for the Airways and check the box labeled “Area / Perimeter Auto Calculate”. The three profile types available in VNet are Rectangle, Circle, and Arched. Each profile type includes a preview window that displays a graphical representation of the airway. If improper or unrealistic dimensions are entered for the profile type, an error message will appear in place of the graphical representation. This feature may be deactivated by unchecking the box so that the user may enter the area and perimeter manually.

When the Auto Calculate Area/Perimeter Tool is enabled, the Area and Perimeter fields will become "read only" or "grayed out" in both the Branches and Branch Data Views. This is indicated by changing the color of the text and fill of the field. The user will not be able to edit this inactive field while the Auto Area/Perimeter Calculated Tool is enabled.

Rectangle Profile Type

The Rectangle Profile Type requires two user inputs height and width to calculate area and perimeter. Maximum values for height and width are 100 meters or 328 feet. However, if the height to width ratio (or width to height ratio) is greater than 10:1, then an error massage will appear. This is to prevent the user from accidentally entering unrealistic values. Figure 7 displays the portion of the Branch Data View that shows the Rectangle airway profile type.

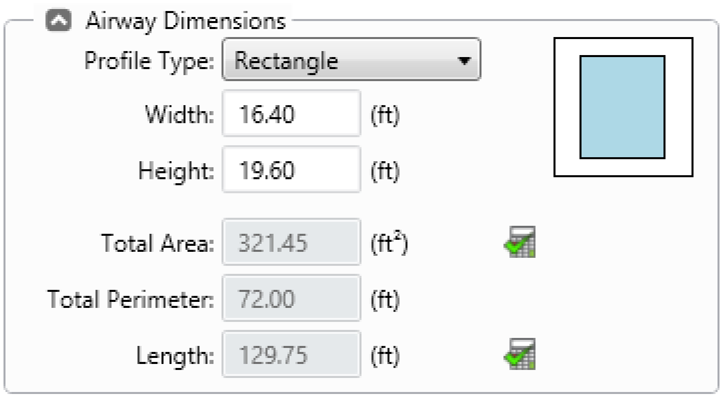


Figure 7: Rectangle Profile Type

Circle Profile Type

The Circle Profile Type requires only the diameter to calculate an area. Maximum values for diameter are 100 meters or 328 feet. The Invert Height cell represents the portion of the circular opening that is typically filled or used for another purpose. For a level or slightly inclined opening the filled in portion is often times used for a road or other travel way. For a shaft, this filled in portion can represent the other part of a split shaft for hoisting or other mine function. The Invert Height cell can be input at any length less than or equal to the radius of the circle. If a length larger that the radius is input, VNet will flag the user with a warning message in place of the graphical representation. Figure 8 displays the portion of the Branch Data View box that shows the Circle airway profile type.

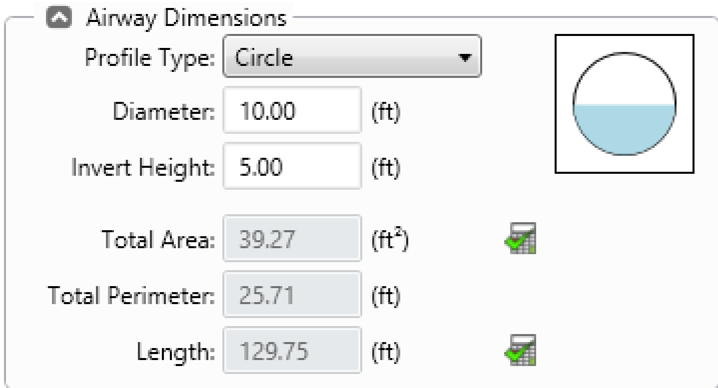


Figure 8: Circle Profile Type

Arched Profile Type
The Arched Profile Type requires the user input width, center height, and rib height for calculation of the area. Maximum values for width, center height, and rib height are 100 meters or 328 feet. The center height is the distance from the center of the floor to the top of the roof. The rib height measures the height of the side walls. The rib height may also be automatically calculated from the Arch Factor. The user must simply check icon next to “Auto Calculate from Arch Factor” and enter an appropriate value in the cell labeled Arch Factor. When auto calculate arch factor is turned on the symbol next to Arch Factor is , and when it it is off the symbol is . If the Arch Factor is too low or too high, the program will prompt the user to enter an Arch Factor between a set of possible values. Arch Factor values vary depending on the dimensions selected. Figure 9 displays the portion of the Branch Data View that shows the arched airway profile type.

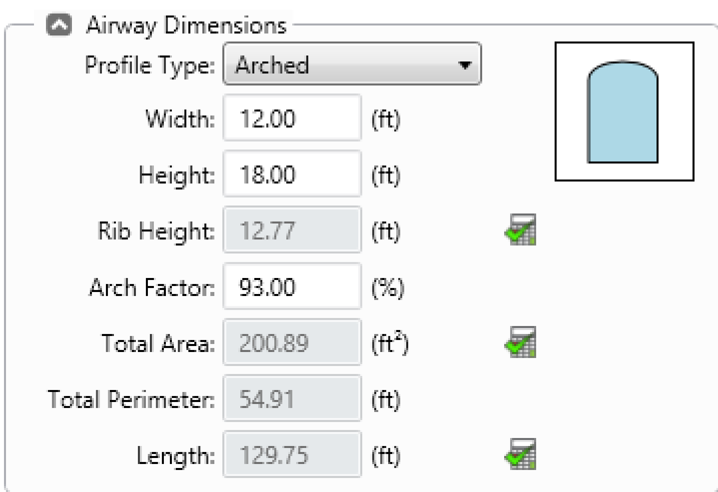


Figure 9: Arched Profile Type

3.11.1.7 Shock Loss Calculator

The VNet program incorporates a tool to calculate and apply shock loss resistances to branches. This feature can be activated for each branch through the Branch Data View in the Model view or the appropriate column in Branches view.

A shock loss resistance may be added to any branch in the ventilation model. A user defined resistance may be added or a shock loss factor may be placed in the model to allow VNet to auto calculate a shock loss resistance. To use a shock loss factor and auto calculate the resistance, the symbol next to "Shock Resistance" must be turned on. When off the icon has a red x mark much the same as auto calculate area/perimeter or auto length tools.

In order for VNet to calculate the shock loss resistance, users must define three parameters; airway cross-sectional area, average mine air density, and Shock Loss Factor. The cross-sectional area is user defined for each branch in the Branch Data View or the Branches view. The area may be either input manually or calculated based on the profile type dimensions directly above the area cell in the Branch Data View. To calculate the area from the cross-sectional area dimensions, the user will need to check the box labeled Area/Perimeter Auto Calculate. If the user changes the cross-sectional area after calculating the Shock Resistance, VNet will recalculate the shock loss resistance and update the value automatically.

The average mine air density is user defined on the Model Information view. Shock loss (X) factors may be defined as the number of velocity heads that give the frictional pressure loss due to turbulence at any bend, variation in cross-sectional area, or any other configuration that causes a change in the general direction of airflow. Users may select Reference for additional information for selecting a Shock Loss Factor. After users enter a shock loss factor the calculated shock loss resistance will appear in the Branch Data View. An example of this is displayed in Figure 10.

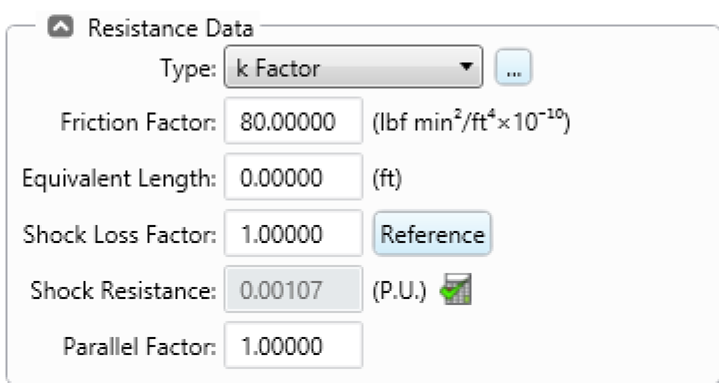


Figure 10: Shock Loss Factor Entry Box

3.11.1.8 Parallel Branch Tool

A tool is available to allow the user to rapidly adjust the resistance of a branch according to parallel network theory. This tool is accessible in both the Branches view (Parallel Factor column) and in Branch Data View > Parallel Factor. The user may enter a number, with the default being 1. If the user selects a 2, then the code will adjust the input branch resistance to double the number of airways represented by the branch. If the user were to enter 0.5, then the resistance would be adjusted to give half the number of airways represented in the branch. If the user enters 1, then the resistance is reset to the original value. During ventilation surveys, resistances are determined for parallel entries and are input directly to the model. Although only one branch is modeled it will sometimes actually represent two or more parallel entries. Care should be taken to identify exactly how many entries are incorporated into the original resistance value.

In previous versions of VNet formally VnetPC, shock loss resistances were only added as separate resistances in the model. Changing the Parallel Factor did not affect the overall shock loss resistance of a set of branches. For instance, if a single branch had a shock loss of 1.0 P.U. and the user applies a parallel factor of 2 (creating two parallel branches each with a shock loss of 1.0 P.U. instead of a single branch), the new overall shock loss resistance of the combined branches would still have been 1.0. The user would have had to change the shock loss from 1.0 to 0.25 in order to properly represent the new branches. VNet accounts for this change in the model and the user need not re-enter new shock losses every time parallel factors are changed.

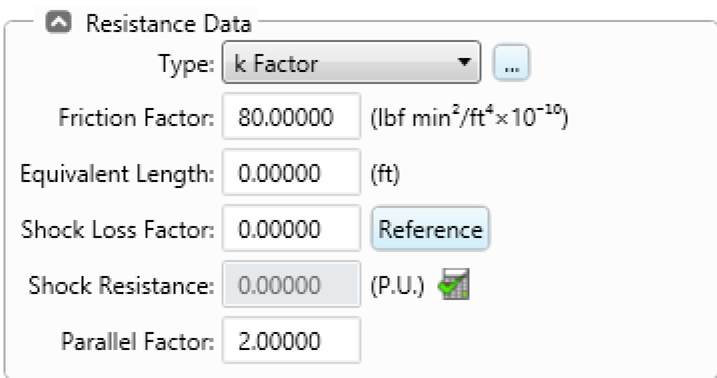


Figure 11: Parallel Factor Entry Box

3.11.2 Branches Input

Branch characteristic data can be modified in a manner typical of spreadsheets in the Branches view. To accept any changes, the apply button must be pressed or any changed data will be lost when closing the window or executing the model.

All of the information pertaining to a branch can be found in the Branch view. Tabs on the Ribbon can be selected to display the representative set of data including results. The tabs in Branches view are as follows: Descriptive, Resistance, Dimension, Parameters, Results, Contaminants, All, Custom. A button in the upper right corner of the view is a pull down menu that lists all of the available columns that can be displayed. Checking a descriptor field can show or remove the corresponding column in the selected tab.

Above the column tabs is several icons. The first is the find and replace icon. This button allows for a search and replace of values and text in a selected sheet. The Replace option allows the user to make single-column or global changes to the input data. When selecting a row in one of the tables the Show Branch icon can be pressed to show the location of the branch in Model view. The Link/Unlink icon will be used in future iterations of VNet as a new feature but is currently not utilized. The apply button needs to be pressed to accept any changes made to the sheet. The button will reject changes made to the sheet. The Execute button can be pressed to execute the Hardy Cross simulation. Next to the buttons is the search bar. Entering text or numbers into the bar will display only the branches containing the number or phrase typed into the box.

3.11.2.1 Backstage

The backstage button , located at the top left of the screen, is where file saving and opening functions are found. In this area, a new model can be created, previously saved model opened, close a model, save model, save the model under a new file name and undo/redo changes to a model. The backstage also allows for previously opened models to be quickly accessed the Recent list. Demonstration models are also provided. Note that saving of a demonstration model has been disabled. VNet also has an import function for models created with VnetPC. After the import of a model the user should save the model in VNet's ".vds" file format before making changes. The model needs to be executed after saving as the model results are not carried over during the import. Figure 12 displays the Backstage view.

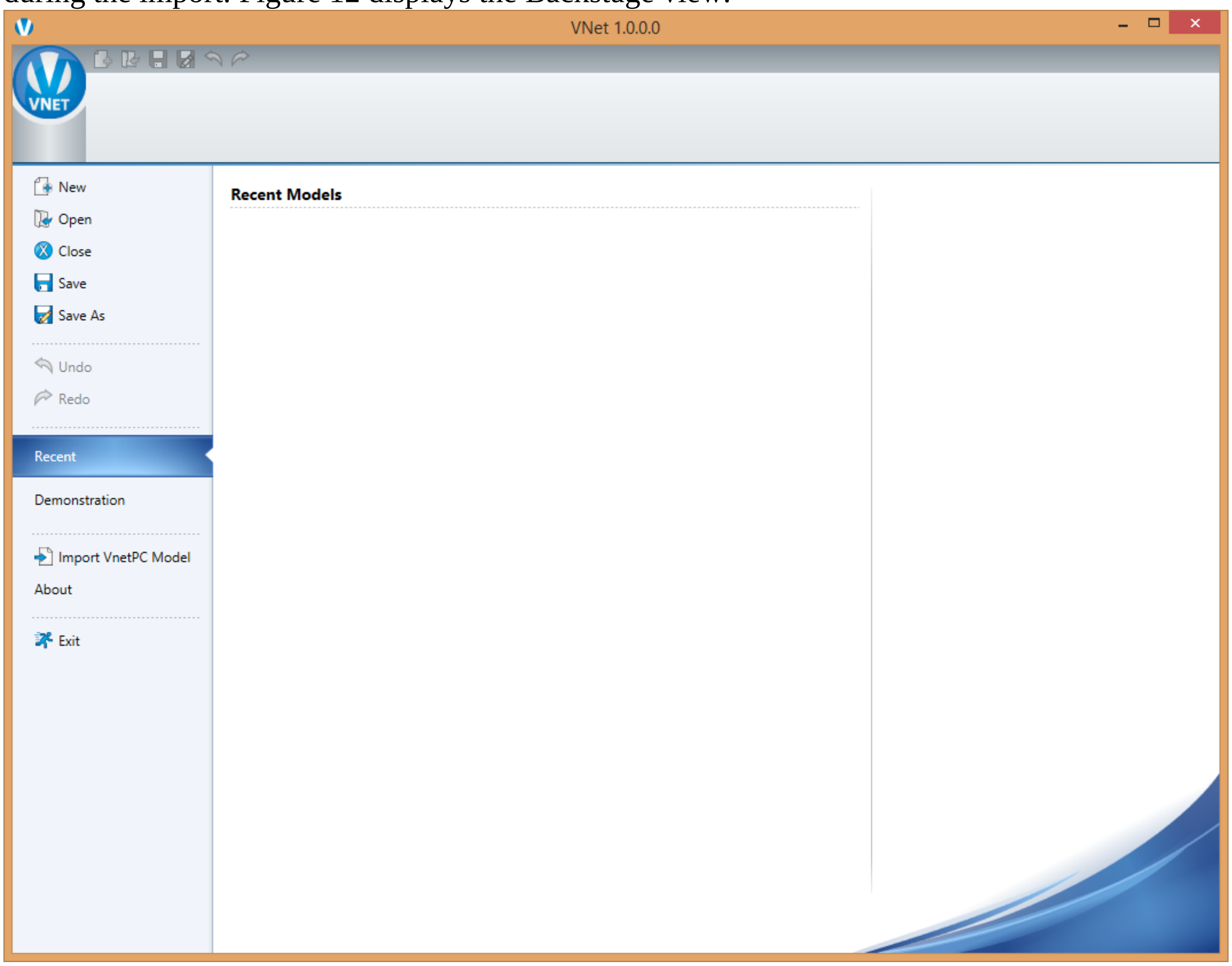


Figure 12: Backstage View

3.11.2.2 Ribbon

Networks are established using functions obtained from the Ribbon. This Ribbon allocates different functions to the selection pointer. The following list of functions is available:

- Selection Pointer
- Move Tool
- Zoom Tool
- Draw Branch
- Branch Data View
- Model Information
- Branches view
- Branch Templates
- Fans
- Fixed Quantities
- Layers
- Junction view
- Error List view
- Branch Types view
- Import DXF Overlay
- Export to DXF
- Import from DXF
- Parameters
- Execute Hardy Cross Simulation
- Execute Contaminant Simulation
- User Preferences

The ***Selection Pointer*** is the default option. This allows the user to highlight branches and by pressing the right mouse button change the attributes of those branches. Selection pointer will be restored when the 'Esc' key is pressed. Double left-click of the mouse on a branch will bring up

Branch Data View. A right-click of the mouse on a branch or junction will bring up a sub-menu of options.

The ***Move Tool*** allows for selected branches and junctions to be moved. Movement is limited to the X-Y plane unless Ctrl is held down limiting movement to the Z plane. When using the move tool a snap feature can be used to connect junctions to other branches and junctions. The move tool can also be used to detach a branch from a junction. To perform this function, use the move tool when no branches are selected and click and hold on a desired branch. The part of the branch closest to the junction that you have selected will detach from the junction and create a new one. This new junction can now be moved.

The ***Zoom Tool*** allows the user to resize the view rapidly. A section of the network may be expanded by dragging the mouse over the selected area while holding down the left mouse button. The user can also press the left mouse button to zoom-in. The zoom –in/out tool is also enabled by scrolling the center wheel on the mouse even when the Zoom Tool is no selected. A double center-click of the mouse will also zoom to the extents of the model in any tool.

The ***Draw Branch*** tool allows new branches to be drawn. The program automatically allocates junctions at the start and end of these branches, unless the user clicks on an existing node. If an existing airway is used for a starting or termination point, then the branch will be divided and a new node will be added. The divided airway will be represented by two new branches, one branch that retains the "From" junction, and one that retains the "To" junction from the original branch. The user-entered pressure loss, fixed resistance, and length values from the old branch will split between the new branches according to length ratio. User entered data for Shock Resistance, Fan/Fixed Q, and In Atmosphere will only be retained by the "From" branch. The X-Y location of the junction will be where there user left-clicks the mouse on the screen. The Z coordinate will be determined either by the set active elevation or when the junction is snapped to another branch or junction.

The ***Model Information*** button will bring up the model information view. Descriptive data consists of both required and optional information for documentation and program initiation. This information is modified in the Model Information view. The Model Information view allows data to be directly entered into fields. Additional information is outlined in Section 3.10.

The ***Branches view*** button will bring up the Branches view box. Additional information on Branches view is outlined in section 3.11.2

The ***Branch Template*** button will bring up the Branch Template view. Additional information on Branch Templates is outlined in section 3.15.

The ***Fans*** button will bring up the fan list view. In this box fan details can be edited and results can be viewed.

The ***Fixed Quantities*** button will bring up a list of the fixed quantities list view in the model. In this box fixed quantity details can be edited and results can be viewed.

The ***Layers*** button is made up of two parts. When the top part of the button is pressed then the Layers View will be brought up. From here layer names can be added, edited, turned on or off and set as active. The lower button will bring down a drop down menu with three choices: All, On, and Active. By selecting “All”, the user will display all layers at once. By selecting “On”, the user will display select layers that are checked in the Layers View. By selecting “Active”, only the active layer will be displayed.

The ***Junctions view*** button will open the Junctions view. This view lists all of the junctions in the model. From here the location of junctions can be edited or set to an atmospheric junction. A temperature for each junction may also be set. Junction temperatures are used only for mine fire calculations.

The ***Error List view*** button will bring up the list of errors and warnings that occurred during the last model execution. For each error or warning a corresponding branch will show up in the list. By double clicking the row with the warning the matching branch will be zoomed to in model view.

The ***Branch Types View*** button will bring up the branch types view. The user may also select to define colors for the Branch Type, as opposed to a parameter range. This allows colors to be assigned for different types of branches, which can be specified from certain categories during entry of the input data.

The ***Show Resources View*** button allows the attachment of DXF lines to the model view. These lines are not converted to airways during import. The user may use these lines as a guide to develop new branches as the draw branch tool can be used to snap junctions to the lines. This function will import lines and polylines. To import a DXF overlay, press the Show Resources View button. The user will be prompted to select a “.dxf” file. A Resources view will open asking the user to select the layers to import into the model. Colors for each layer can also be selected here. When the user has selected the desired layers and color select the “Ok” button and the lines will be displayed in model view. Further manipulation of the DXF overlay can be performed with the DXF Reference button  located in the Tray icons

The ***Export to DXF*** button allows the user to export the ventilation model centerlines to a DXF file. This feature is accessed through the Model view using the Export to DXF button . To export fist display any parameters or text that should be included in the export. Select the branches to put into the file. When all the selections are made press the Export to DXF button and window will open prompting the user to input a file name. The exported DXF file layers will be named (automatically) to allow the user to easily recognize what data is contained on each layer.

The ***Import from DXF*** button allows the user to import a network or level from a CAD or mine planning program using a DXF file to transfer the data. A browser window will be displayed for the user to find the appropriate DXF file. When the user selects a DXF file, VNet will examine the file for available layers and then prompt the user to select the layers to be used. The imported layer will create a new VNet Layer for every layer selected and convert all of the lines in the selected layers to branches**.** The units drop down menu is utilized when the DXF file and VNet model have different units. For example, if a VNet model is developed in Imperial units but the DXF files are in SI units, the user will select SI units on the pull down menu. This function will convert the DXF files units to the VNet model units. Figure 13 displays the layer selection view that is displayed after selecting a file to be imported

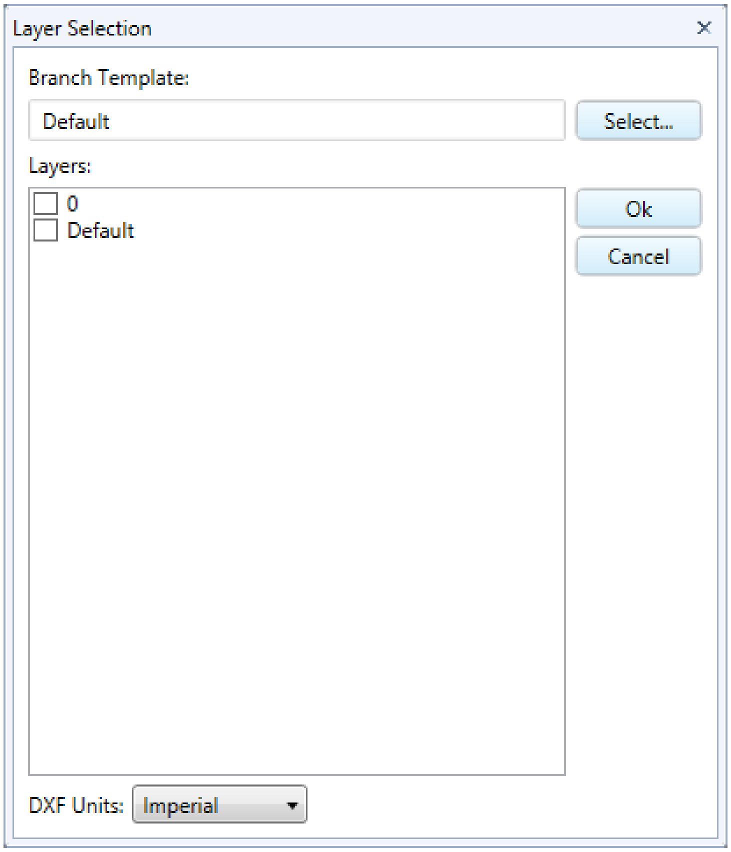
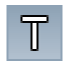


Figure 13: DXF Import - Layer Selection

The DXF import feature is not limited to CAD programs and will support DXF data from most mine planning software. If the mine plan is not simplified and centerline coordinates are imported for all the lines and polylines, then an extremely large network will result (for example, a coal mine could import every crosscut in the mine). The resulting network may be unworkable.

Establishing a suitable DXF file requires a program that supports layers (such as AutoCAD™). The user should develop the network in the <u>CAD program using only Lines and Polylines</u>. If another object type is created, such as text or hatching, in a layer with lines and polylines, only the lines and polylines will be imported to VNet. The end point for each line or section of a polyline should represent a node location. Care must be taken to ensure that the end and starting points of connected branches are at <u>exactly</u> the same coordinate (i.e. the nodes do actually connect). This would be done in AutoCAD™ using the snap-to <endpoint of> or <intersection of> options. Failure to do this will result in the data being imported as separate lines rather than a network.

The DXF import feature is not limited to CAD programs and will support DXF data from most mine planning software. Care needs to be taken to ensure that a layer is contained in the DXF file, which represents the simplified schematic. If the mine plan is not simplified and centerline coordinates are imported for all the lines and polylines, then an extremely large network will result (for example, a coal mine could import every crosscut in the mine). The resulting network may be unworkable.

The ***Parameters*** button is used to display the Branch Parameters View, Figure 14, which controls display of various branch inputs and results. This is done by displaying text above the branches and/ or coloring branches based on a range of data. To select the data to be represented in model view use the pull-down menu under actions and select the desired data. Text must be toggled on using the Branch Data Text button  in the icons Tray. For the branches to be colored by range of data, the Branch Data Color Button must be set to the following  under in the icons Tray. VNet will automatically determine a range of values and corresponding colors to be displayed. User values may also be entered in the right-hand column.

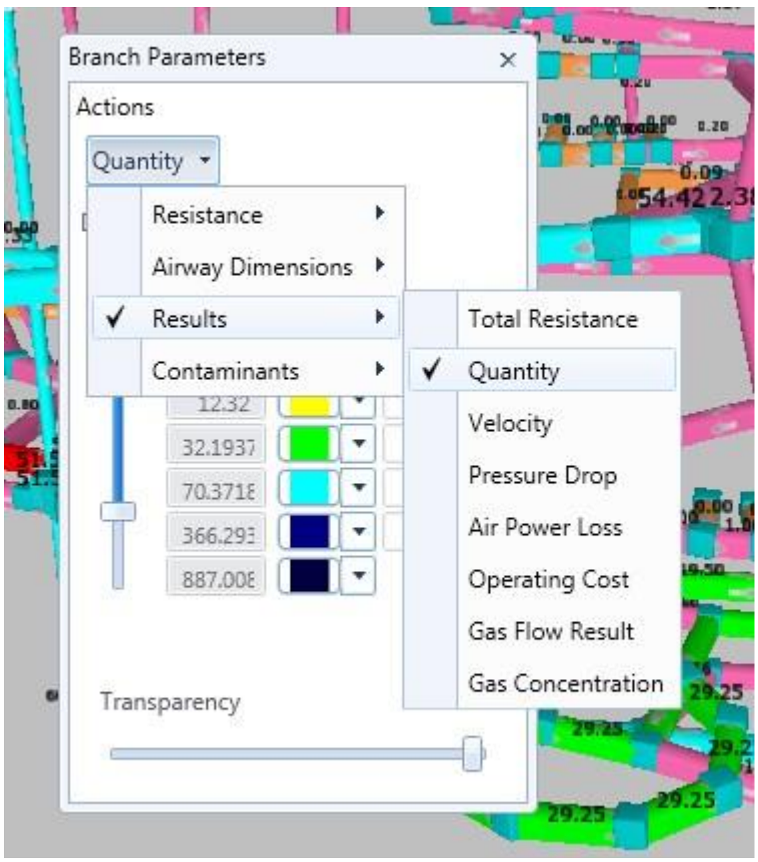


Figure 14: Branch Parameters View

The ***Execute Hardy Cross Simulation*** button will perform the Hardy Cross calculations for the model. This needs to be performed for the model to update the results with any changes to the model.

The ***Execute Contaminant Simulation*** button will perform the calculations for a contaminant simulation. Contaminants can be entered into a branch using Branch Data View. After selecting the desired branch in which to place a contaminant, the user is required to input either a contaminant volume flow or a concentration. The input concentration represents the concentration of the emission at that point in the airway. The user should not enter the total contaminant concentration, which will include any upstream sources. The output contaminant flow and concentration (evaluated by the program) will integrate all of the sources to determine actual concentration and volume based on a steady state condition.

The ***User Preferences*** button will bring up the Preferences view. In Preferences view there are three tabs in the box to select from: Branch Display, Other Display and Miscellaneous. Under each one of the tabs are subset of boxes that can be used to change the display or setting of the program.

Under the Branch Display tab, the settings for how branches and text are displayed in Model view. There are four subcategory boxes under this tab: Branch Text, Branch Color, Excluded Branches, and Branch symbols. In Branch Text the text settings on the branches can be modified. A check box is there to toggle on and off the branch text. The font size can be changed with a range of 4 to 72. The font color may be changed using the drop down window. Hiding text at a distance is also helpful in large models for easier viewing and better clarity. A slide bar is used to adjust at what distance the text can be hidden. In the Branch Color category there is a choice to color the branches by type, parameter and by the default color. In the excluded Branches box there is an option to show or hide excluded branches from the model. The excluded branches are also assigned a color and can be changed using the drop down window. A slide bar is also available to adjust the transparency of the excluded branches. In the Branch symbols box, the display of branch symbols can be toggled on and off. Animation of symbols and branches may also be toggled on and off. A slide bare to adjust the speed of the animation is also found in this box. Under the Branch display tab the display of inject/reject branches can be turned on or off as well as the display of 3D solids of the branches. The Branch display tab is displayed in Figure 15.

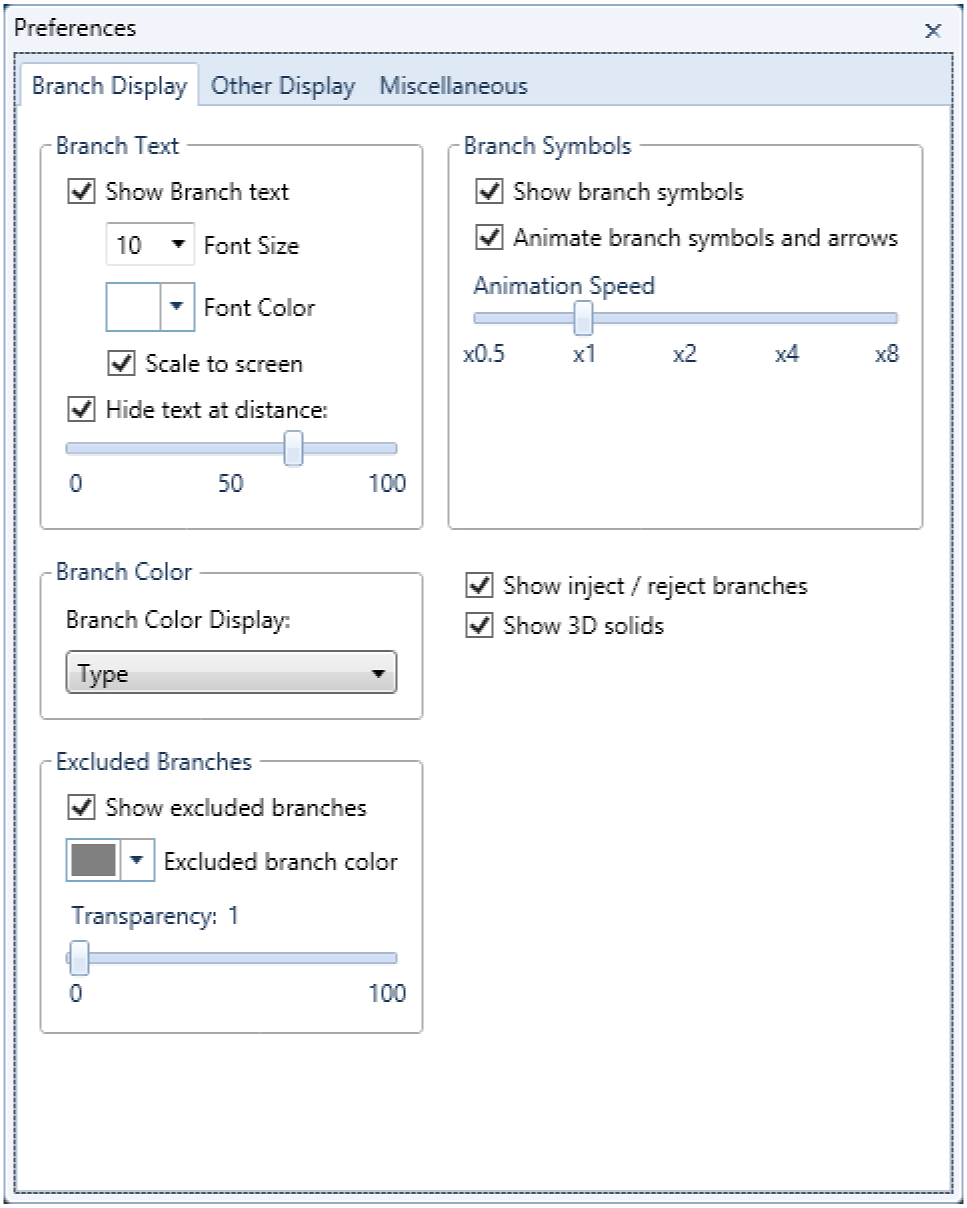


Figure 15: Preferences (Branch Display)

The Other Display tab contains the display options for the model view other than branches. The tab is split into four display category boxes; Labels, Projection, Grid and Junctions. In the Labels box the display of labels can be turned on and off. Scaling to the labels to the screen man also be toggled. The default text font, size and color may also be modified. The display of the grid major and minor scales can be turned on and off and the scale may be adjusted. In the Projection box the display of model view can be changed between orthographic and perspective view. Perspective view displays objects that are in the foreground, larger than objects that are in the background. Orthographic view displays all objects the same size no matter the distance from view. In the Junctions box the display of junctions can be turned on and off and the color may also be adjusted. The relative pressure text display, color and font size can be changed as well as scaling the text to the screen. There is also an option to toggle whether or not the reference junction is highlighted in the model. Also, under the Other Display tab, the background color may be changed. A hidden layer transparency bar can be adjusted to the user's preference. The Other Display tab is displayed in Figure 16.

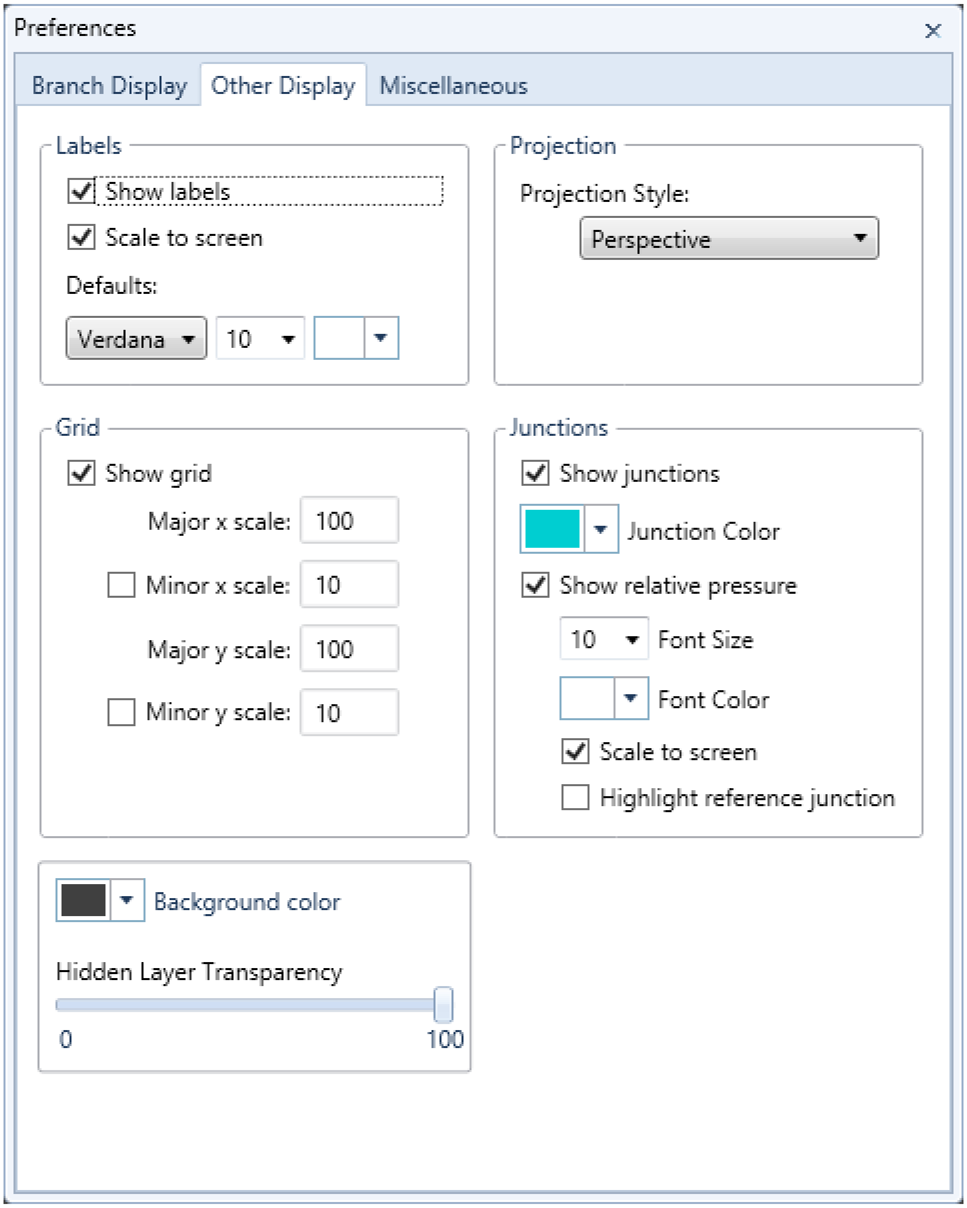


Figure 16: Preferences (Other Display)

The Miscellaneous tab contains additional display options for the model. The units can be changes between Imperial and SI. A starting junction number can be set. The Tray icons can be toggled between being displayed as icons or as text. Another important function is the Reset Branch Direction. Pressing this button will change all of the branch junctions "from" and "to" to match calculated direction of flow in the branch. The Miscellaneous tab is displayed in Figure 17.

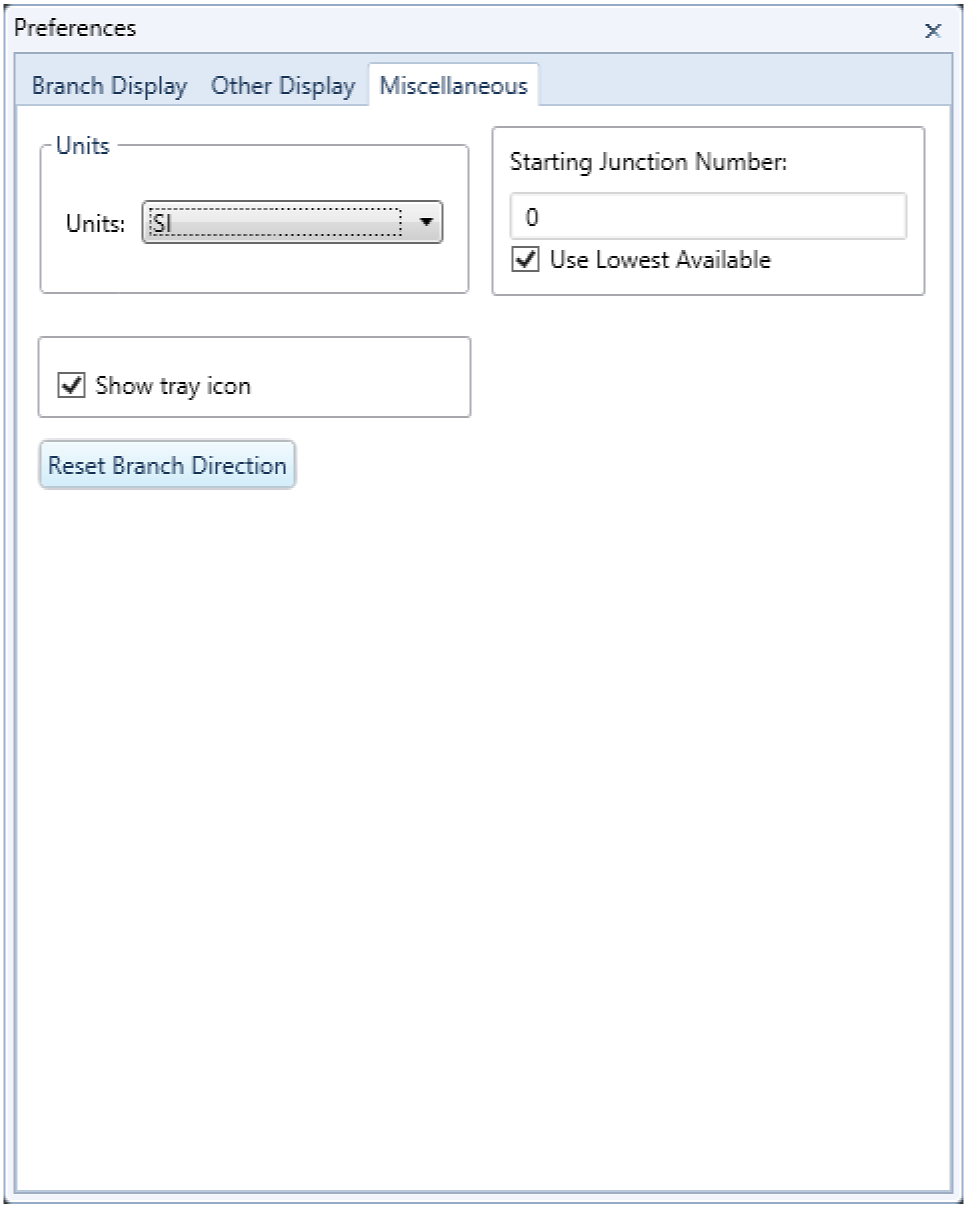


Figure 17: Preferences (Miscellaneous)

3.11.2.3 Quick Access Toolbar

The Quick Access Toolbar is located just above the Ribbon and performs the following functions:

 Create New Model

This button will create a blank model in the model view and is called “newmodel” until the user saves and names the file.

Open Model

This opens a window prompting the user to select and open a valid ".vds" file created by VNet.

Save Model

This will save the current state of the model.

Save As

This will save the model by a name the user specifies with a ".vds" extension.

Undo

This button allows the users to undo changes in the model.

Redo

This button will allow data that was undone to be restored in each branch.

3.11.2.4 Tray icons

The Tray icons are provided to quickly change how the model is displayed in Model view. The following functions are available in the Tray icons.

Branch Data Color

This button can be pressed to change the color of the branches. When this symbol is displayed , branch colors are defined based on branch type. The branch type color can be modified in the Branch Types View. When this icon is displayed , the branch colors are defined based on the selected range of parameters for each branch. These parameters are specified in the Branch Parameters view. When this icon is displayed , branches are displayed with the default color.

Branch Data Text (On\Off)

This button toggles the branch text data on and off. The displayed text is selected in the branch parameters view.

 3D Solids

This button toggles the branch 3D solids on and off. When the branch solids are turned off centerlines of the branches are displayed.

 Show/Hide Symbols

This button toggles the display of symbols in the model view.

 Turn Animation On\Off

This button toggles the animation of airflow direction arrows on the branches and animated symbols.

 Show IR Branch Data

This button toggles the display of inject and reject branches on and off.

 Exclude Branch Data

This button toggles the display of excluded branches on and off.

 Show/Hide Junctions

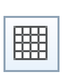
This button toggles the display of junctions on and off.

 Show/Hide Relative Pressures

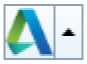
This button toggles the display of relative pressures on and off.

 Show/Hide Labels

This button toggles the display of labels on and off.

 Show/Hide the Grid

This button toggles the display of the grid on and off.

 DXF Reference

This button allows layers from a DXF import to be turned on and off and colored by layer and as a whole.

 Ortho or Perspective

This button toggles model view between orthographic and perspective view. Perspective view displays objects that are in the foreground, larger than objects that are in the background. Orthographic view displays all objects the same size no matter the distance from view. This allows the user to see more of the ventilation network easier while sacrificing some of the realism of Perspective View.

 Plan View

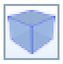
This button locks the view into the XY plane.

 XZ View

This button locks the model to the XZ plane.

 YZ View

This button locks the model to the YZ plane.

 Isometric View

This button allows the model to be rotated in isometric view. To rotate, the user must click and hold the right mouse button while dragging the cursor across the screen. The user may left right anywhere in the Model view to rotate the model. The model will rotate and zoom around the centroid of the last selected branch(es).

3.11.3 Branch Selection and Editing

VNet supports editing multiple branches through multiple branch selections and branch templates. Branch selection is indicated by a gray color of the branch. Branches can be selected by placing the cursor over the branch and clicking the left mouse button. A branch is deselected when the 'Shift' key is held down and the branch is clicked on again. The branch selection is cumulative: selecting new branches will not change the selection status of branches that have already been selected. The entire selection can be aborted by hitting the 'Esc' key at any time.

Multiple branches can be selected simultaneously using selection boxes. A selection box is started when the left mouse button is pressed and held while the cursor is dragged across the screen. The selection box closes and the selection is made when the mouse button is released. A selection box generated from left to right will select all the branches entirely contained within the box. Both branch junctions must be included for the branch to be selected. A selection box made by moving the cursor from right to left will select all branches that are partially contained within the box. Branches can also be deselected using selection boxes when the 'Shift' key is held down. To apply an action to multiple branches, use the Branch Data View. If Branch Data View is not already open, double clicking a branch or selecting the Branch Data icon will bring the view. Alternatively, place the cursor over one of the selected branches and click the right mouse button to access the branch functions. Multiple branches can also be deleted using the delete key.

When modifying multiple branches, the number of branches selected will display in the top box in Branch Data View as shown in Figure 18. This number aids the user by helping to prevent accidental deletion or modification of an entire group as well as confirm the amount of branches the user wishes to modify. Branch Data View will also distinguish between similar and different information between branches. If a value is displayed when multiple branches are selected, this means all of the branches share that characteristic. If the field displays *Varies* then there is a difference between the branches in that field. Changing a field will change the parameter of every branch selected. The apply button must be pressed for the changes to be saved.

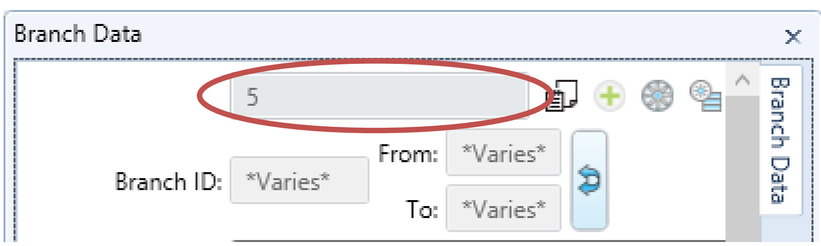


Figure 18: Branch Data View (number of branches selected).

3.11.3.1 Surface State

The user needs to select the surface state of a branch during data entry by checking the box labeled "In Atmosphere". This can be done using the Branch Data View. VNet will automatically select the correct junction to make an atmospheric junction.

3.11.3.2 Excluding Inactive Branches

To exclude a branch from the simulation, the user simply has to check the box labeled "Excluded" in Branch Data View to deactivate branches from simulation. The user may also change the activation status of branches in the Branches view by checking the box under the column labeled "Excluded".

3.11.3.3 Branch Colors

VNet allows the network to be color coded according to the type of airway, as well as parameter range. Branch colors can be enabled by selecting the following three options using the Color Wheel button in the icon Tray or in User Preferences / Branch Display tab. 'None' or turns all features to the default color. 'Type' or will display branches colored by the associated branch type. 'Parameter' or refers to the specific color ranges allocated to the parameters total resistance, quantity, velocity, pressure drop, air power loss, operating cost, gas flow results and gas concentration. Color Range data is accessed by selecting the Parameters button in the Ribbon and selecting the desired parameter to be displayed. Color Range allows for branches to be colored according to the magnitude of the value displayed. The values entered under the range column represent the maximum value that may appear with that color.

In Branch Data View and Branches View, the user may select from a list of airway types/codes and other user defined types. The Branch Type colors may be changed in the Branch Types View by pressing the Branch Types Button in the Ribbon as shown in Figure 19.

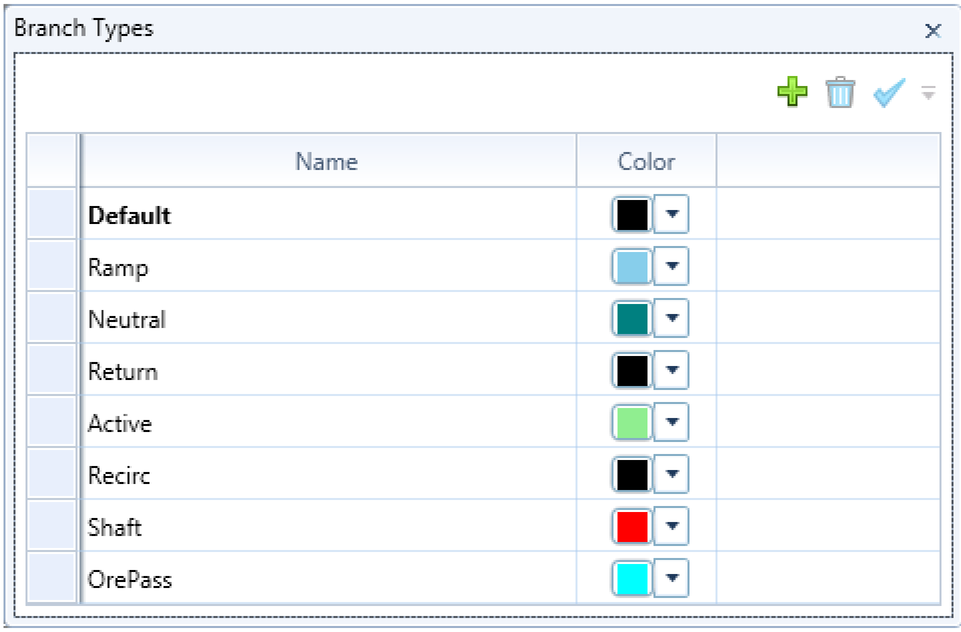


Figure 19: Branch Types View

3.11.3.4 Ventilation Structure Symbols

Ventilation structure symbols are entered in either the Model view or Branches view. From the Model view, the user enters a symbol in the Branch Data View, and in the Branches view the user selects from a list of six symbols. These symbols are available: Door, Double Door, Single Stopping, Double Stopping, Brattice Curtain and Regulator. These symbols can be toggled on/off by toggling the Show/Hide Symbols button in the Tray icons or in the Preferences menu.

3.11.4 Model View

The Model view allows the user to three-dimensionally view a ventilation schematic. It takes into account airway dimensions to construct a three-dimensional representation of the model's airway profiles. This gives the model a realistic feel and can aid the user in visualizing the ventilation system clearly.

3.11.4.1 Animation and Text Fade

Model view allows the user to animate airflows in the model. This feature is found by toggling the Animate button in the Tray icons. When turned on, the arrows depicting airflow direction for each branch move along the branch according to air velocity. Also, fans spin and doors and regulators open and close. This does not affect model execution; it is simply meant for visualization purposes only. While animation mode is activated, the user is still able to modify other features in Model view. When turned off these icons are frozen and arrows do not move along airways

3.12 Fan Data

The user may add fans in the Branch Data View or the Model view. The Fans view will be updated to incorporate the new fan details. It is important that the user is aware of the From/To direction of the branch as this will be the direction of a fan or fixed quantity that is entered into the branch.

In the Model view, a fan or fixed quantity can be added to a branch by right clicking on a branch and then selecting either either "Fan" or "Fixed Q". This will bring up the Fans or Fixed Q tab in Branch Data View. Alternatively a Fan or Fixed Q may be added to a branch in Branch Data View by selecting Access/Add fan or Access/Add Fixed Quantity buttons at the top of the window.

3.12.1 Fan Location and Flow Direction

A fan can be located in any branch that does not contain a fixed quantity and vice versa. The branch number and junction numbers dictate the fan location. The order in which the junction numbers are entered defines the direction of the fan. To view or edit (or add to) the fans in the model, the user may use the Fans view.

3.12.2 Fan Type

Any fan can be entered with either a fixed pressure or with a characteristic curve of pressure against volume flow. The fixed pressure and description of the fan can be entered in the Fan tab in Branch Data View. If a fan curve is not input, this dialog box allows the user to enter a fixed fan pressure (regardless of quantity). If a fan curve is input it will override the fixed fan pressure input. The user is also allowed to input data for multiple fans (series or parallel). When multiple fans are selected, the program will develop an equivalent fan curve based on series/parallel fan theory. Users may change the operating status for fans in VNet models without removing them. When a fan status is turn "Off", the program will use the entered branch resistance and it will not assume or add resistance to the airway created by the fan dampers closing or by a non-operating/idle fan. To simulate the resistance of an idle fan or closed dampers, the user must modify the resistance in the branch for the arranged conditions.

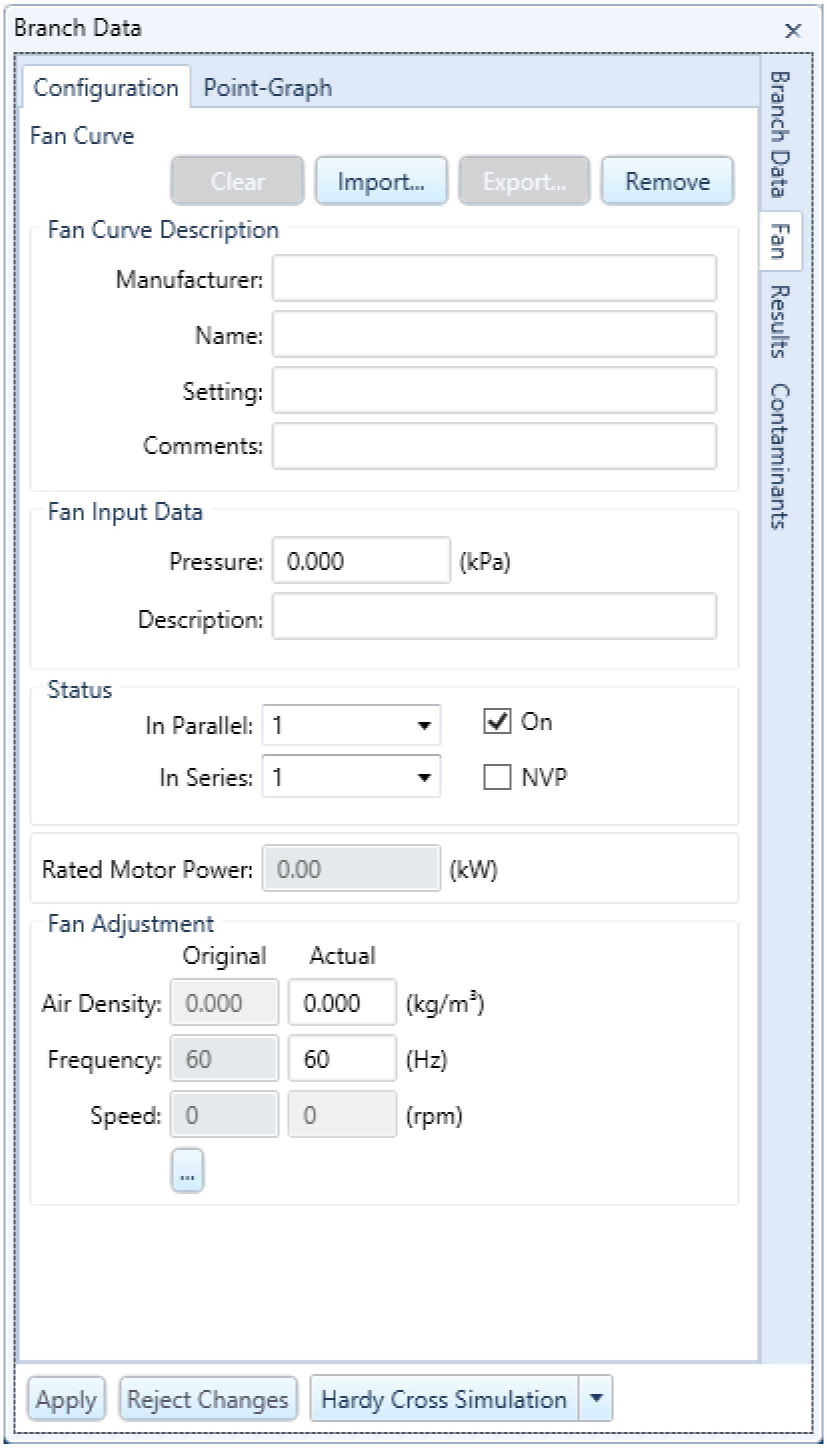
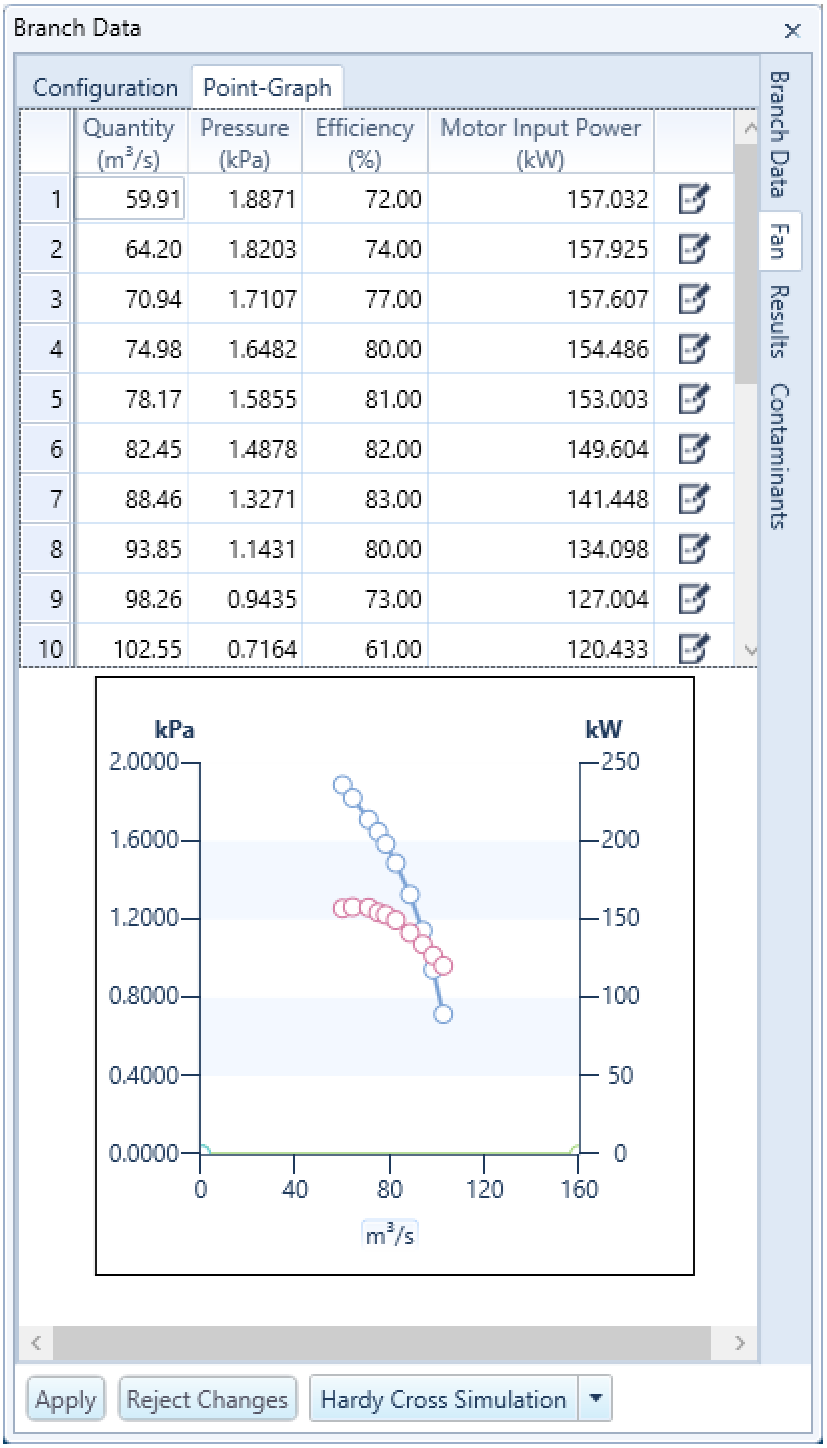


Figure 20: Fan Data Configuration

The user may enter a fan curve by selecting Point Graph tab from the Branch Data View illustrated in Figure 20. Fan characteristic curves are registered by entering between two and twenty sets of pressure/airflow data points (see Figure 21). These points should be chosen such that they adequately represent the full extent of the curve. Users may add efficiencies for each of the fan curve points entered. The program will use the entered airflow, pressure and either the efficiency or Motor Input power to calculate one of the latter values. If the efficiency is given the program will calculate the Motor Input power and vice-versa. The program assumes a linear line between any two points on the fan curve. Once the points of the fan curve are entered into the Point Graph the user can select “Apply” to incorporate the curve into the model or “Export” to export the curve to an external fan curve data base. Note that the fan curves are unit-dependent and that the curves are converted if the unit conversion utility is used. Using the entered fan characteristic curve, VNet will generate a graphical display. After the simulation is executed, the predicted operating point with motor input power is plotted.

For each fan curve entered into the point graph a reference density for the curve and a drive frequency can be entered. The user can elect to change the reference density of the fan. In this way, a fan curve that is supplied from the manufacturer at standard atmospheric density can be entered and changed to a different density. By shifting the fan operating density, the fan curve will also be shifted according to the ratio of the new density but will retain the original settings from the Fan File Manager. The user may also modify the frequency and speed of the fan.



	Quantity (m^3/s)	Pressure (kPa)	Efficiency (%)	Motor Input Power (kW)
1	59.91	1.8871	72.00	157.032
2	64.20	1.8203	74.00	157.925
3	70.94	1.7107	77.00	157.607
4	74.98	1.6482	80.00	154.486
5	78.17	1.5855	81.00	153.003
6	82.45	1.4878	82.00	149.604
7	88.46	1.3271	83.00	141.448
8	93.85	1.1431	80.00	134.098
9	98.26	0.9435	73.00	127.004
10	102.55	0.7164	61.00	120.433

Figure 21: Point Graph

After execution of the ventilation model, a warning message will appear in the Error List view if one or more fans are operating off their fan curves (see Figure 22). The warning does not affect the execution of the simulation.

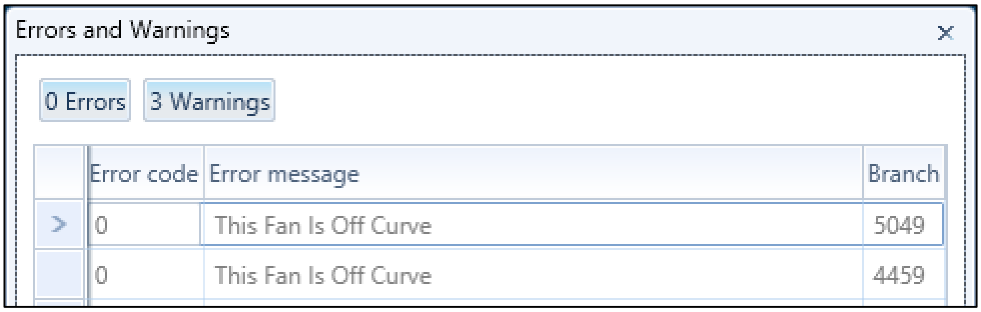


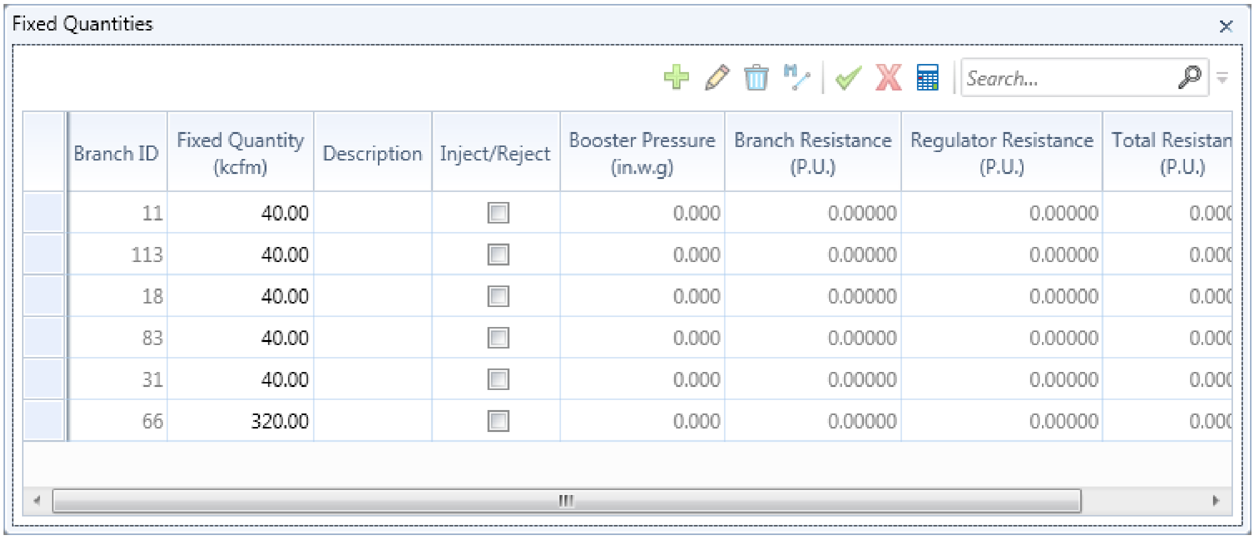
Figure 22: Off Fan Curve Status Warning Dialog Box

Fixed pressure fans are useful when modeling a known fan at a specific operating pressure or when modeling natural ventilation pressure (NVP). In the case of a fixed pressure fan, the fan curve should not be defined, only the fan pressure should be input.

3.13 Fixed Quantity Tool

The user may add a fixed quantity to a branch in the Branch Data View or the Model view. In the Model view, a fixed quantity can be added by right clicking on a branch and selecting “Fixed Q”. This will bring up the Fixed Q tab in Branch Data View. Alternatively a Fan or Fixed Q may be added to a branch in Branch Data View by selecting Access/Add fan or Access/Add Fixed Quantity buttons at the top of the window. The Fixed Quantity tool is used to simulate control of airflow, and will determine the resistance, pressure drop and orifice area for a regulator or the operating pressure of a booster fan. A fixed quantity can be allocated to any branch that does not contain a fan. This fixed quantity may then be edited or deleted later in Branch Data View.

The Fixed Quantities view will automatically be updated according to the information entered in the Model view (See Figure 23). The input data type (R, p/Q, k factor, R/L) dictates the resistance of the branch. It should be noted that negative integers cannot be entered and it is necessary to swap the branch node numbers if airflow is to be reversed. This resistance is usually the natural resistance of the airway without a regulator or fan. Upon execution, the program calculates the regulator resistance and orifice area or the pressure of the booster fan required to achieve the specified airflow. The new resistance or booster pressure is added to the existing resistance data (whether the input data type is R, p/Q, k factor, R/L). If the fixed quantity results in increased resistance, the new Total Resistance is the combined resistance of the branch input data and the calculated resistance of the fixed quantity. If the fixed quantity results in an added booster fan, the pressure of the booster fan will reflect the pressure needed to overcome the branch resistance and resistances elsewhere in the model. Figure 24 and Figure 25 show the last results for branches with fixed quantities resulting in increased resistances and added fan pressures.


Fixed Quantities

Branch ID	Fixed Quantity (kcfm)	Description	Inject/Reject	Booster Pressure (in.w.g)	Branch Resistance (P.U.)	Regulator Resistance (P.U.)	Total Resistan (P.U.)
11	40.00		☐	0.000	0.00000	0.00000	0.000
113	40.00		☐	0.000	0.00000	0.00000	0.000
18	40.00		☐	0.000	0.00000	0.00000	0.000
83	40.00		☐	0.000	0.00000	0.00000	0.000
31	40.00		☐	0.000	0.00000	0.00000	0.000
66	320.00		☐	0.000	0.00000	0.00000	0.000

Figure 23: Fixed Quantities view.

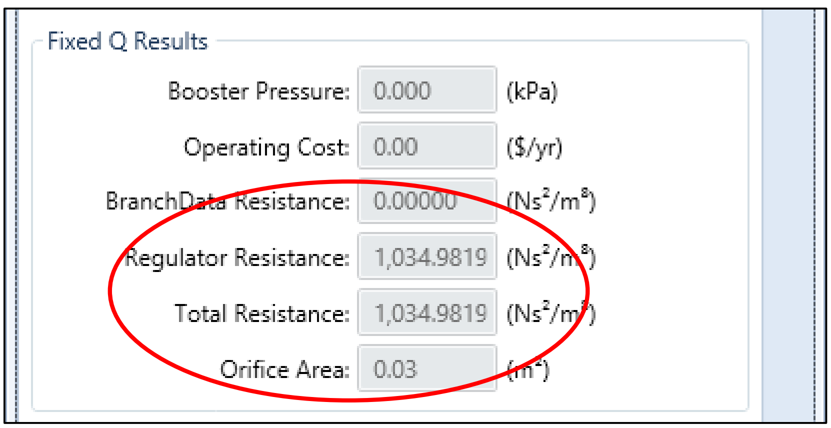


Figure 24: Fixed Quantity Resistance

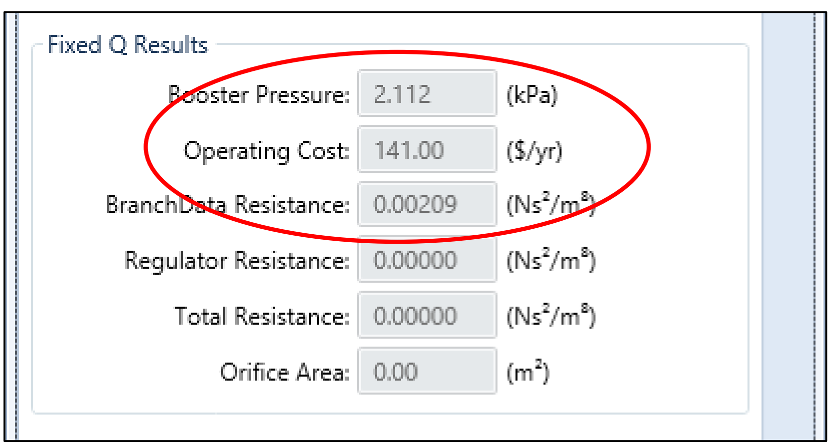


Figure 25: Fixed Quantity Booster Fan

Within the Fixed Quantity dialog box there is the option of specifying the branch as an Inject or Reject branch. This tool is used to add or remove air from selected junctions to account for compressibility effects, ducts, compressed air lines, or areas of the facility not otherwise represented in the network. For example, as air passes down a shaft it is compressed due to autocompression. Since VNet assumes incompressible flow, this compression may need to be modeled separately by removing air (rejecting) from the model at the base or along the length of the intake shaft. Note that air will probably need to be injected in deep mines to account for the effects of expansion as the air rises. This tool is only used to assist the user by flagging the inject/reject status of the fixed quantity and does not change the functionality of VNet in any way.

3.14 Contaminant Distribution Analysis Data

The contaminant distribution utility incorporated in VNet utilizes results of the network exercises to evaluate contaminant concentration and gas flow distributions. The user specifies locations and magnitudes of contaminant sources in the Contaminants tab in Branch Data View. The program uses airflows from the last execution of the ventilation simulation to calculate contaminant flow assuming steady-state conditions. The program also assumes fully turbulent flows with complete mixing.

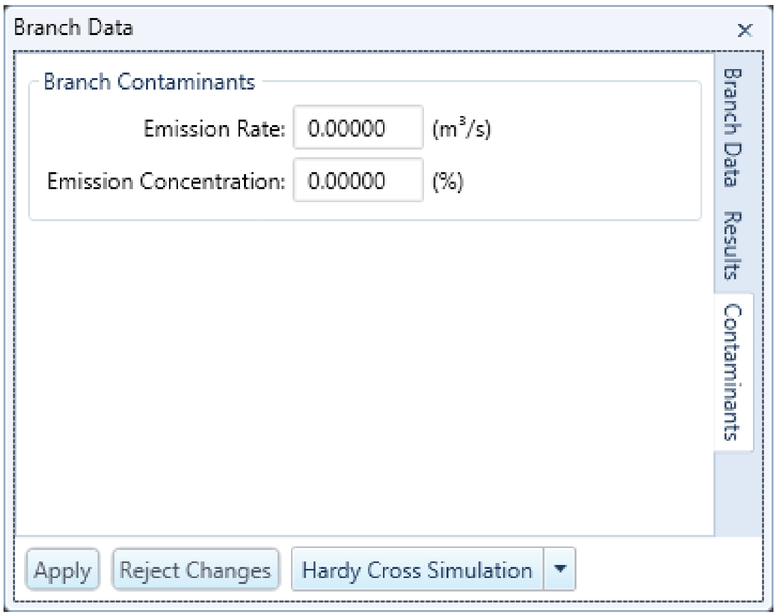


Figure 26: Contaminant Data View

Identifying the branches representing the location of the contaminant emissions lets the user specify the sources. Contaminant sources are entered as quantities or concentrations in the various columns. Valid entries for emission rate must be positive and less than 10.0 kcfm or m^3/s. Data can be entered to four decimal places. Contaminant data is entered in the Model view using Branch Data View, and clicking on the branch where the contaminant will be added. The input concentration represents the concentration of the emission at that point in the airway. The user should not enter the total contaminant concentration, which will include any upstream sources (this value is computed by the program).

The contaminant distribution analysis routine requires that branches representing intakes carrying fresh air directly from the surface be identified. VNet uses those branches selected as Intake from the Model view (used for mesh closure as well as contaminant analyses). The contaminant execution is conducted by selecting Execute Contaminant button located on the Ribbon. After executing, columns labeled Contaminant Flow and Contaminant Concentration will update with the results of the model execution in Branches view and in the Results tab in Branch Data View. The results may also be displayed on the branches by selecting them using the Parameters view.

3.15 Branch Template

The Branch Template feature equips users with the ability to apply data to individual or multiple branches. Users define individual branch data properties using a Branch Template (see Figure 27). After a Branch Template is defined, users may apply this to a single branch or multiple selected branches. Users can locate the list of templates by selecting the Templates button in the Ribbon.

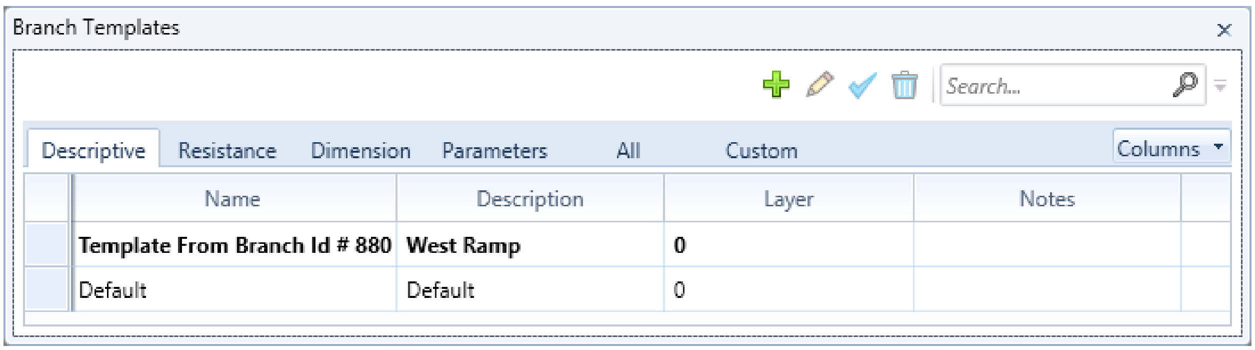


Figure 27: Branch Template View

Branch Templates allow users to apply either complete branch data or selected branch data. Using Template Fields (see Figure 28), users can select which fields of data will be changed when the template is applied. The Template View can be accessed by right clicking on a branch and selecting “Make Template”. The Template View is used to modify or select fields to be used as the template. For example, a user creates multiple branches with varying resistance data types but would like to modify the Branch Type of each branch to a single value without altering other fields. The user will check to apply the Branch Type and ignore the other available fields then select ok.

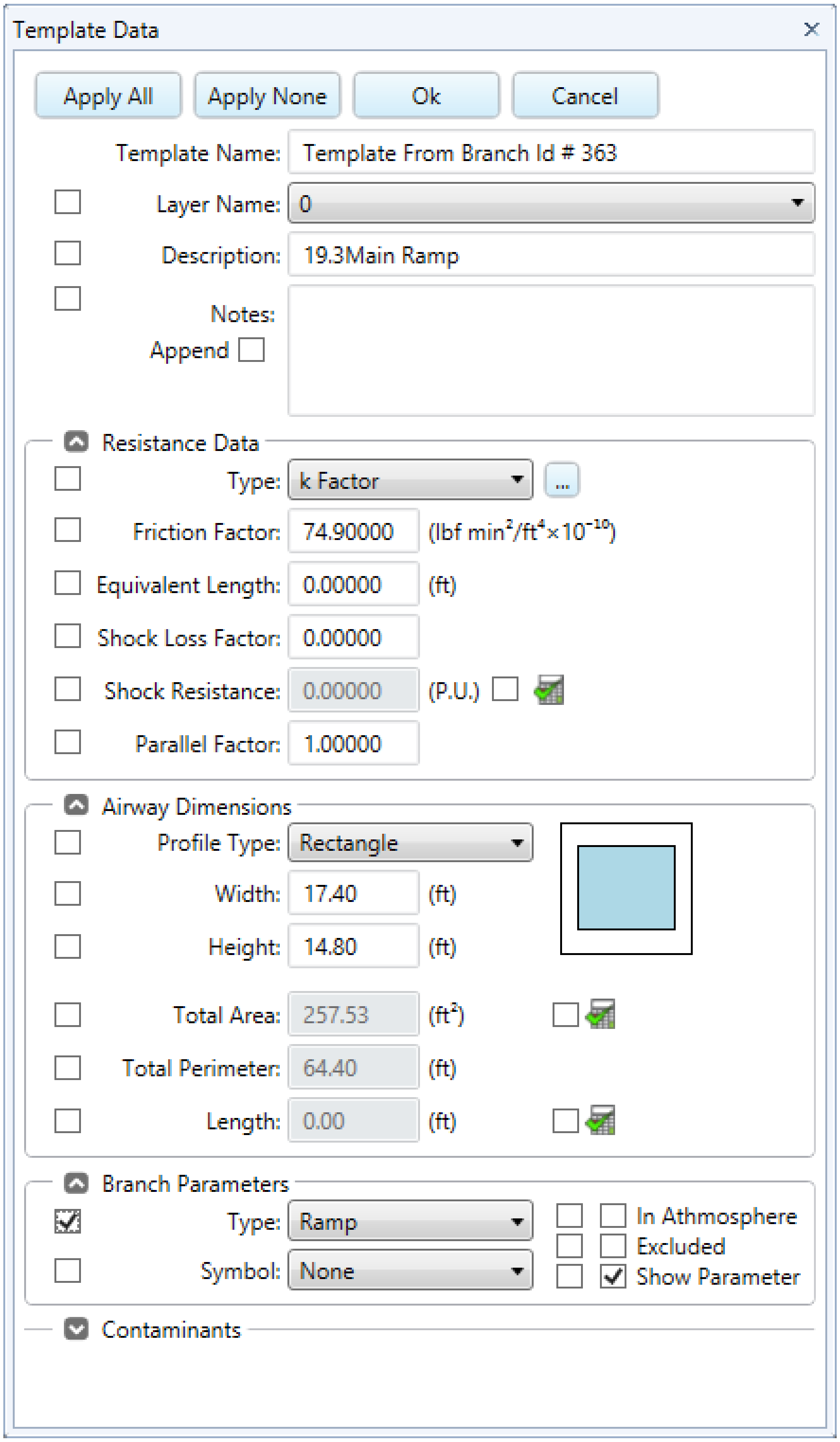


Figure 28: Branch Template Fields Selection View

New Branch Templates can be added to a ventilation model in the Templates view. New Branch Templates may be created or deleted by selecting Add Template Button or Delete Template Button respectively. To apply a template in the Model view, a user may select a branch or branches using the Selection Pointer tool. Using the Selection Pointer, right click on a selected branch and choose Apply Template or Make Template. "Apply Template" allows the user to apply an existing Branch Template to the selected branch. "Make Template" allows the user to make a Branch Template from the selected branch. This will create a Branch Template using all possible Template fields of that branch and will not allow the user to select specific fields. A Select Template dialog box will appear as shown in Figure 29. The desired template can be selected and applied by clicking on the appropriate row and selecting 'OK.'

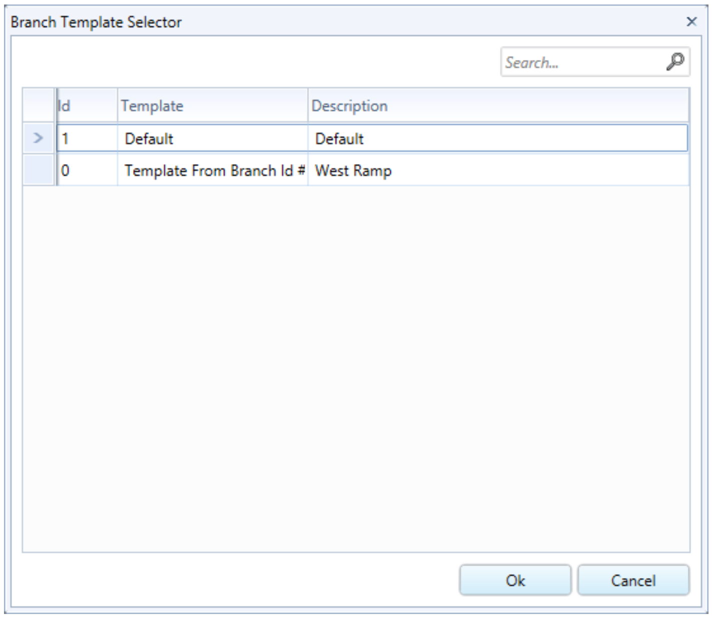


Figure 29: Select Template Dialog Box

The input data types Resistance (R), Atkinson Friction Factor (k-Factor), and Resistance per Length (R/L) <u>can</u> be used as estimates/predictions of actual or future mine conditions. Pressure/Quantity (p/Q) data cannot be used in estimating because p/Q data refers to actual measured data, specific to a particular mine location. For this reason, VNet does not allow application of p/Q data by using Branch Templates. If the user tries to apply or make a Branch Template by using the p/Q setting, p/Q data will not be applied. New branches will only contain data from the selected fields. Since neither pressure nor quantity is listed as one of the fields to be applied in the Template Fields dialog box, they may not be added to branches using Branch Templates.

New Branches drawn in VNet have the attributes of the default branch template. To change the active branch template open the Branch Templates view using the Templates button on the Ribbon. Select the row that the user wants to set as active, then press the Set as Default button .

3.16 Transient Time Calculator

The transient time calculator is used to calculate how long it will take for a particle to travel through a defined section of the network. This time is determined using the air velocity (which was calculated from the airflow quantity), and the length of the branches. The calculator is accessed by selecting a continuous line of branches, then right clicking on one of them, and selecting "Transient Time Calculation" from the list. In the Transient Time dialog box, shown in Figure 30, the series of junctions selected to create a transient time path is shown. It is important that correct cross-sectional area and length values of the individual branches selected for the study are incorporated in the model to provide accurate results. The program will extract the pertinent airflows, lengths, and areas from the branch data. Once the user has input the dimensions of the branches, the total time to traverse the path is computed by pressing the Calculate button. The sequences are stored after hitting the "Ok" button.

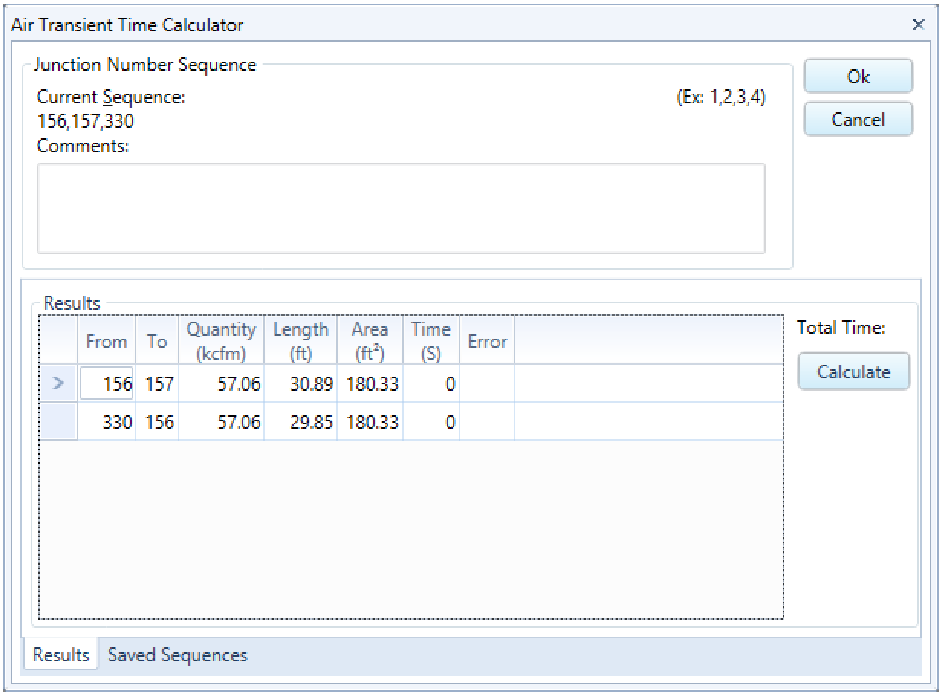


Figure 30: Transient Time Calculator Dialog Box

4. Operating the Program

4.1 Manage Network Files

VNet utilizes conventional Windows protocol for managing files. VNet files are searched for under the designated .vds file extension and fan files under the .fds extension. Files may be accessed from the host computer or through a network system.

4.2 Data Conversion – Previous VNet/VnetPC Versions

VNet allows import of files from previous versions of VNet (VnetPC 2003, VnetPC 2007, VnetPC Pro, and VnetPC Pro+). To convert a file, the user opens VNet, and selects “Import VnetPC Model”. From here the user is prompted by a file manager to select the VnetPC file to be imported. Select the file and click “Open”. The model will then be imported into VNet. It is important that the file to be converted has coordinates specified for all the junctions in the network. If the user has not specified coordinates for all the nodes, then errors will appear when the file is opened.

4.3 Execute Ventilation Simulation

Executing the program is accomplished by selecting the Execute Simulation button on the Ribbon. This should only be done when the branch, fan, and descriptive data for the network have been fully entered. When the program has finished execution, each view, and any previously accessed windows, will be updated with the current information. The contaminant simulation must be executed separately and directly after the airflow simulation has been accomplished. If the user changes the model in any way after executing the airflow simulation, the user must execute the airflow simulation again before the contaminant simulation may be executed. The contaminant simulation is executed by selecting the appropriate button on the Ribbon.

Unlike the previous versions of VnetPC, relative pressure analyses are conducted during every execution of the code (the user does not have to tag on or off). Relative pressure is the difference in pressure from each node to the user specified reference junction. The user may specify the reference junction in Model Information view. This reference junction is highlighted in pink in Model view. Under User Preferences view, there is an option to highlight the reference junction under the Other Display tab (see Figure 31).

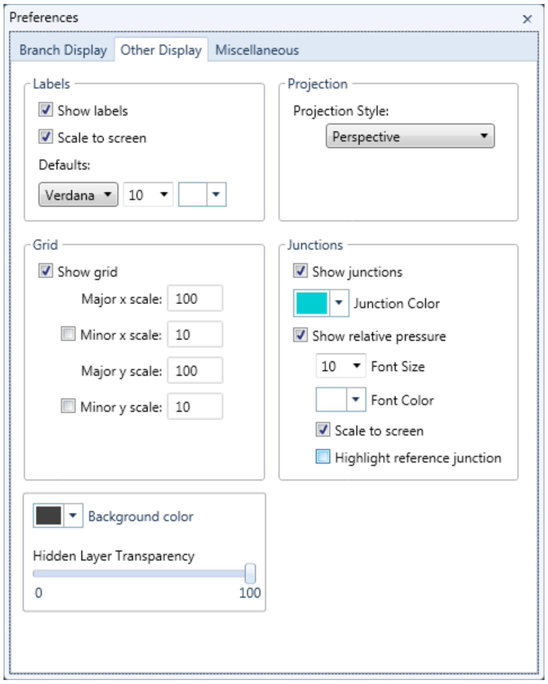
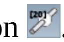


Figure 31: Highlight reference junction check box.

Highlighting the reference junction will cause it to blink in Model view. This reference is often useful to determine relative pressure difference between two unconnected junctions. Output of the relative pressure is viewed in the program either in square brackets above each junction in Model view or in the Junction Data view. The user can select whether to view or hide the relative pressure data in Model view by selecting the appropriate Tray icon .

4.4 Viewing the Results of a Simulation

Once the program has been executed, the results of a simulation may be viewed in Branch Data View, Branches view, Fans view, Junctions view, Fixed Quantities view, and Model view. Any computational errors are automatically listed in the Error List view immediately following execution.

4.4.1 List Errors/Warning

VNet identifies some basic execution errors and warnings. The difference between an error and a warning in VNet is that an error does not allow the model to converge to a solution while a warning will allow the program to converge to a solution, while noting some potentially problematic issues with the ventilation system. Once a warning has been identified in a branch, the program does not stop the execution, but continues operation until it converges on a solution. Once an error is identified the program will terminate execution a report a partial set of data.

2 Too Many Fixed Quantities in Branch

This error message arises if the input data file contains an excessive number of fixed quantities or inject/reject branches. If fixed quantity branches are used excessively in interconnecting branches, some fixed quantities will be omitted from the mesh selection process. Too many fixed quantities can mean that the model is over constrained with fixed quantities, or that there are simply too many fixed quantities for the program to converge to a solution properly. In the case of this error, the number of fixed quantity or inject/reject branches should be decreased before the network is re-executed.

4.4.1.1 Branch Omitted in Mesh Selection

For this warning, the branches that appear under this heading in the error screen were not included in the mesh formation process. The truncated network is still evaluated, but without the omitted branches. Junctions connected to only one branch (e.g. dead-end branches) usually cause this error. If this message appears the network should be scrutinized and amended. It may be simply that the associated branches be excluded from the model to properly model the system.

4.4.1.2 No Mesh Found for Branch

This warning arises from the basic branch and mesh selection processes. The minimum number of independent closed meshes required for every network is defined as (number of branches - [number of junctions - 1]). If, for any reason, this value is not attained during the basic branch selection process, or the mesh selection process, this error message will occur. The program is designed to continue evaluation of the network based on the number of meshes attained.

4.4.1.3 Iteration Limit Exceeded

The number of iterations for the Hardy Cross process used to solve the network is limited to 1000 iterations. If, after 1000 iterations a balance has not been reached, the program terminates and the values obtained after the 1000th iteration are listed as the results in the output.

This error is most often caused by excessive use of very high resistance branches. The network data should be checked and the model viewed to identify any erroneous branches. The iteration limit is set in order that the computer does not spend excessive time performing iterations trying to resolve an unsolvable network.

4.4.1.4 Locate Error/Warning in Model view Tool

In the event an Error toast appears after execution, the user may double click an error to locate the associated branch in the model. Upon double clicking the error, the model will center itself and zoom in on the associated branch. The error list will remain on the screen to assist the user with locating other errors in the ventilation model or be hidden and referenced later by selecting the appropriate icon . Figure 32 shows the Errors and Warnings View being used for finding problematic branches.

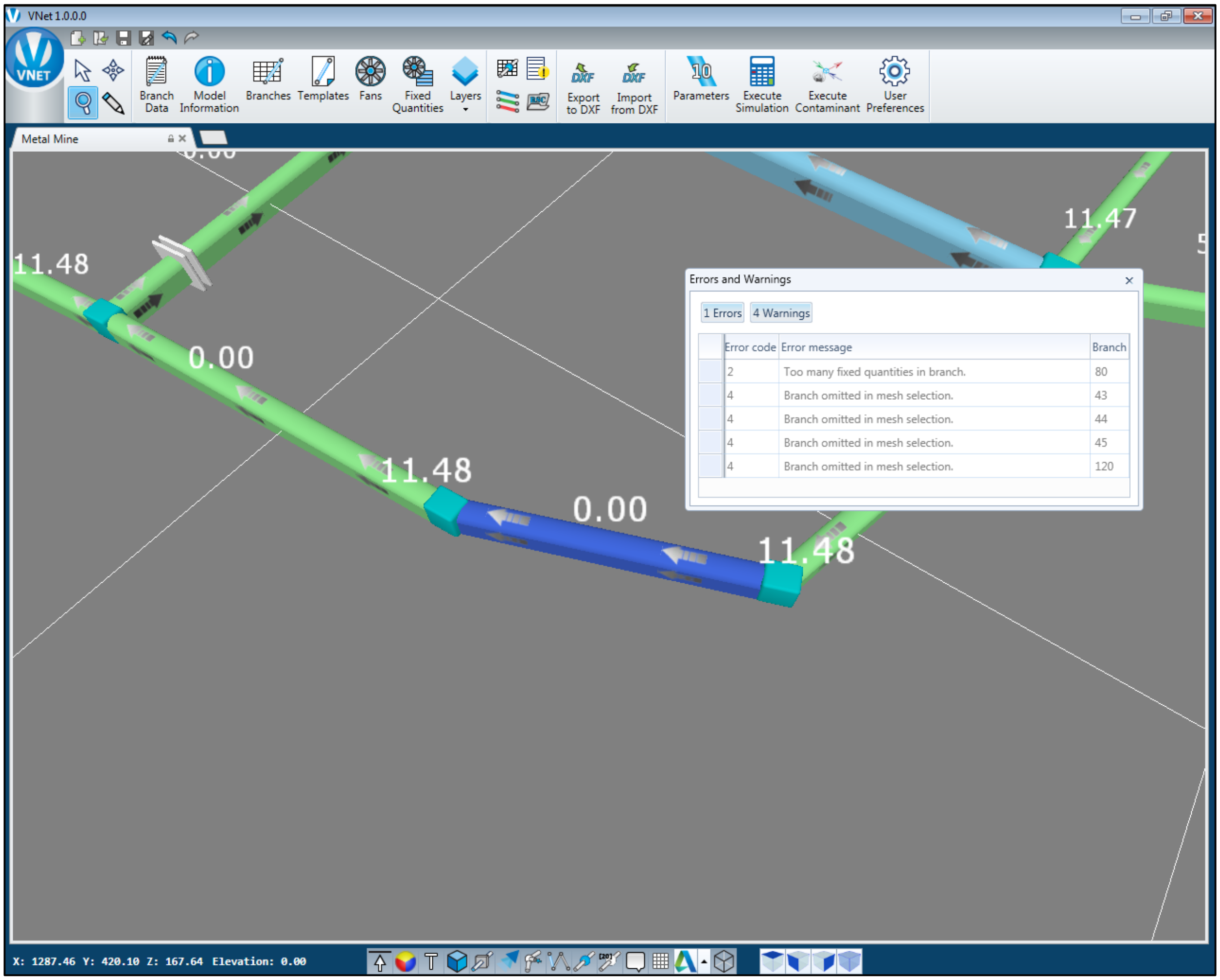


Figure 32: Errors and Warnings dialog box locator tool.

4.4.2 Fan Results

The fan results for each simulation execution are listed under the fan results tab in Fans view (example shown in Figure 33). In the fan results tab the user has the option of viewing the operating pressure, airflow, air power, input power, annual operating cost, curve status, a description of the fan, Branch ID, number of fans in parallel, number of fans in series, rated motor power, NVP, and whether or not the fan is on. If the user supplies a fan curve, then the fan results tab also lists whether or not the fan is operating on the curve. The user may modify each fan by clicking on the fan input tab and selecting the edit fan icon, or by clicking on the Fan tab in Branch Data dialog. However, the model must be executed again in order for changes to be updated in the fan results tab.

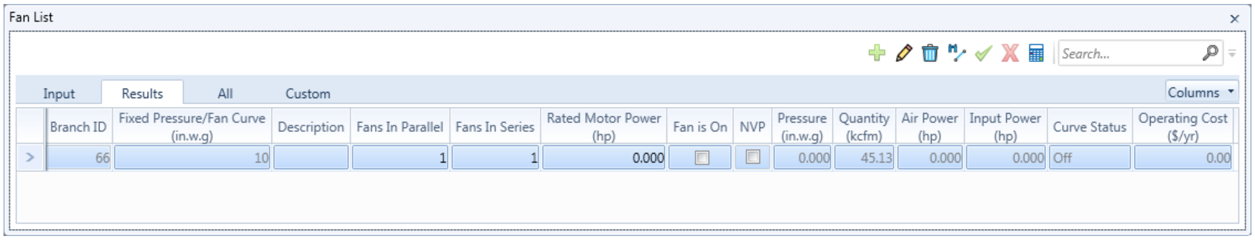
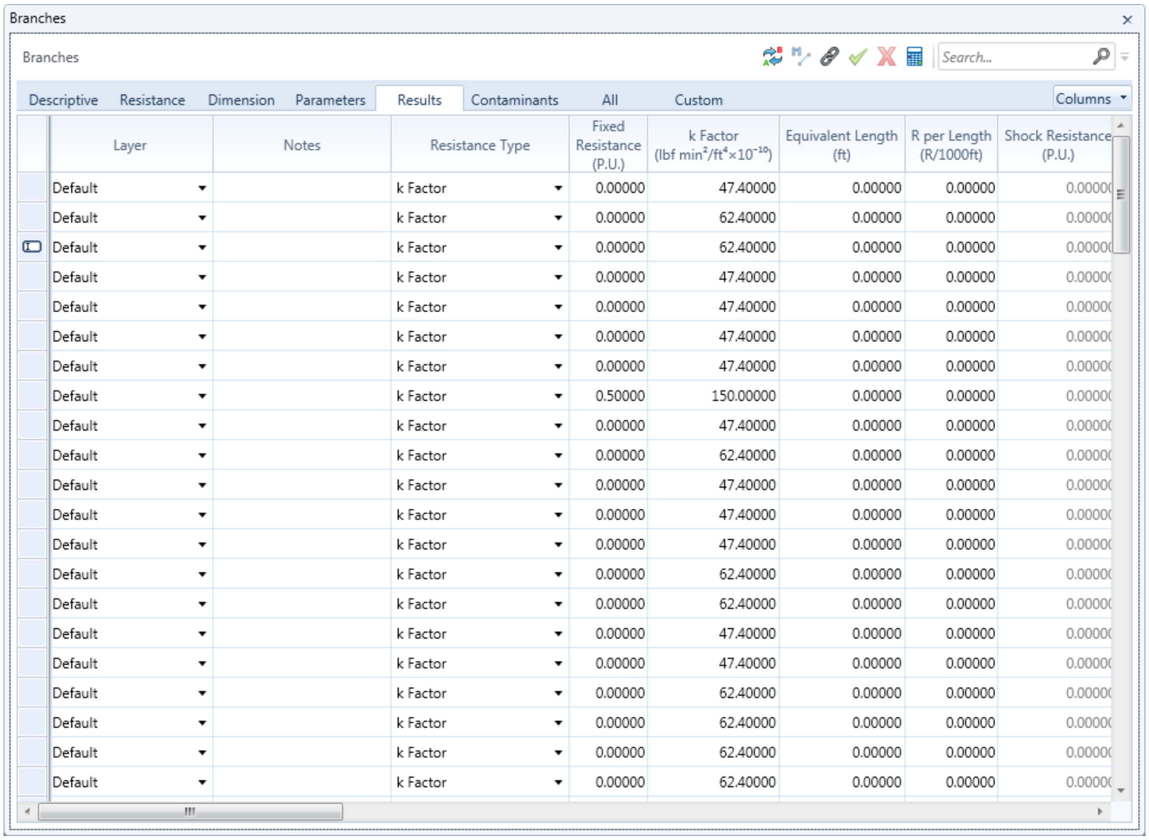


Figure 33: Fan results tab in Fans View.

4.4.3 Branch Results

The branch results for each simulation execution are listed under the branch results tab in Branches view. The branch results tab lists the output in spreadsheet format (see Figure 34). In the branch results tab the user has the option of viewing the Branch ID, junction numbers, airway calculated resistance, airflow, pressure drop, air power loss, velocity, branch description, annual operating cost, layer name, notes, resistance type, fixed resistance, k Factor, Equivalent Length, Resistance per Length, Shock Resistance, Shock Loss Factor, Auto Calculate Shock Loss check box, Parallel Factor, Profile Type, Auto Length check box, Length, Diameter, Invert Height, Width, Height, Rib Height, Auto Rib Height check box, Arch Factor, Auto Area check box, Area, Perimeter, Branch Type, Symbol, Excluded, In Atmosphere, Show Parameter, Quantity Results, Pressure Results, Emission Rate, Emission Concentration, Gas Flow Result, and Gas Flow Concentration. The output sheet is designed such that it is easy to read and simple to scroll through. The calculated resistance column reports the total of the branch input resistance and the resistance of any regulation resulting from fixed quantities. Open the Fixed Quantities view to see the individual resistance values.



Layer	Notes	Resistance Type	Fixed Resistance (P.U.)	k Factor (lbf min²/ft⁴×10⁻¹⁰)	Equivalent Length (ft)	R per Length (R/1000ft)	Shock Resistance (P.U.)
Default		k Factor	0.00000	47.40000	0.00000	0.00000	0.0000
Default		k Factor	0.00000	62.40000	0.00000	0.00000	0.0000
Default		k Factor	0.00000	62.40000	0.00000	0.00000	0.0000
Default		k Factor	0.00000	47.40000	0.00000	0.00000	0.0000
Default		k Factor	0.00000	47.40000	0.00000	0.00000	0.0000
Default		k Factor	0.00000	47.40000	0.00000	0.00000	0.0000
Default		k Factor	0.00000	47.40000	0.00000	0.00000	0.0000
Default		k Factor	0.50000	150.00000	0.00000	0.00000	0.0000
Default		k Factor	0.00000	47.40000	0.00000	0.00000	0.0000
Default		k Factor	0.00000	62.40000	0.00000	0.00000	0.0000
Default		k Factor	0.00000	47.40000	0.00000	0.00000	0.0000
Default		k Factor	0.00000	47.40000	0.00000	0.00000	0.0000
Default		k Factor	0.00000	47.40000	0.00000	0.00000	0.0000
Default		k Factor	0.00000	62.40000	0.00000	0.00000	0.0000
Default		k Factor	0.00000	62.40000	0.00000	0.00000	0.0000
Default		k Factor	0.00000	47.40000	0.00000	0.00000	0.0000
Default		k Factor	0.00000	47.40000	0.00000	0.00000	0.0000
Default		k Factor	0.00000	62.40000	0.00000	0.00000	0.0000
Default		k Factor	0.00000	62.40000	0.00000	0.00000	0.0000
Default		k Factor	0.00000	62.40000	0.00000	0.00000	0.0000
Default		k Factor	0.00000	62.40000	0.00000	0.00000	0.0000

Figure 34: Branch results tab in Branches View

4.4.4 Fixed Quantity Information

Fixed quantity input and output data are shown under the Fixed Quantities view (refer to Figure 23). This view lists the fixed quantity airflow, branch ID, whether the branch is designated as inject/reject (I/R), booster pressure, regulator resistance, regulator orifice area, input branch resistance, total resistance of the branch (if regulated), and description for the fixed quantity, and annual operating cost.

4.4.5 Displaying Results in the Model View

The on-screen Model view is perhaps the most user-friendly way to input and view data. Ventilation networks can be entirely developed within Model view, and it provides a rapid means of viewing the network results. In Model view, different parameters may be plotted onto the network using the Parameters view menu.

4.4.5.1 Parameters View

The Parameters view allows the user to select which result parameters are to be shown and how to show them. There are key features from this menu that enable the user to easily compare different sections of the model.

Actions

The Actions section is where the user selects which parameter is to be displayed. Under the actions tab there are four different parameter categories to choose from: resistance, airway dimensions, results, and contaminants. Under each category the following parameters are available to display in Model view.

Resistance:

Fixed Resistance, Calculated Resistance, Friction Factor, Pressure Drop, Quantity, Resistance per Length, Shock Resistance, Sock Loss Factor, Equivalent Length, Parallel Factor

Airway dimensions:

Length, Diameter, Invert Height, Width, Height, Rib Height, Arch Factor, Area, Perimeter

Results:

Total Resistance, Quantity, Velocity, Pressure Drop, Air Power Loss, Operating Cost, Gas Flow Result, Gas Concentration

Contaminants:

Emission Rate, Emission Concentration

Data Exclusion/ Transparency

The Data Exclusion section uses shading to give the branches different colors based on the magnitude of the parameter selected. In order to activate this display option the user must select "Parameter" under the Branch Color Display menu under the Branch Display tab in User Preferences view.

In this section, the user is able to define a list of values in which parameters are shaded based on the magnitude of the value (See Figure 14). The user enters the desired value range in the column on the right. Each value is assigned the color corresponding to the left of the value. For the convenience of the user, VNet also provides an automatically generated set of values that are based on the type of parameter selected. The left shaded column represents the automatically generated values while the right column represents the user defined values. The vertical slider bar to the left of the VNet defined column, changes the range of the values of the column and the respective parameter color.

For values outside of the spectrum of defined values, there is a Transparency slider to adjust the visibility of these branches. In order to completely hide all of these values, the user can select the Turn Branch Data Test On/Off Tray icon on the bottom of Model view.

4.4.5.2 Branch Types View

The Branch Types View is opened by selecting the appropriate icon on the Ribbon in Model view. Once this is selected a window opens allowing the user to change existing branch type names and colors as well as add or subtract to the list of branch types (See Figure 35).

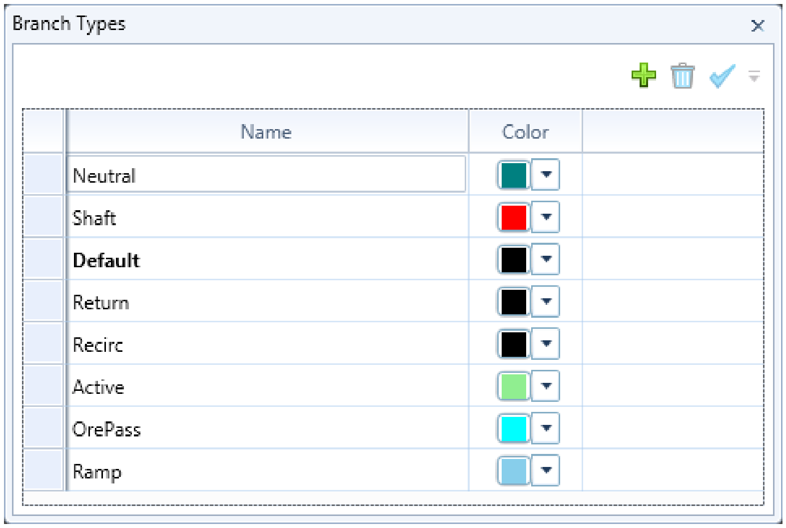


Figure 35: Branch Types View.

The basic branch types available are Default, Intake, Neutral, Return, Active, and several user defined branch labels.

Letter Size Adjustment

Adjusting the properties of the branch text in Model view can be adjusted by selecting User Preferences Menu > Branch Display > Brach Text. Under the Branch Text section the user has the option of showing or hiding this text, adjusting the font size, font color, and whether the text size is scaled to the screen or scaled to actual dimensions. As well the user has the option to hide text if it is a certain distance from the screen. This distance is adjusted by moving the slider bar to the desired level.

Junction Nodes

This command toggles the junction nodes on and off in the Model view. This is helpful when branch values and node numbers become cluttered. Removing the junction nodes may help to clarify the drawing. To toggle the junction nodes the user can either select the appropriate icon on the quick access Tray  or select the box next to “Show junctions” in the Junctions section under the User Preferences view.

Relative Pressure

This feature shows the total differential pressure drop between the branches in the model and a fixed reference junction defined by the user in the model. To assign the reference junction, the user should modify the appropriate field in Model Information view. In Model view, the relative pressure is shown as a number above each junction. This feature is toggled on and off in the Model view by selecting the appropriate icon in the quick access Tray at the bottom of the screen. The relative pressure is also shown in junctions view as well in a column next to each point.

Symbols

This command toggles on and off any symbols the user has specified in the network. This can be toggled either using the appropriate Tray icon or by checking the box next to "Show branch symbols" in User Preferences view under the Branch Display tab.

Display Labels

This command toggles on and off the labels created in Model view. This feature is toggled by selecting the appropriate Tray icon or by checking the box next to Show labels in the User Preferences menu under the Other Display tab.

Show Inject/Reject Branches

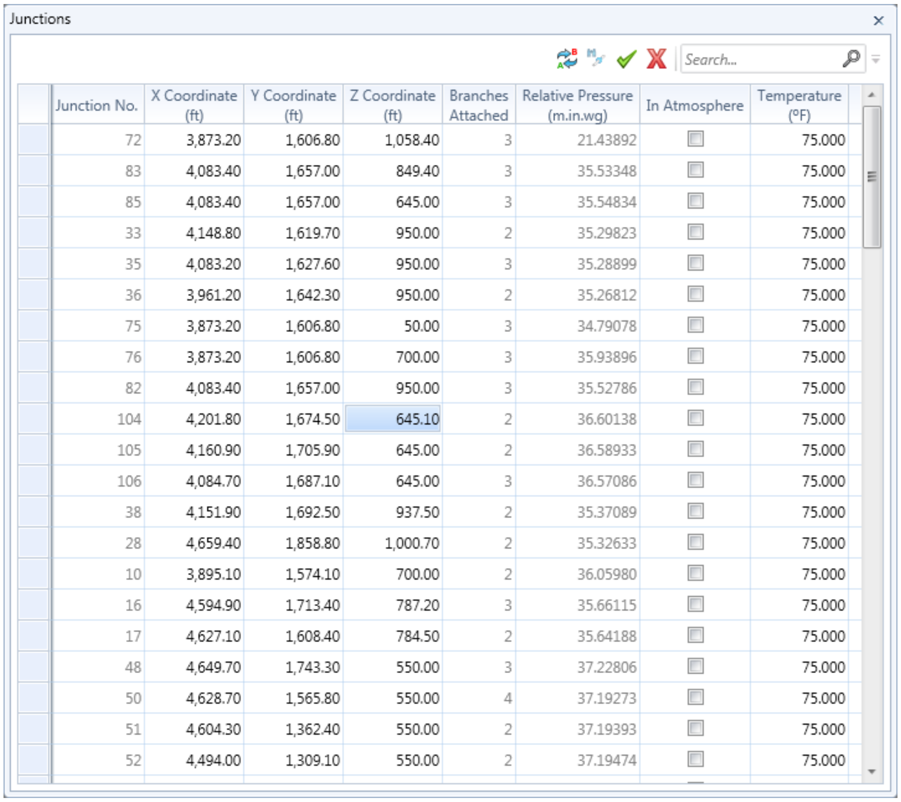
This command toggles on and off any inject/reject branches that the user has specified in the network. This setting is toggled using the appropriate Tray icon or by checking the box next to "Show inject/reject branches" in User Preferences view under the Branch Display tab. If the branches are turned off, the branches are still included in the calculation, but are not shown in Model view.

Zoom Tool

The user can zoom in and out in Model view by either using the scroll wheel on the mouse or the appropriate zoom tool on the tools Ribbon. To zoom to the extents of the model the user simply double clicks on the center mouse wheel. Panning from one portion of the Model view to another can be accomplished by pressing down the center mouse wheel and dragging the selection pointer.

4.4.6 Junction Data

In the Junction Data view, the junction numbers appear on the left column, and X, Y and Z coordinates are shown in the adjacent three columns. The column marked Branches Attached indicates how many branches are connected to each node. There are also adjacent columns for Relative Pressure, In Atmosphere, and Temperature. On the tool bar in this view the user has the option to Find and Replace, Locate the Junction in Model view, and decide to apply/reject changes to the junctions. The user can also search for any specific text on the search bar.



Junctions

Junction No.	X Coordinate (ft)	Y Coordinate (ft)	Z Coordinate (ft)	Branches Attached	Relative Pressure (m.in.wg)	In Atmosphere	Temperature (°F)
72	3,873.20	1,606.80	1,058.40	3	21.43892	☐	75.000
83	4,083.40	1,657.00	849.40	3	35.53348	☐	75.000
85	4,083.40	1,657.00	645.00	3	35.54834	☐	75.000
33	4,148.80	1,619.70	950.00	2	35.29823	☐	75.000
35	4,083.20	1,627.60	950.00	3	35.28899	☐	75.000
36	3,961.20	1,642.30	950.00	2	35.26812	☐	75.000
75	3,873.20	1,606.80	50.00	3	34.79078	☐	75.000
76	3,873.20	1,606.80	700.00	3	35.93896	☐	75.000
82	4,083.40	1,657.00	950.00	3	35.52786	☐	75.000
104	4,201.80	1,674.50	645.10	2	36.60138	☐	75.000
105	4,160.90	1,705.90	645.00	2	36.58933	☐	75.000
106	4,084.70	1,687.10	645.00	3	36.57086	☐	75.000
38	4,151.90	1,692.50	937.50	2	35.37089	☐	75.000
28	4,659.40	1,858.80	1,000.70	2	35.32633	☐	75.000
10	3,895.10	1,574.10	700.00	2	36.05980	☐	75.000
16	4,594.90	1,713.40	787.20	3	35.66115	☐	75.000
17	4,627.10	1,608.40	784.50	2	35.64188	☐	75.000
48	4,649.70	1,743.30	550.00	3	37.22806	☐	75.000
50	4,628.70	1,565.80	550.00	4	37.19273	☐	75.000
51	4,604.30	1,362.40	550.00	2	37.19393	☐	75.000
52	4,494.00	1,309.10	550.00	2	37.19474	☐	75.000

Figure 36: Junction Data View

4.4.7 DXF File Generation

The user can export some or the entire model to a DXF file. This feature is accessed through the Model view by selecting the appropriate icon labeled "Export to DXF" on the tools Ribbon . In order to export to a DXF file format the user must first select which branches to export. After the branches are selected the user selects the icon. A dialog box will appear for the user to Save As in DXF format. Each branch is exported with a label to designate its branch number.

4.4.8 Changing the Appearance of a Table View

The display and arrangement of columns in table views can be customized by the user. The columns and rows can be rearranged, widened or narrowed, removed or added. The columns can be easily rearranged by clicking on the column or row header with the left mouse button to hi-light it, then by clicking and dragging it to its new position. The column width can be changed by clicking on the column separators in the column header and dragging it in one direction or another. The columns can be removed or added by selecting the "Columns" drop down menu near the top right of each table view. This is useful so that the items on a view can be limited to only those parameters actually used in the simulation. Figure 37 shows the columns drop down selection menu for Branches view. Users may designate which columns are to be viewed by selecting the box next to item. Branches may be filtered by using the search bar in each table view.

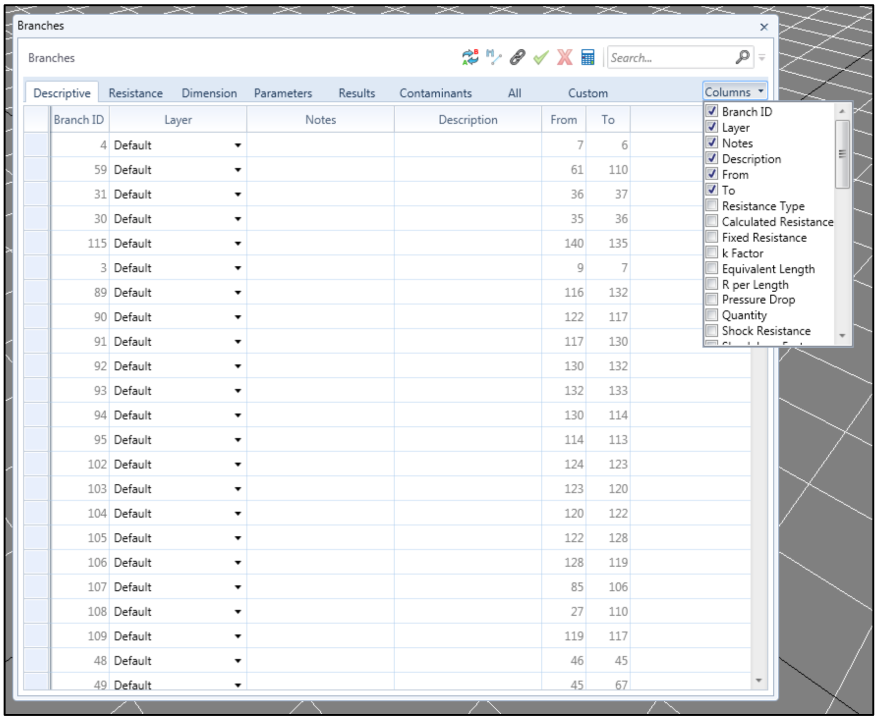


Figure 37: Columns Menu for Branches View.

4.4.9 Windows Tabs

VNet allows the user to edit multiple different models at the same time. To navigate between models the user simply selects the appropriate tab at the top of the screen. To create a new model without out closing and reopening VNet, the user can simply select the new model tab or select New after selecting the backstage button on the Ribbon. Figure 38 shows the program with multiple models open and circles the tab to create a new model.

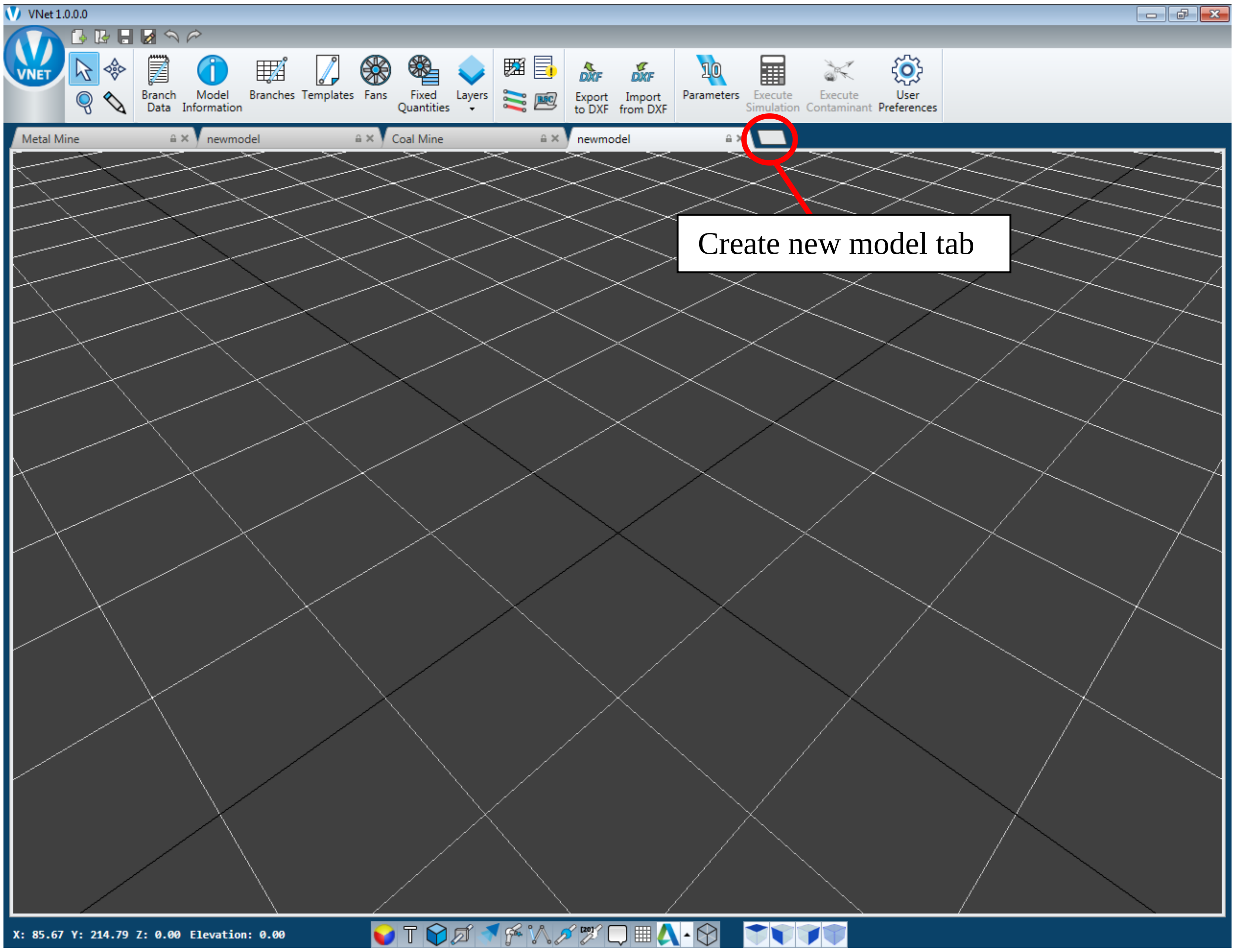


Figure 38: New model tab and multiple models open.

5. Tutorial

5.1 Introduction

This tutorial describes how to establish a ventilation model in VNet using AutoCAD™ (or a DXF file generated by another mine planning or CAD package) to establish a network Schematic. The following sections detail how to establish a ventilation Schematic in AutoCAD™ and create a new VNet file from the data. The step by step process provides the user with an in-depth look at how to get started.

5.2 Setting Up the Model in AutoCAD

Ventilation Schematics for underground mines can be developed by overlaying a branch network onto the mine plan using AutoCAD, saving as a DXF file, and importing the file into VNet. The following subsections describe this process.

5.2.1 Adding the Ventilation Layers

The first step is for the user to create layers using the Layer Properties Manager in AutoCAD. It is suggested that for each section/component of the mine, a new layer be created for the network Schematic (e.g. set up new layers for each level, ramp, shaft, etc.). An example Layer Properties Manager dialog box has been copied out of AutoCAD™ and is shown in Figure 39 to demonstrate this feature. The original drawing layers are 1400, 1600, 1800, 1920, and 2000. The layers 1400VENT, 1600VENT, 1800VENT, 1920VENT and 2000VENT were created for the purpose of importing a schematic into the VNet program.

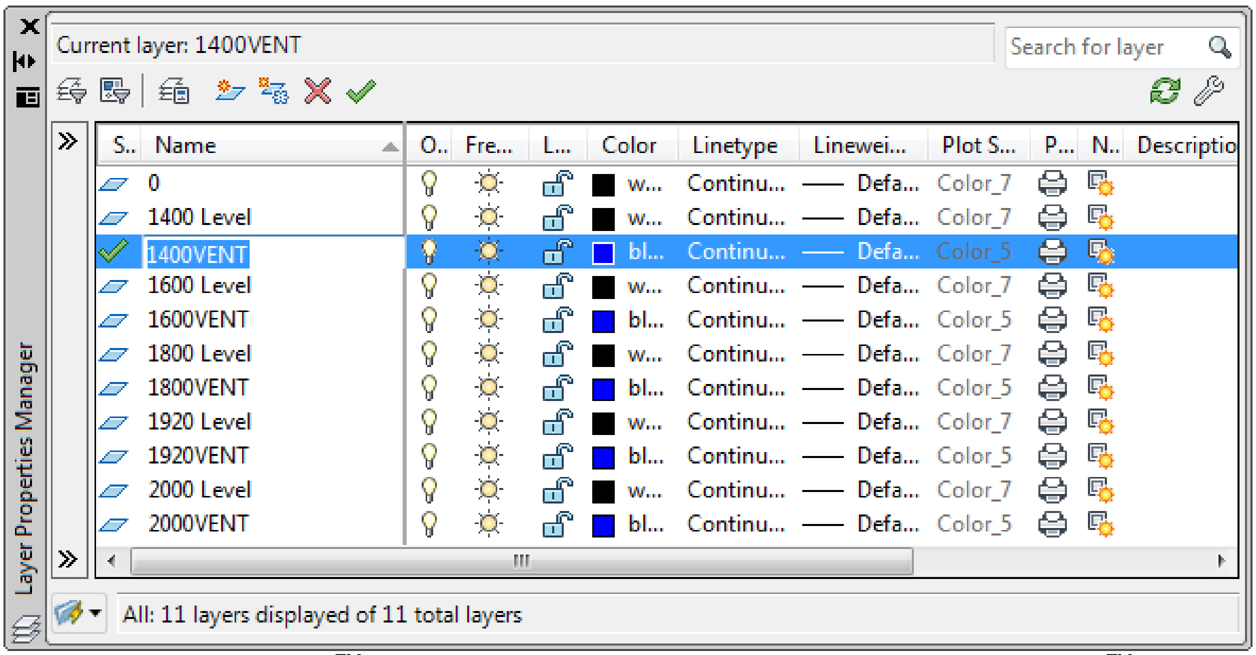


Figure 39: AutoCAD™ Layer Properties Manager Dialog Box - copied from AutoCAD 2010™.

Each of the layers denoted with the suffix VENT, will contain a portion of the overall schematic. When transferring the schematic to VNet, each level must be individually imported. Because VNet uses the digital exchange format (DXF), it can import files from other software applications. Layers to be imported must consist of only simple lines and polylines. Layers cannot contain text, 3D polylines, arcs, circles, etc. If the user tries to import a layer containing one of these layer types, VNet will ignore all objects in the layer regardless of object type. An example metal mine is shown below with each layer turned on to show how they overlay. This procedure can be done with multiple files (one for each level); however, it can be more efficient to develop a mine map in one DXF file with multiple layers (as shown on Figure 40). Figure 41 shows a single level of the mine. This level will be used to start a Schematic drawing.

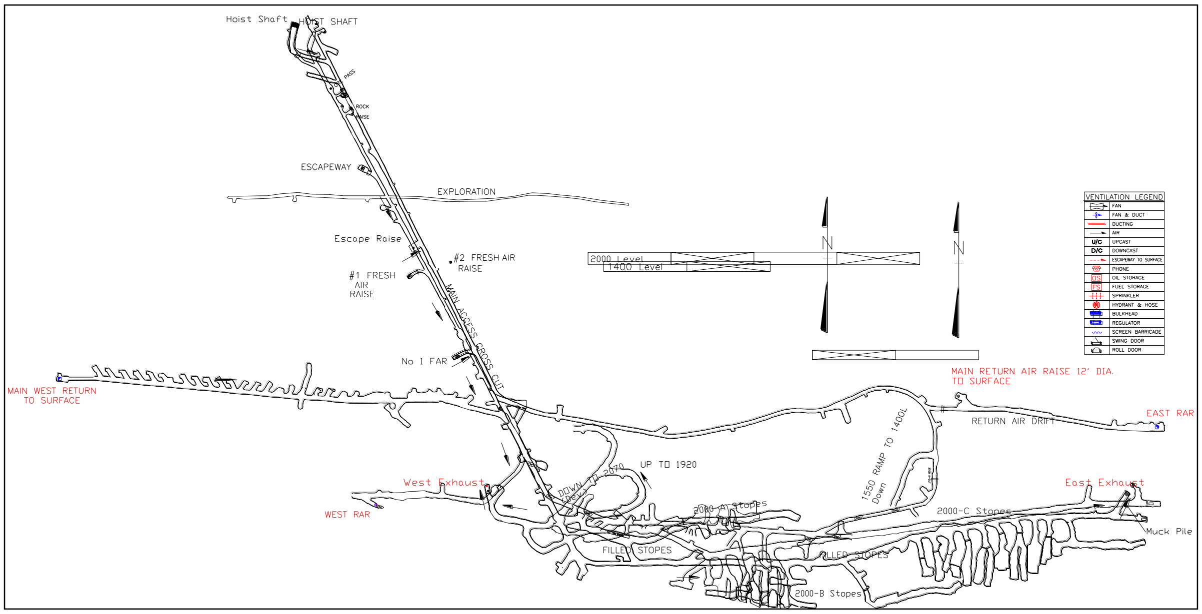


Figure 40: Drawing of Metal Mine Airways (Plan View with multiple levels active).

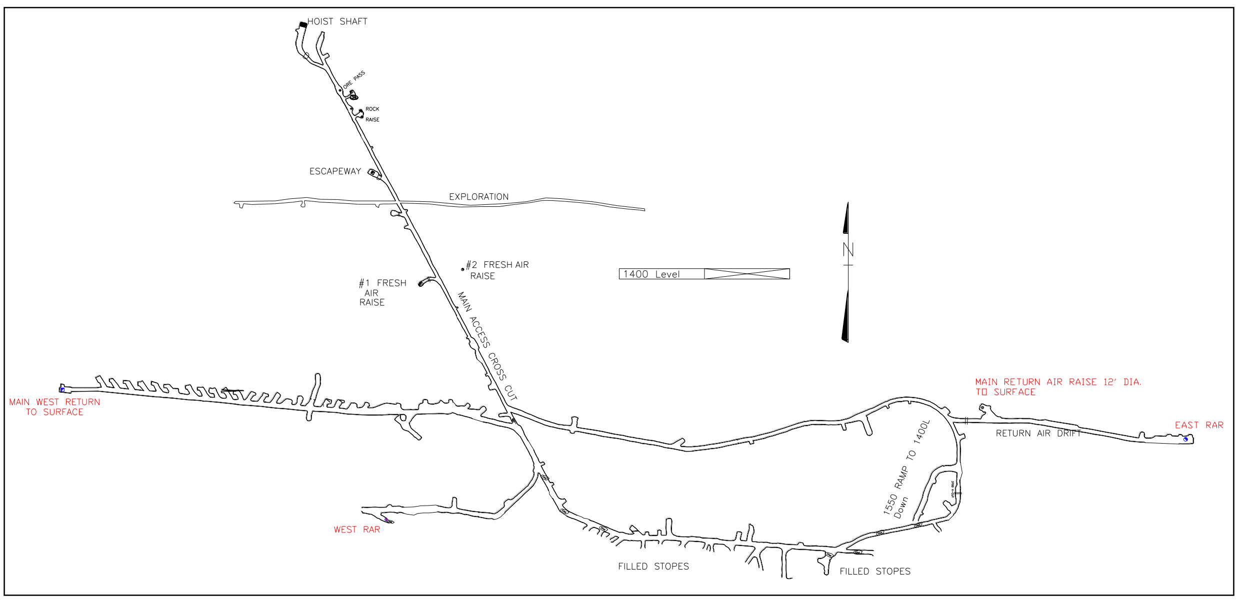


Figure 41: 1400 Level.

5.2.2 Drawing the schematic (Line Diagram)

When drawing the schematic, it is important to ensure that each branch is connected. **Do not terminate a branch and then begin the next branch without ensuring that the two are connected**. In AutoCAD™, the user should enable the [endpoint] running object snap to connect the branch endpoints where junctions would occur. The schematic will be drawn on the VENT layer while displaying both the VENT layer and the corresponding mine level (basically overlaying the mine map). The schematic will be a line diagram, with each line representing an airway. When drawing the schematic, it may be helpful to draw the schematic lines along the centerlines of airways. Not all airways need to be drawn. Common airways arranged in parallel, such as those in a coal mine, should typically be drawn as one line. Care should be taken to ensure all air courses are properly represented in the ventilation schematic. An excessive number of airways can result in model inefficiencies and lead to a greater potential for errors. Large networks require more time to execute and will not necessarily provide increased accuracy. The AutoCAD™ schematic does not have to be exact, since it can be adjusted in the VNet program for evenness, spacing, and alignment. Figure 42 through Figure 46 illustrate the five levels with the network lines drawn on overlying layers.

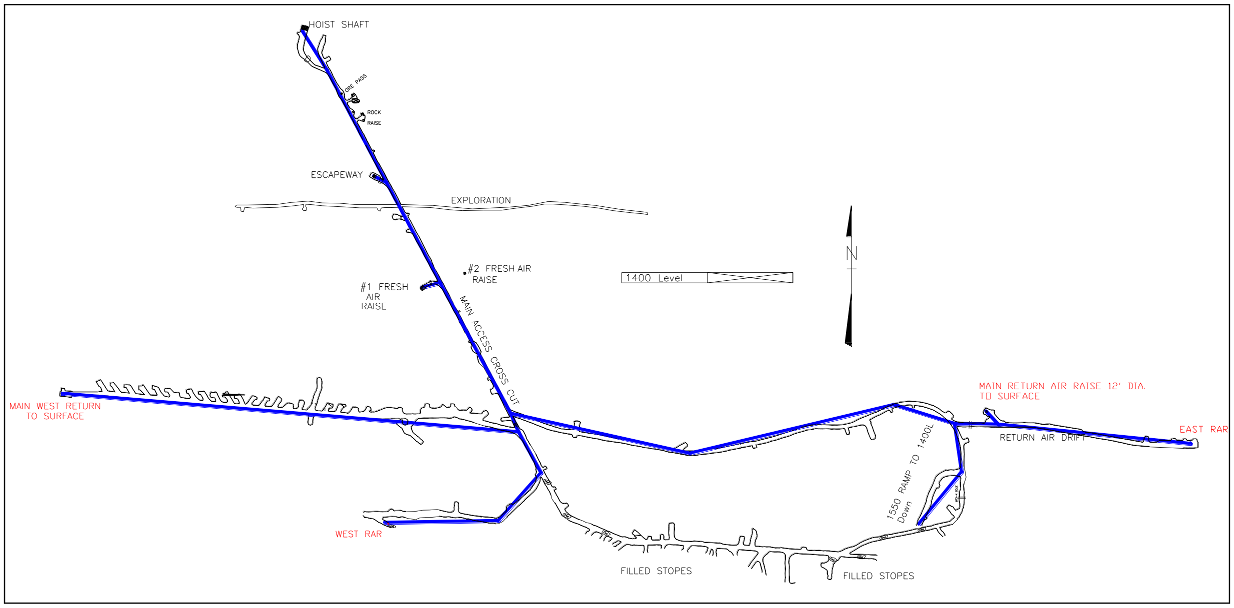


Figure 42: 1400 Level with Wire Frame Drawn.

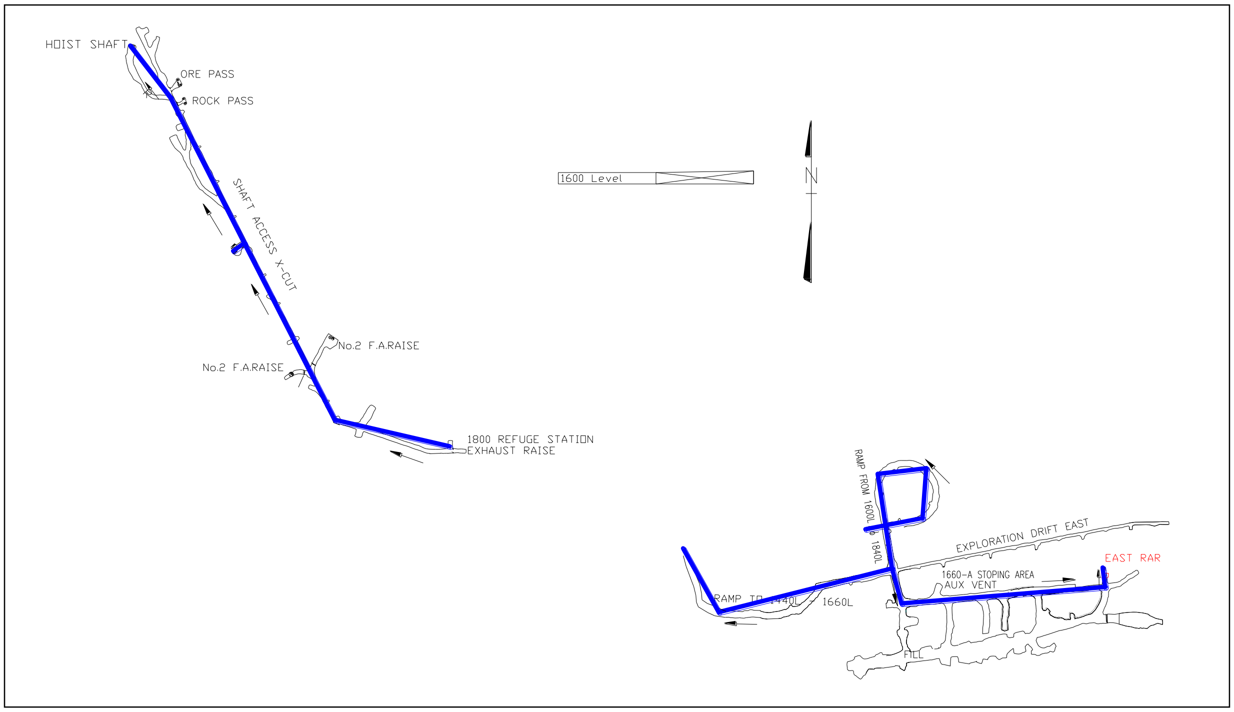


Figure 43: 1600 Level with Wire Frame Drawn.

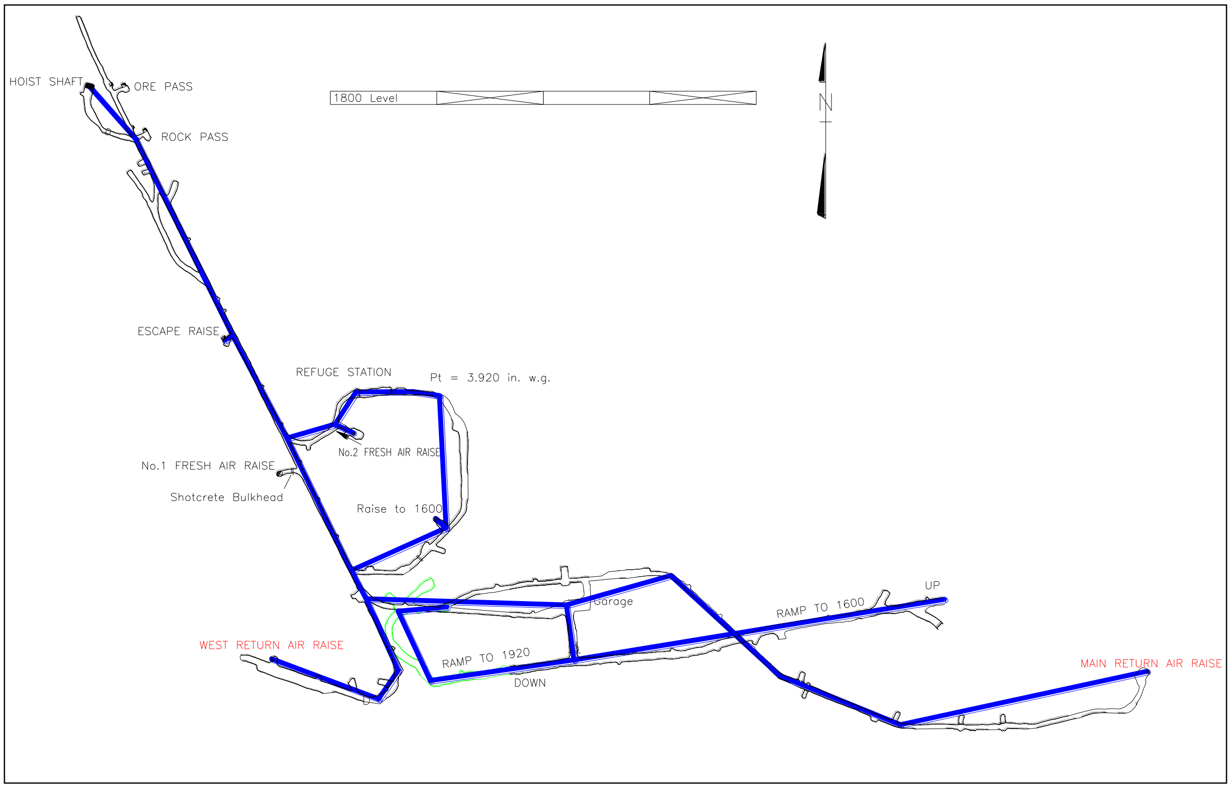


Figure 44: 1800 Level with Wire Frame Drawn.

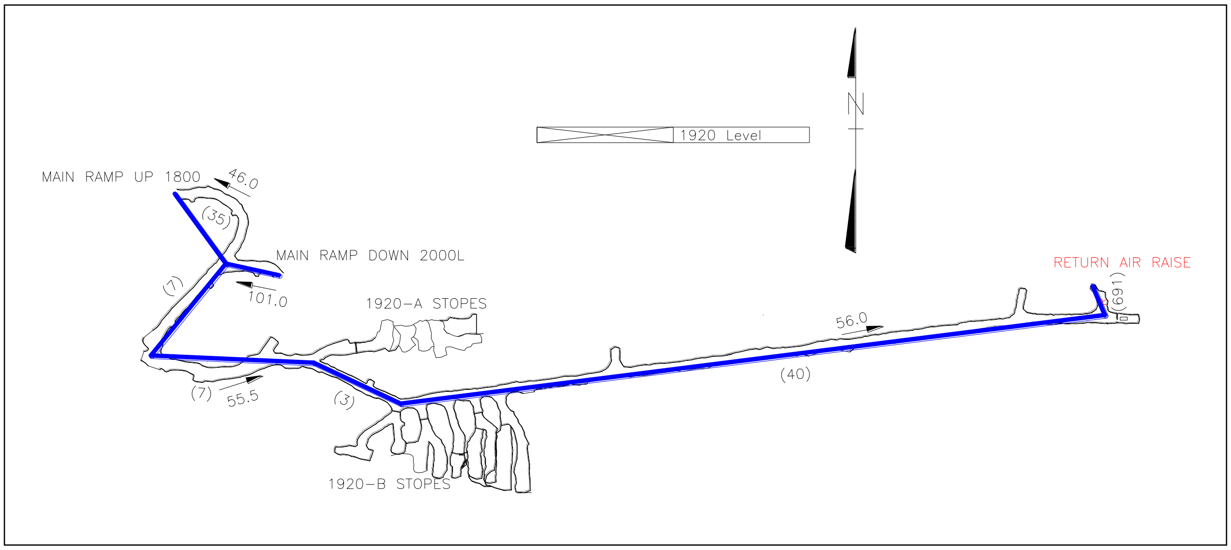


Figure 45: 1920 Level with Wire Frame Drawn.

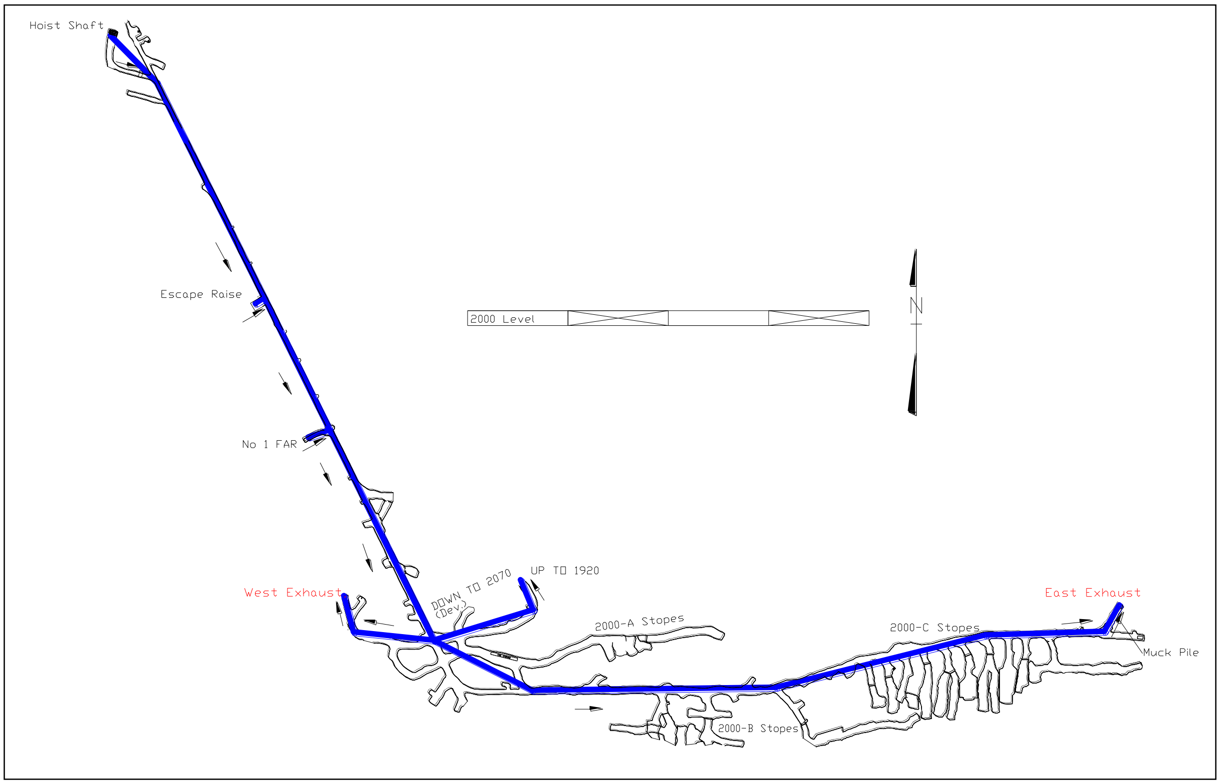


Figure 46: 2000 Level with Wire Frame Drawn.

After the line diagrams are established for each level, the ramp is then identified. VNet does not treat each of these layers as a distinct "level", although in some cases it can be thought of in this manner. Instead, each layer imported to VNet is identified as a group of branches with similar general characteristics. When all of the branches have the same general elevation then they can be considered a 'Level'. However, since a ramp will have various elevations for each set of branches, it may be easier to think of them as a Layer. The branches drawn for the ramp are shown on Figure 47.

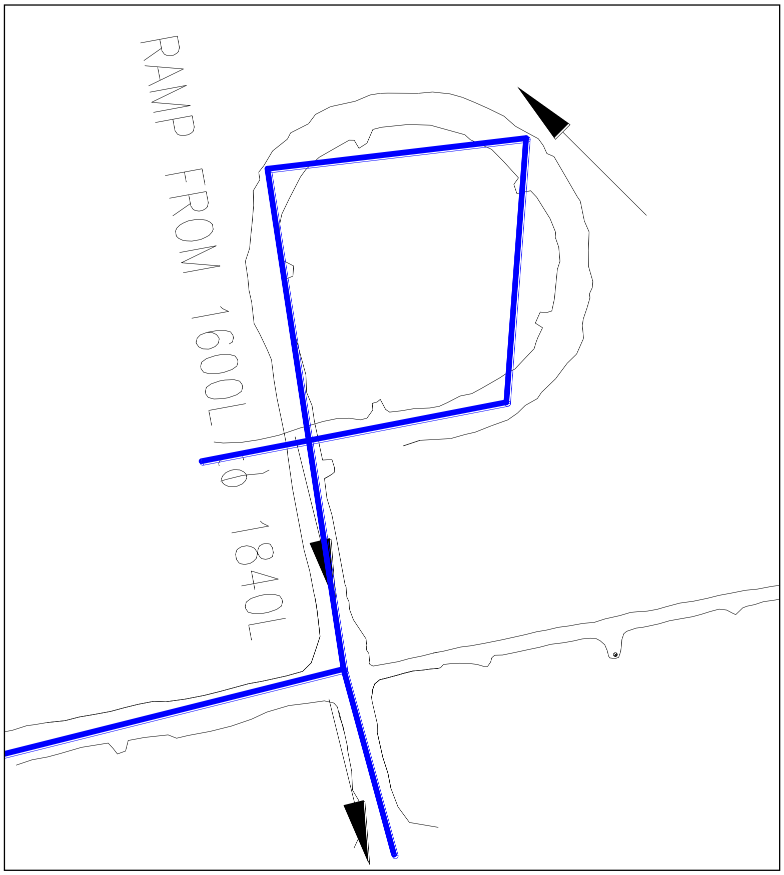


Figure 47: Close-up of Branches Drawn in Ramp.

The ramp is traced using large line segments. Wherever the ramp connects to a level, the schematic wire frame is connected to the intersection previously drawn as displayed in Figure 48.

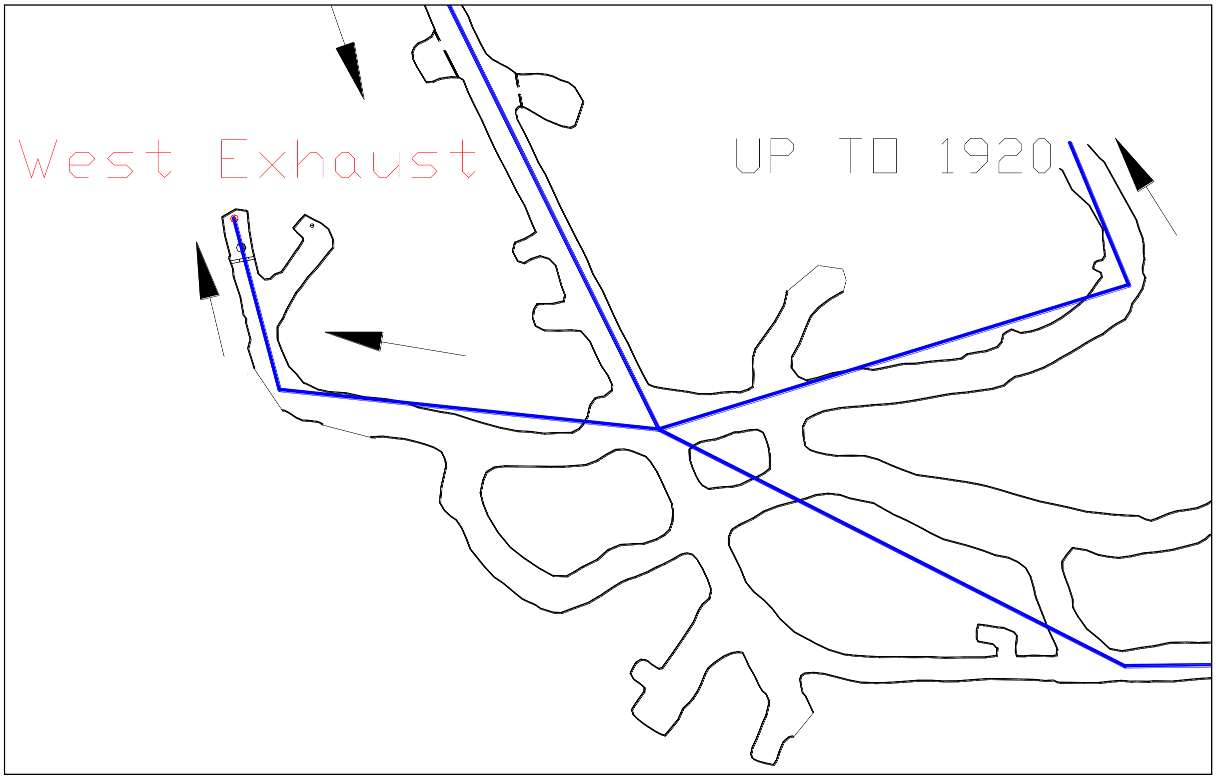


Figure 48: Ensure all Branches are Connected.

Once the wire frame diagrams are drawn they will look like the pictures in Figure 49 through Figure 53 in plan view.

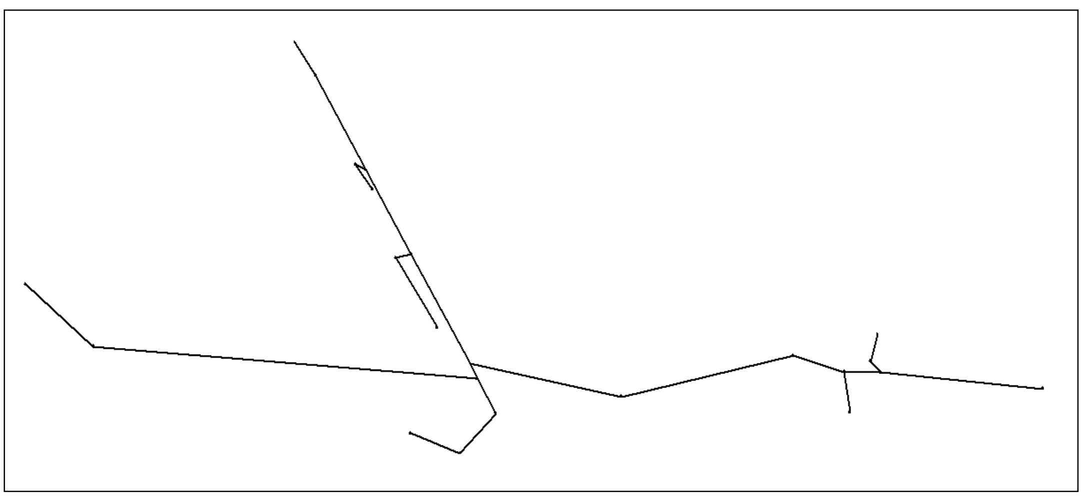


Figure 49: 1400 Level VnetPC Pro+ schematic.

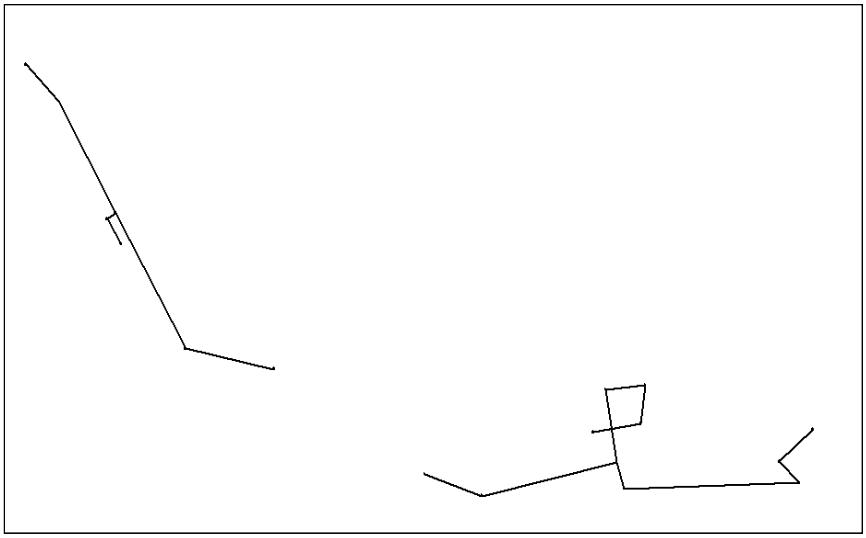


Figure 50: 1600 Level VnetPC Pro+ schematic.

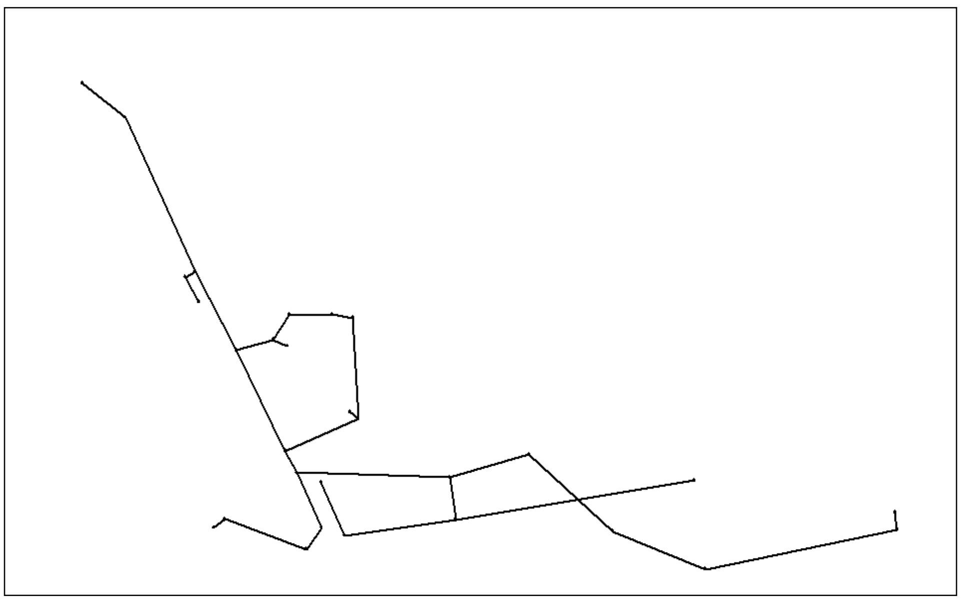


Figure 51: 1800 Level VnetPC Pro+ schematic.

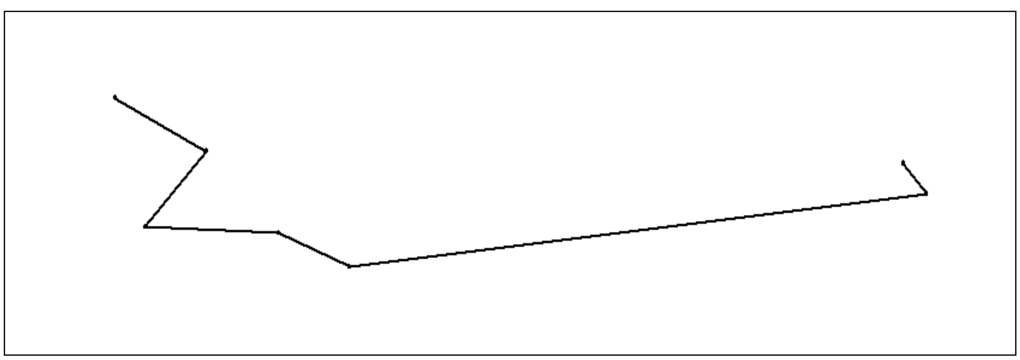


Figure 52: 1920 Level VnetPC Pro+ schematic.

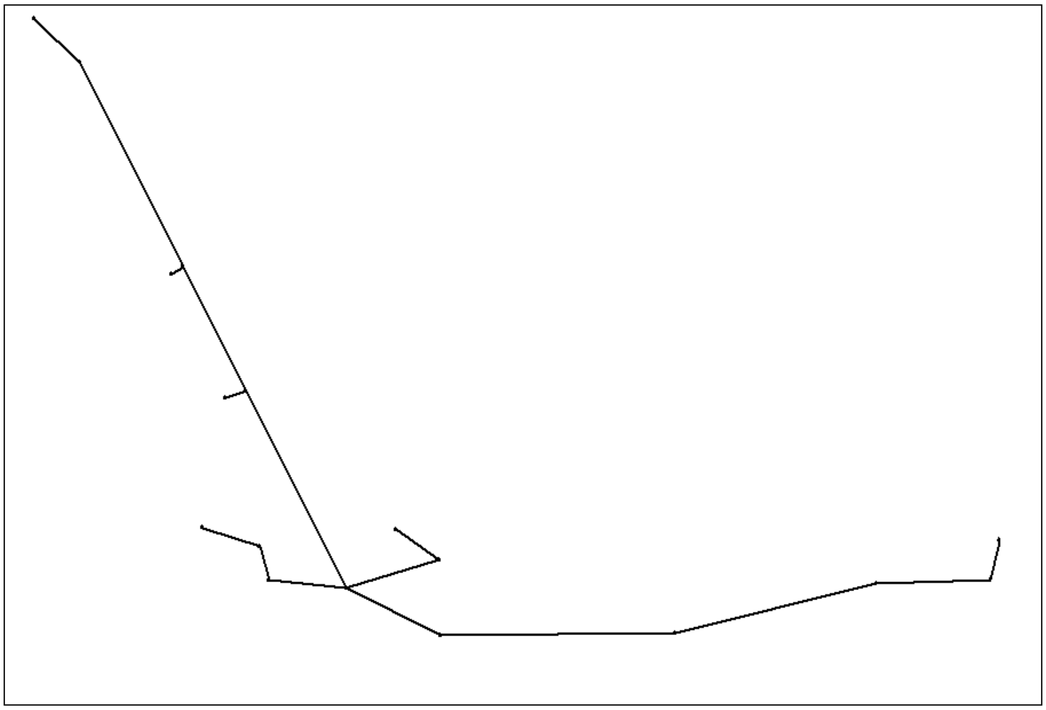


Figure 53: 2000 Level VnetPC Pro+ schematic.

5.2.3 Exporting the DXF File

Once the line diagrams are completed, a DXF file needs to be generated. This is done in AutoCAD^{TM} by selecting "File" > "Save As". Be sure to select the DXF option under the File Type drop down menu. Also, make sure that the DXF file is saved in the proper location. The Save As dialog box is shown in Figure 54 for the tutorial example.

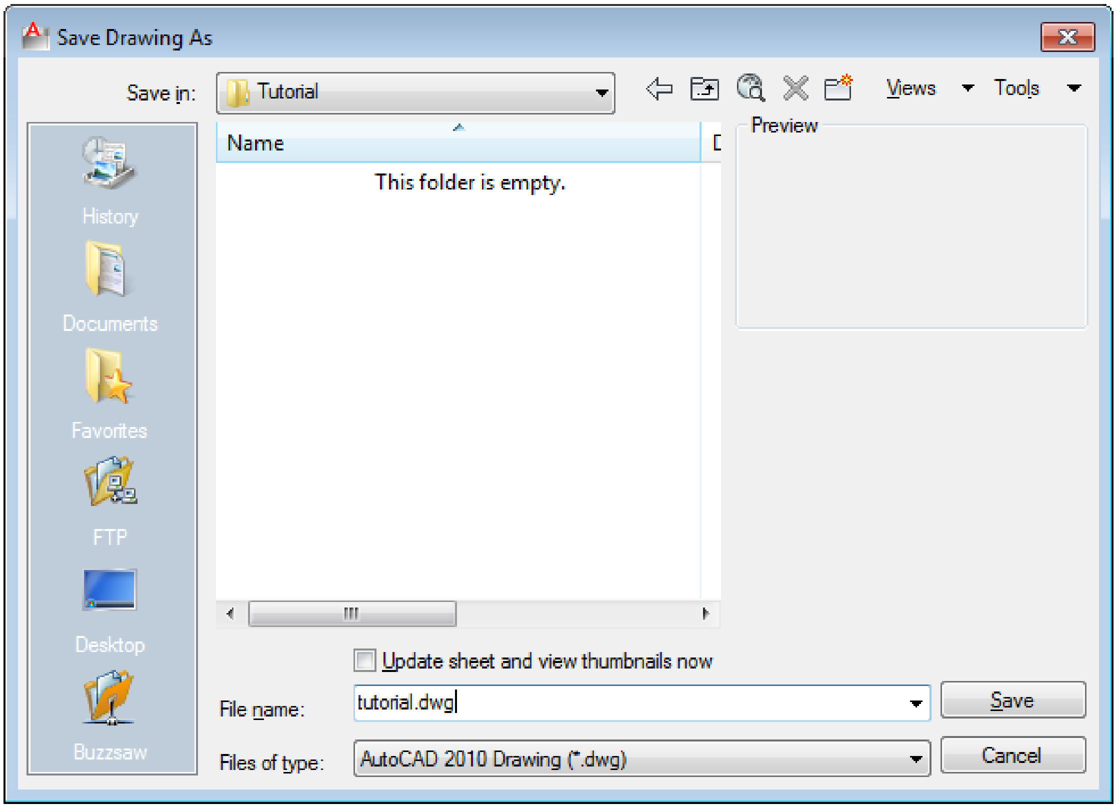


Figure 54: AutoCAD™ Save Drawing As Dialog Box

Once a DXF file has been saved, the AutoCAD™ program can be closed.

5.3 Working in the VNet Program

5.3.1 Setting Up the VNet File

To set up the VNet File, first open a new program. The program should display Model view upon opening with a view titled newmodel as the default model name. If it is not, select the large blue VNet button at the top left of the screen to get to the Model view. Figure 55 shows VNet opened to Model view.

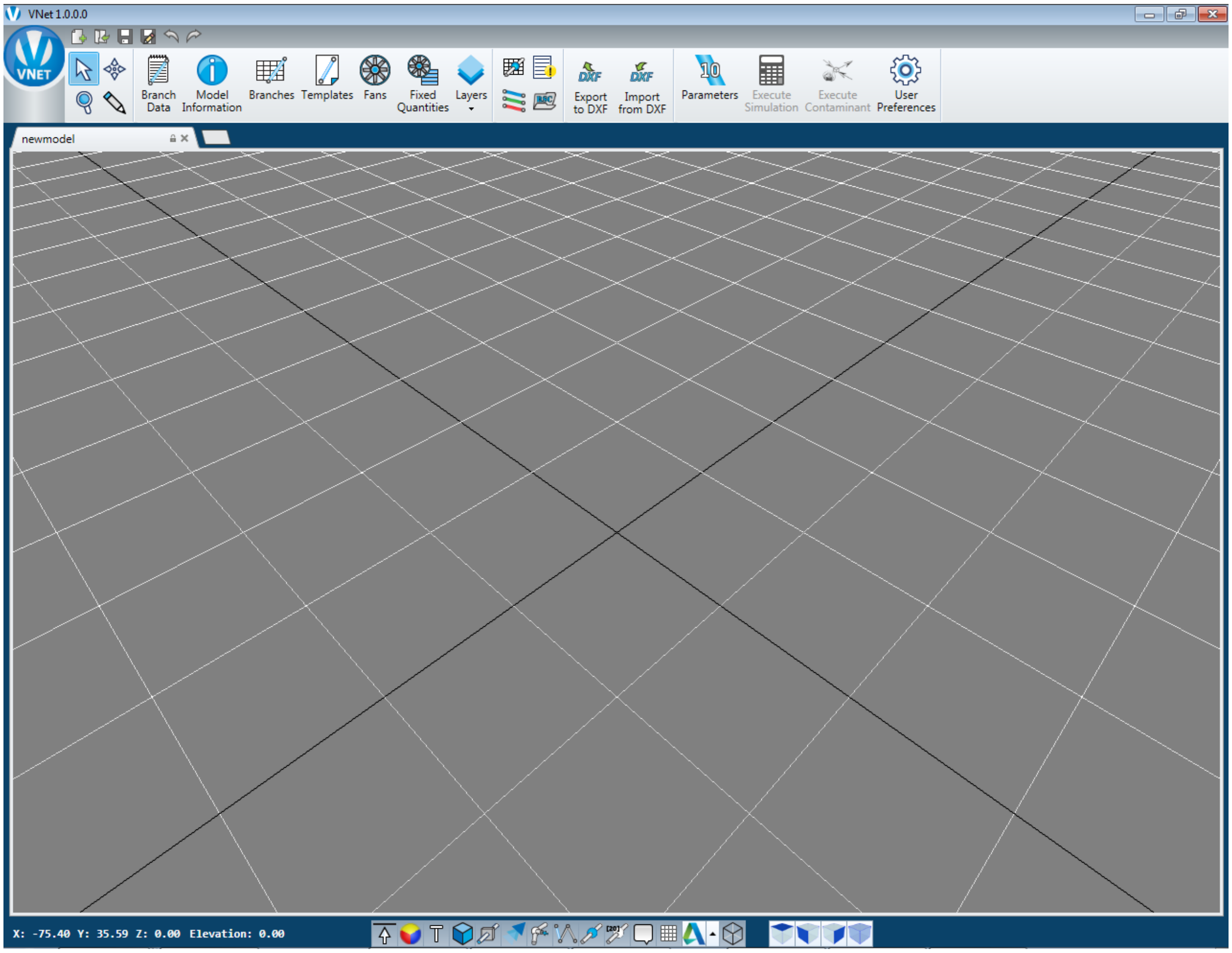


Figure 55: Model View upon opening model.

Upon starting a new model, the user may want to change the default settings of the program. By selecting Model Information view on the Ribbon, the user may change the general settings of the program. A sample Model Information view is shown in Figure 56.

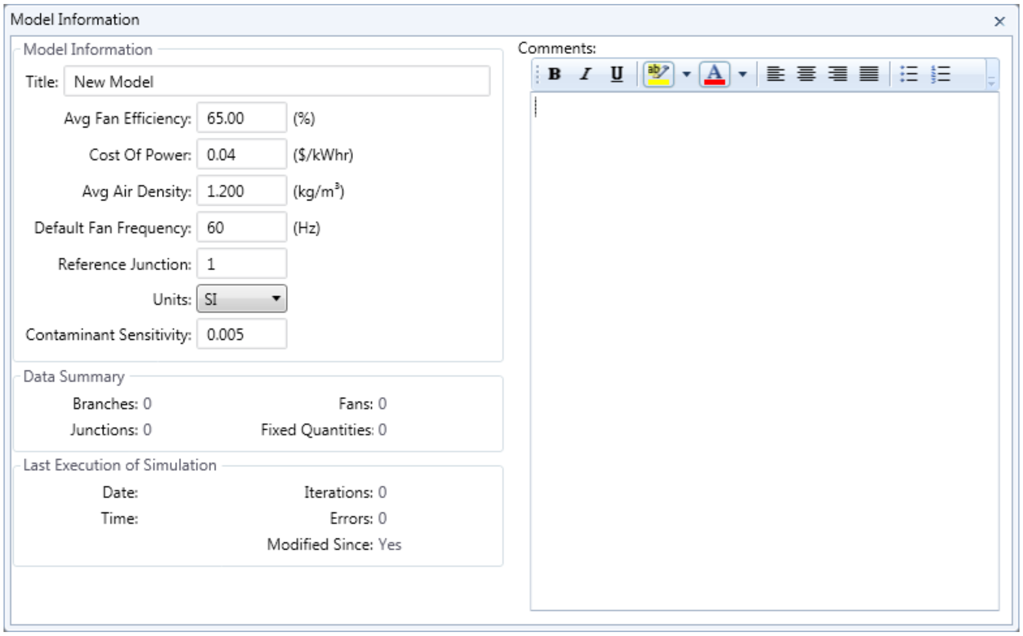


Figure 56: Model Information view.

The model title and any particular description can be entered to further identify the purpose of the simulation. The user can also enter the average power cost and fan efficiency in this view. A reference junction is also selected. This junction is usually associated with a surface condition. A relative pressure table will be calculated relative to this point. The average air density is also entered in this view. This density may be estimated based on average mine conditions but it is usually most accurate if several measurements are taken at different points in mine to get an average density. This value is defaulted to the mean air density at Sea Level (0.075 lb/ft^3 or 1.20 kg/m^3. This value is needed to compute the orifice area for any regulators listed in the Fixed Quantities view. This air density is not used anywhere else in the program.

5.3.2 Importing the schematic

To bring the network into VNet, the user should select “Import from DXF” from the Model view Ribbon (see Figure 57).

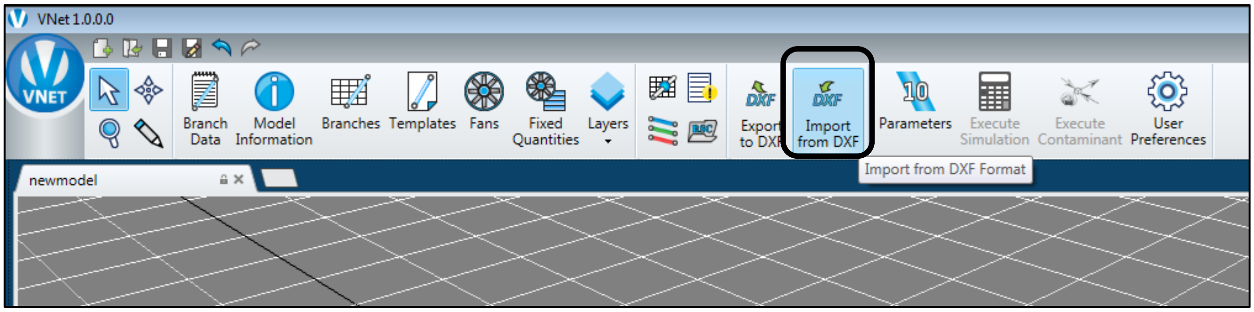


Figure 57: Location of “Import from DXF” tool on Model View Ribbon.

Once the user selects the Import from DXF tool, a standard Open file dialog box will appear prompting the user to identify the DXF file to be imported. The user then selects the DXF file. The Layer Selection dialog box, shown in Figure 58, will then appear prompting the user to identify the layer(s) to be imported. In this case, the 1400 Level, 1600 Level, 1800 Level, 1920 Level, and 2000 Level layers will be imported. By selecting the appropriate selection box next to each layer to be imported the user can import multiple layers at a time. The units drop down menu is utilized when the DXF file and VnetPC model have different units.

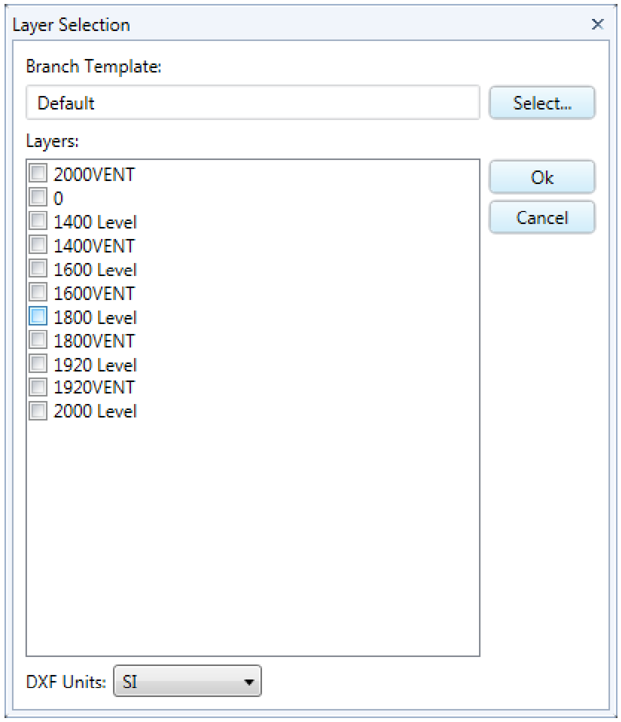


Figure 58: Layer Selection Dialog Box.

After the layer(s) are imported new branches should appear on the screen followed by a confirmation message at the bottom right of the screen. If the branches are not in view, double clicking on the center mouse wheel/button will center the view over the existing branches. Initially, all branches will appear with default branch dimensions and colors; however, these parameters may be changed later. Figure 59 shows the imported branches in Model view.

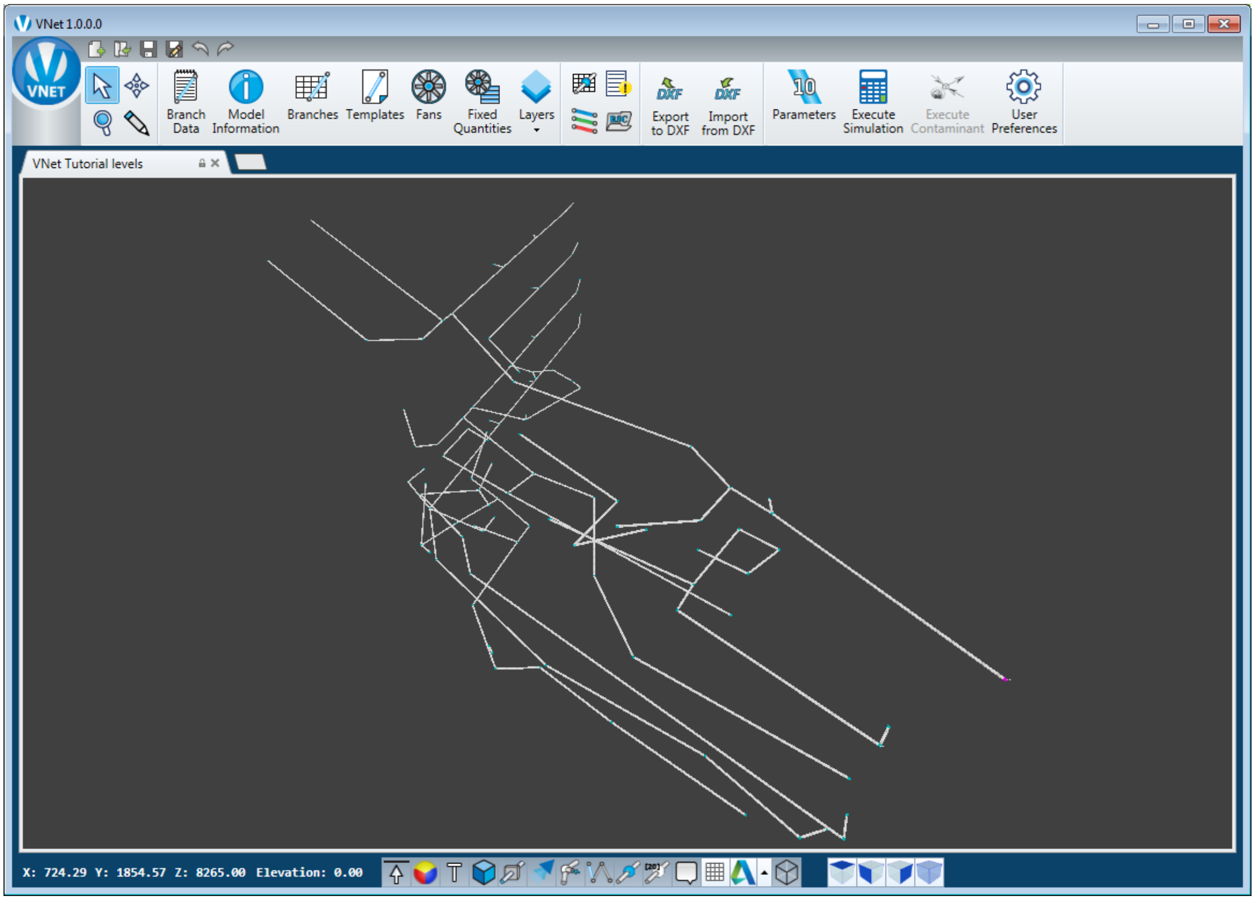


Figure 59: Layers imported into VNet.

Initially, the ventilation network may seem complex; however, each node can be moved after the import process is complete. Furthermore, the layers can be hidden from view to simplify the screen data. Once all of the layers have been successfully imported into the program, their general layer attributes need to be defined. When branches are imported into the program the junction numbers are automatically defined. This numbering is conducted sequentially and progresses from right to left across the network in Plan View.

5.3.2.1 Defining Layer Attributes

Each layer has a set of general attributes, which separate it from the other layers. In this case, each layer represents an individual level having a discrete range of elevations. For example, a layer labeled 1800 Level may have a range of elevations from 1750 to 1850 which separates it from the other layers. Any changes to a layer's attributes may be made by clicking on the Layers view on the Ribbon (shown on Figure 60).

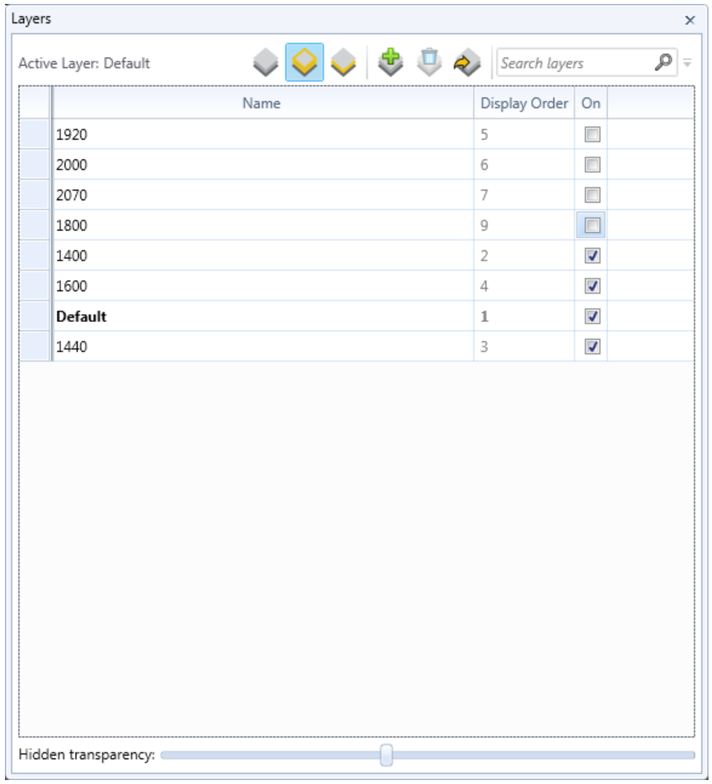


Figure 60: Layers View

The Layers view dialog box will appear which allows the user to select the layer to be modified from the list provided. In this case, one may choose to modify the attributes of the Layer 2000 Level. To modify this layer, select any of the layer attributes shown and select “Make Layer Active”. At this point all additional branches added to the model will be added to this layer unless a new layer is made the active layer.

In VNet, often a “RAMP” layer is created to include all branches that identify a mine ramp connecting multiple levels in the mine. This usually provides the user a little more challenge in that it is not a level; rather it is a layer that spans a wide range of mine levels. For this reason, the ramp is often created within VNet by connecting the different levels with a single line representing a section of ramp between two points, rather than having to specify elevations for multiple broken sections of ramp. However, if you choose to create a 3D ramp in AutoCAD™ or other CAD program to be follow the exact path of the ramp, the z-coordinate values will be automatically imported with the rest of your model.

If the ramp was created in 2D, the elevations for the nodes in the RAMP layer can be entered in either one of two ways. In Model view, existing nodes can be moved anywhere in the vertical or horizontal planes with the mouse by using the Move tool, or each node can be selected individually and an elevation assigned to it. The junction can be edited by right clicking on the junction with the selector tool and selecting Junction Data. The Edit Junction dialog box will appear allowing the user to change various properties of the junction. The users may also change the elevation in the Junction Data view by editing the “z” coordinates.

If desired, layer names can be modified. Initial names are defaulted to the layer names imported from AutoCAD™. Layer 1, entitled “Default” is the initial default level. This level should not be deleted; however, the user can re-name the layer if desired. It is important to note that only the active layer can be modified by the user (the user cannot construct branches in non-active layers). Furthermore, only one layer can be active at any one time, although all or multiple layers can be displayed.

5.3.2.2 Viewing and Editing the Model

The VNet program automatically defaults to Isometric View. In this view the user is able to rotate the model in all directions. In some instances it may be easier for the user to lock the model to a certain plane of orientation. In this way the model is held in either one of two vertical orientations or in plan view. The three locked views are Plan View, XZ View, and YZ view. Some of these views allow the user to draw branches easier in certain instances. For instance, in order to add a vertical shaft in free space (unconnected to other branches on at least the “to” junction) it is necessary for the model to be perfectly vertical. This would mean the user would rotate to XZ or YZ Views to draw the shaft. To toggle these views the user should select the corresponding Tray icons located at the bottom of the Model view (see Figure 61).

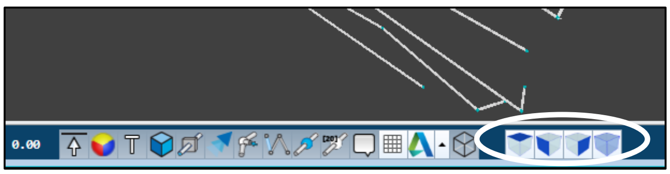


Figure 61: View adjustment Tray icons.

The schematic can be rotated by right clicking and dragging with the selector tool. By clicking and dragging the center mouse wheel the user can pan across the screen. If portions of the schematic rotate off the edges of the screen, the user can automatically resize the schematic to fit the screen by double clicking the center mouse wheel or by scrolling the center mouse wheel to a desired size.

5.4 Adding Branches to the Schematic

Branches can be added to the ventilation model directly in the Model view by selecting the draw branch tool. To add a branch, click on the branch origin (from node), then holding the left mouse button down, move the mouse to the branch termination point (similar in operation to drag and drop features of other Windows based programs). A segment of the exhaust shaft is being inserted in Figure 62. If there is an existing node in close proximity to either of the two nodes, (From/To) then the branch will automatically “snap” to those junctions. If the user chooses to either begin or terminate a branch by intersecting an existing branch, then the existing branch will be split, and a junction inserted. Branches can be added, deleted, or split in any view.

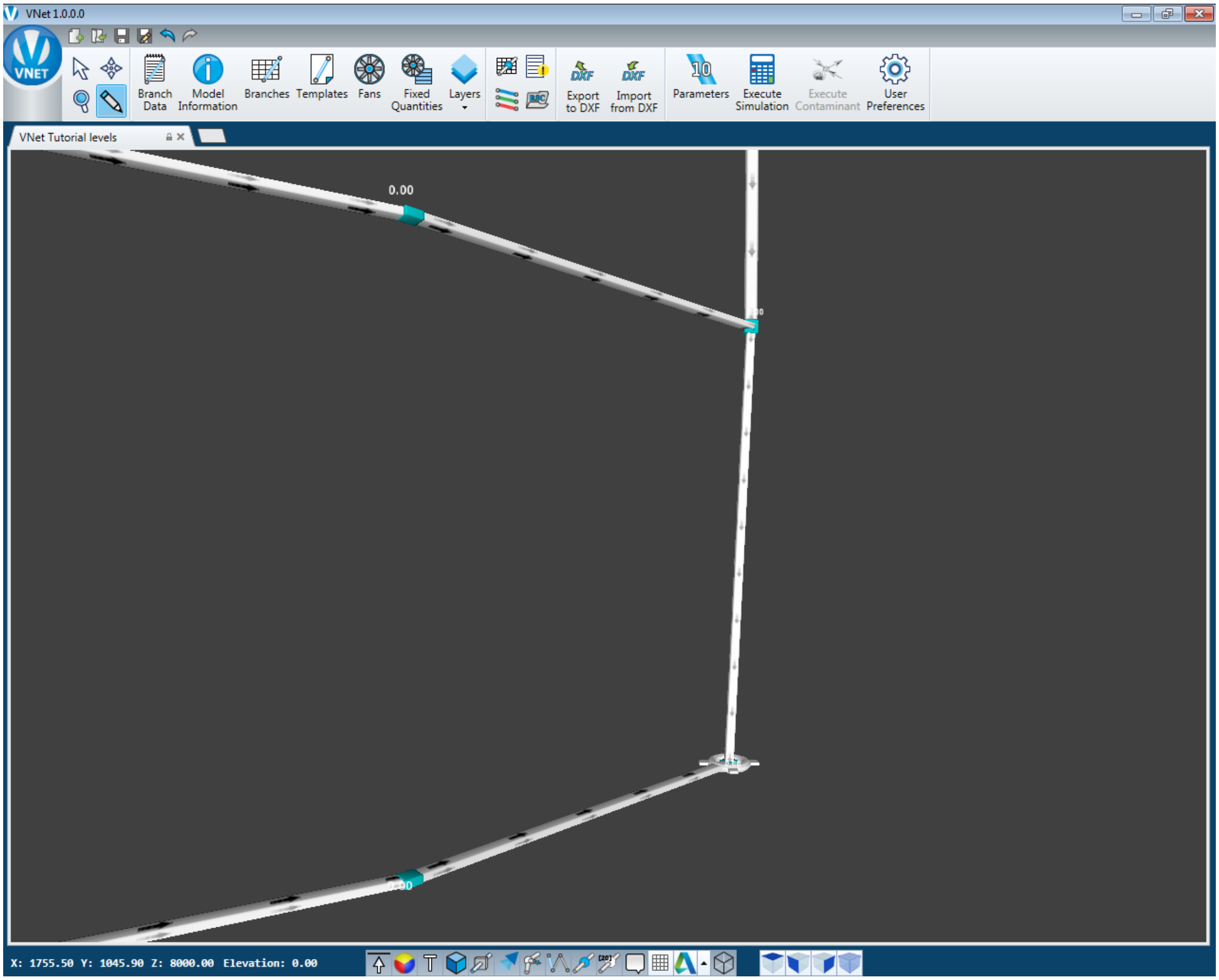


Figure 62: Drawing Branches in Model View

To isolate the a layer, the user selects the layer from the Layers view, selects Make Layer Active , and checks the Active selection under the drop down tab below the Layers view icon (as shown in Figure 63). If the user wants to adjust the transparency of the other non-active layers they can move the “Hidden transparency” slider bar. This tool allows the user the ability to view other parts of the model in reference to the Active Layer while those layers are not selectable.

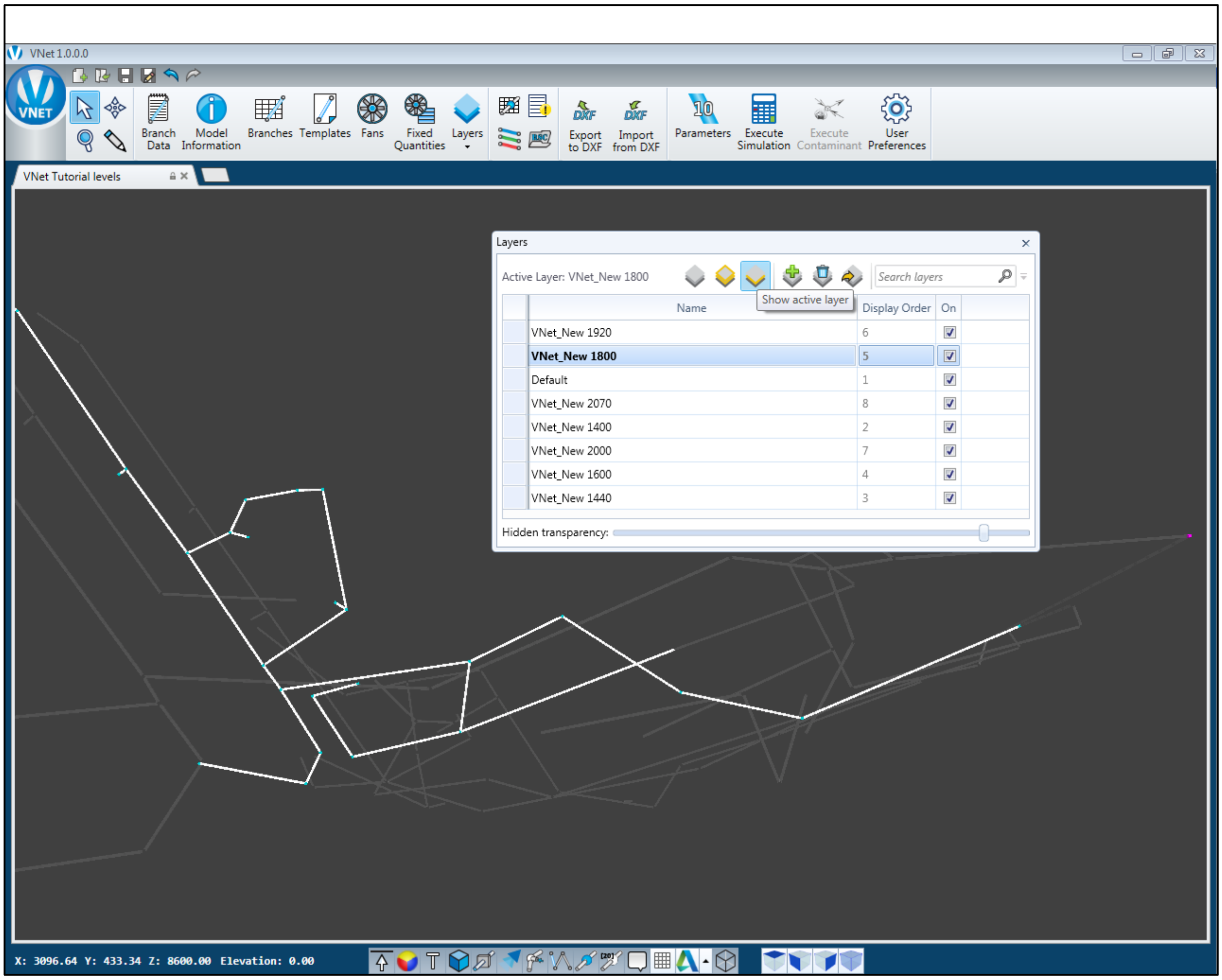


Figure 63: Isolation of the 1800 Level using the Active Layer Filter

The VNet program will assign the junction the next free junction number and automatically place the newly created branch 1800VENT layer.

5.5 Defining Branch Attributes (Resistances)

Branch attributes can be defined or modified through either the Model view or the Branches view. Because all subsurface airways have some resistance, each branch should have a resistance value assigned to it. The exception is if the branch is being used solely for graphical representation. To define the attributes or resistances for each branch, there are a number of ways to edit the branches. Vnet allows the user to edit each branch individually by right clicking on a branch and selecting “This branch” from the menu. Double clicking on a branch in Model view will also allow the user to edit the branches. If more than one branch is selected. Double clicking on one of the selected branches will allow the user to edit the branch properties of every selected branch at the same time. Each operation will bring up a Branch Data dialog view by which the branches may be edited (See Figure 64). All data that can be modified in this dialog box can also be modified in the Branches view.

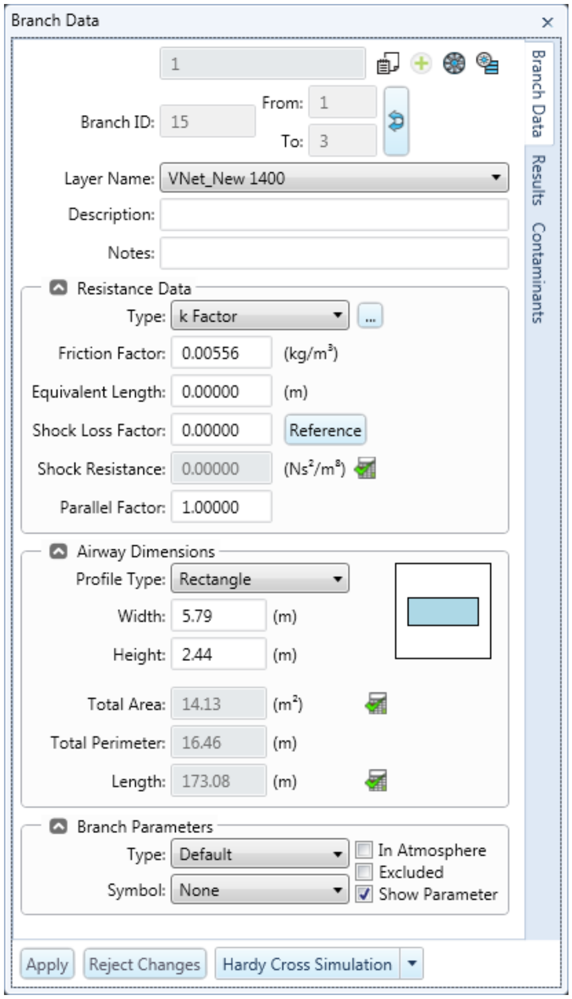


Figure 64: Branch Data Dialog Box

Each branch can be color coded to visually differentiate between airway types. The Branch Types View menu allows the user to color code the schematic. Each airway type can have an individual color assigned to it and modified by selecting the appropriate drop down tab from the "Color" column (see Figure 65). Branches can be colored by type or by preferences. To switch this setting, the user changes the Branch Color setting under the Branch Display tab in User Preferences view (see Figure 66).

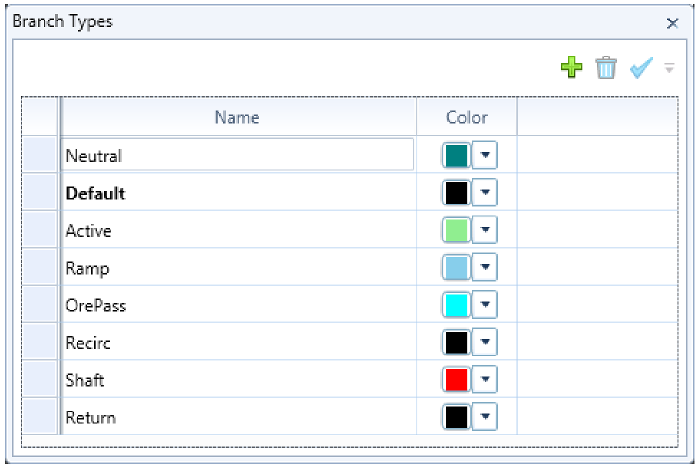


Figure 65: Branch Types View.

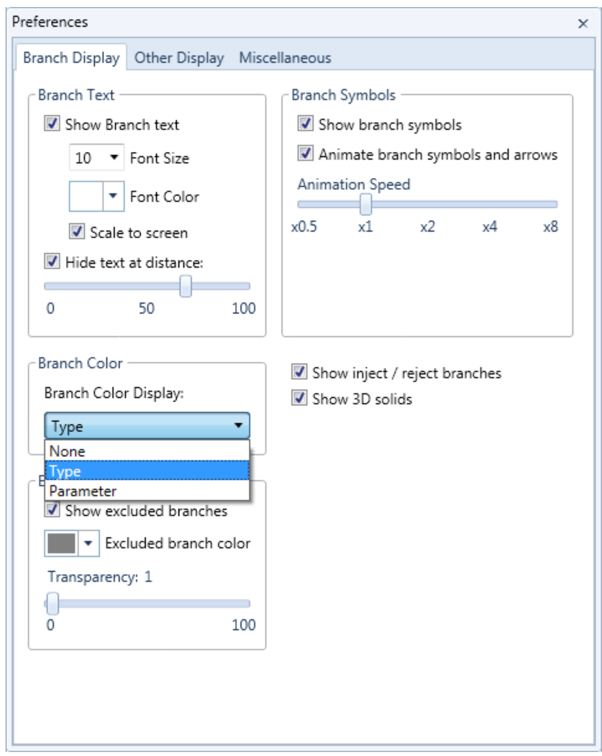


Figure 66: Branch Color Display toggle.

Every ventilation network, as with every mine, must have at least one intake and one exhaust airway connected to the surface (atmosphere). The VNet program requires that the intake and exhaust portals and shaft surface connections be identified. To identify a branch as a surface connection, the user must check the box next to “In Atmosphere” in the Branch Data dialog menu.

In the Branch Data dialog box, see Figure 67, each branch can also be allocated a symbol, airway profile type (cross-section), shock resistance, airway dimensions, and branch type (color). Symbols include bulkheads/stoppings, doors, brattices, and regulators. Airway profiles include rectangular, circular, and arched cross-sections. In addition to the descriptive data, each branch can have a resistance assigned to it through this dialog box. One of four methods, R, P/Q, k-Factor, and R/L can be used to assign or calculate the resistance for each branch by selecting from the drop-down list.

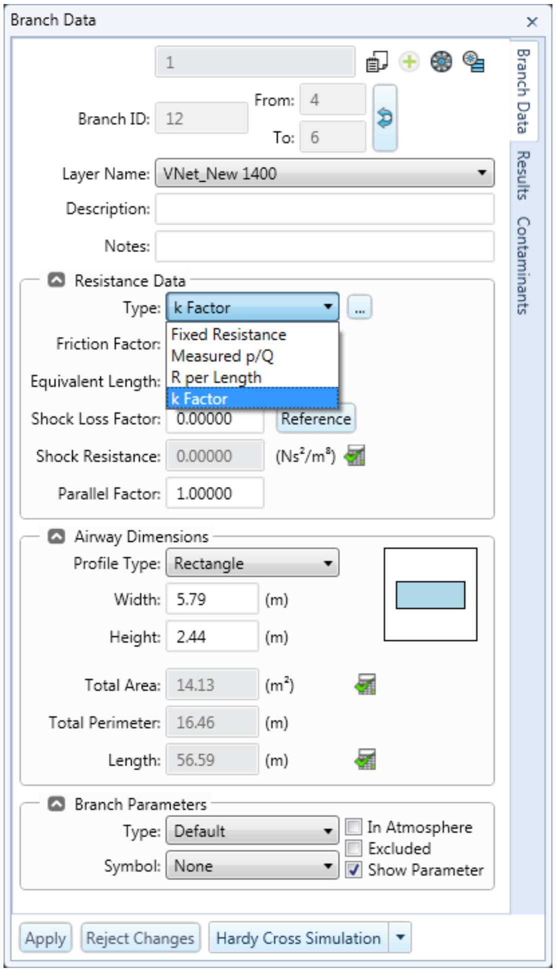


Figure 67: Branch Data Dialogue Box

When entering resistance data for k Factor or Resistance per Length (R/L), a tool (Auto Length) has been incorporated that will calculate the lengths of the branches according to their coordinate positions in the Model view. This will only work for models that have been drawn to scale. When entering resistance data for which a length is required, the Auto Length box can be selected for each branch individually to enable it. If multiple branches are selected at the same time the use can change all selected branches to Auto Length by double clicking one of the branches and selecting the Auto Length icon to enable it for all branches. Figure 68 shows the location of the Auto Length, Auto Area, and Auto Shock Loss calculator icons in Branch Data dialog. Circled at the top of the figure is a number which denotes the number of branches selected. Before applying changes, the user should take note of the number of branches that are selected. If more than one branch is selected in which some of the values differ the corresponding field will be labeled *Varies*.

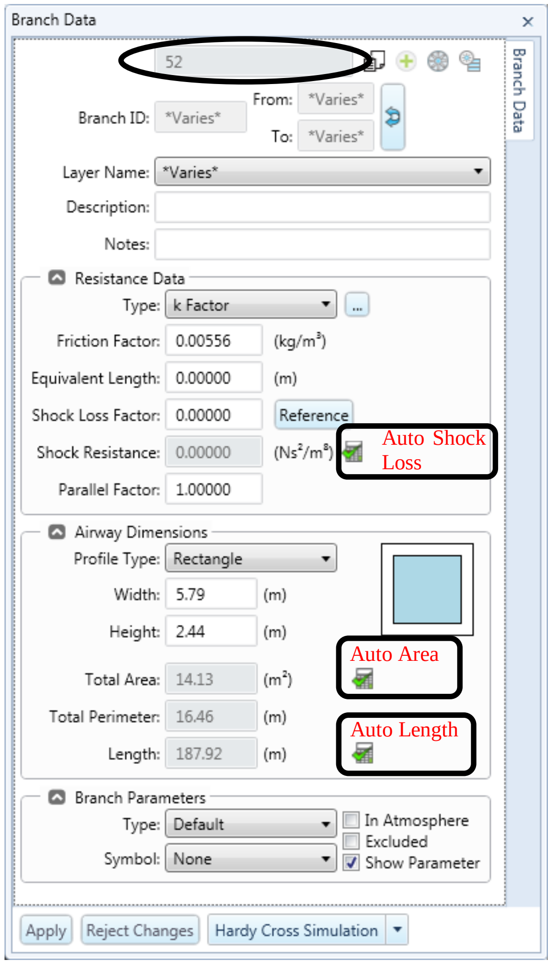


Figure 68: Auto Length, Auto Area, and Auto Shock Loss Calculator.

5.6 Inserting Fans and Fixed Quantities

Once the attributes for each branch have been entered, the next step is to add fans or fixed quantities in the ventilation model. These can be rapidly input to the model in the Model view; however, they may also be added in the Branches, Fans, or Fixed Quantities views. To insert a fan, use the selector tool to select a branch (note only one branch can be selected at a time to add a fan or fixed quantity). Once the branch is selected, select either the icon labeled Access/Add Fan or Access/Add Fixed Quantity to add a fan or fixed quantity. Once one is selected its corresponding dialog box will be displayed. Figure 69 and Figure 70 show these dialog boxes.

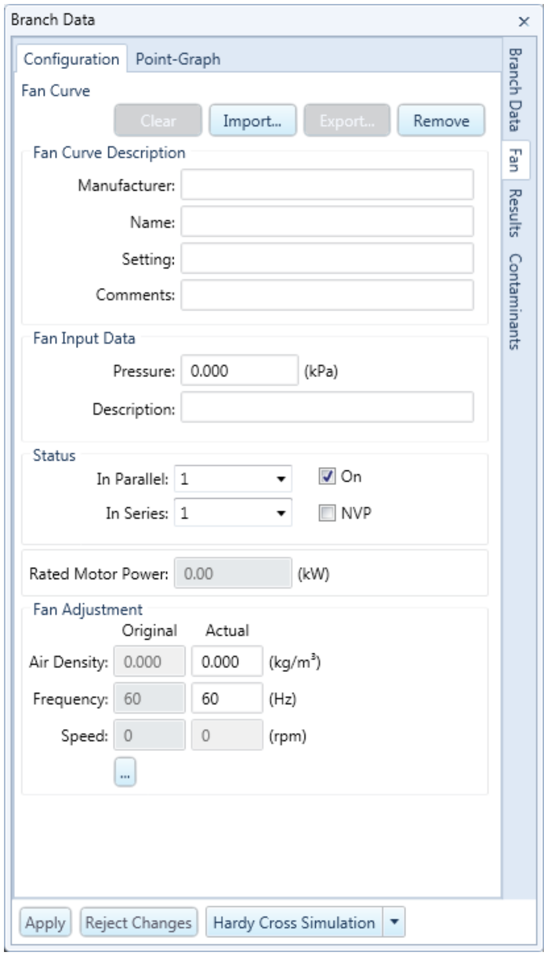


Figure 69: Fan Dialog Box

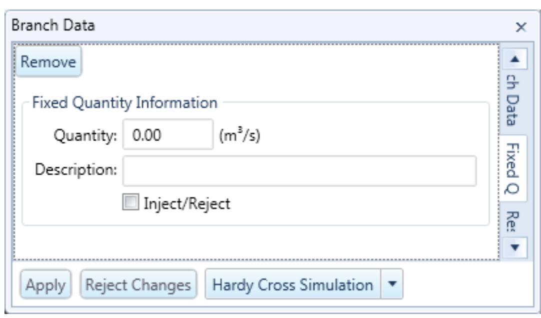


Figure 70: Fixed Quantity Dialog Box

If the fan option is selected, the dialog box will give the user options for entering the fan curve, fan curve description, fixed pressure information, fan configuration status, and fan adjustment. If fixed quantity is selected, the quantity of air, description and inject/reject may be designated. For each case the Apply button must be selected to apply any changes. Note that the nodes' From/To order will specify the airflow direction for the fixed quantity or fan.

The fan status tool allows the user to create a single fan and apply it to the model as a multiple, series or parallel installation. This tool will automatically adjust the fan curves for multi-fan installations with identical fans.

By selecting the Point-Graph tab, the user is able to manually input fan curve information including pressure, quantity, efficiency, and motor input power, as well as input some general notes for each operating point entered. Note, if the efficiency is entered the motor input power will change accordingly, as well if the motor input power is changed the efficiency will update accordingly. The program will not allow an efficiency of greater than 100% to be entered. A maximum of 20 points are allowed to be input for each curve. It is generally a good idea to cluster the greatest number of points along the operating section of the fan curve. The program will linearly interpolate between each of these points. Once the fan curve is entered, select "Apply" to save it to model. The "Import" and "Export" tools allow the fan curve to be either imported from a fan file (*.fds file) or exported to a *.fds file. These files contain the fan curve and may be used in other VNet models. This removes the task of continuously developing the same fan curve for different models. The "Clear" tool removes all fan information for the Fan dialog box while the "Remove" tool removes the fan completely from the model.

5.7 Adding a Contaminant

In the VNet program, a contaminant can be traced through the network. This contaminant is added to the network by selecting the Contaminants side tab in Branch Data dialog or under the Contaminants tab in Branches view. In each case, to enter each branch contaminant, enter the emission rate and emission concentration in the appropriate place. In Branch Data dialog contaminants may only be entered if one branch is selected. Figure 71 shows the Contaminants side tab in the Branch Data dialog box.

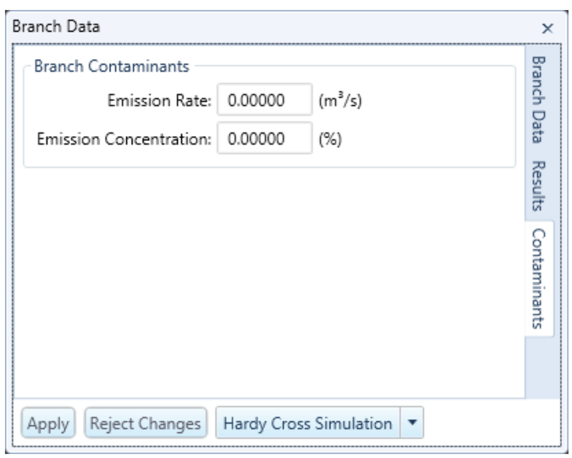


Figure 71: Contaminant side tab

The downstream steady state concentrations and flow rates of the contaminant will be calculated for all affected branches.

5.8 Program Execution

Once the model is established, the user should execute the simulation. After successfully simulating the mine ventilation system, the user can export the schematic back into AutoCAD™ through a DXF file to provide an overlay of the projected ventilation values. The user can create a

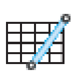
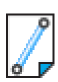
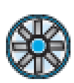
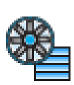
DXF from the schematic by selecting “”Export to DXF” in Model view. Once selected, the user will be prompted with a save as screen to save the file as a DXF.

During the program execution, any simulation errors detected by the program will be listed in a dialog box on the screen. Information regarding these errors can be found in Section 4.4.1.

6. Appendix A: Tools and Tool Buttons

The following list is a description of the buttons and tools available in VNet.

The Ribbon has the following buttons and tools.

	Selection Pointer	This button selects branches, and is the default mode.
	Move Tool	Allows for selected branches and junctions to be moved.
	Zoom Tool	Allows the user to resize the view rapidly
	Draw Branch	This tool allows new branches to be drawn.
	Branch Data dialog	This button opens Branch Data dialog. Branches can be edited from here.
	Model Information	This button will bring up the model information view. Descriptive data consists of both required and optional information for documentation and program initiation.
	Branches view	This button will bring up the Branches view box. All of the branch data/ results are shown here.
	Branch Templates	This button will bring up the Branch Template view. Branch templates can be edited and created here.
	Fans	This button will bring up the fan list view. In this box fan details can be edited and results can be viewed.
	Fixed Quantities	This button will bring up a list of the fixed quantities list view in the model. In this box fixed quantity details can be edited and results can be viewed.
	Layers	From here layer names can be added, edited, turned on or off and set as active. The lower button will bring down a drop down menu with

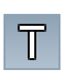
	three choices: All, On, and Active. The selection of one of the options will only show the branches that fall within the specified settings.
Junction view	This button will open the Junctions view. This view lists all of the junctions in the model. From here the location of junctions can be edited or set to an atmospheric junction.
Error List view	This button will bring up the list of errors and warnings that occurred during the last model execution. For each error or warning a corresponding branch will show up in the list.
Branch Types View	This button will bring up the branch types view. The user may also select to define colors for the Branch Type. This allows colors to be assigned for different types of branches, which can be specified from certain categories during entry of the input data.
Import DXF Overlay	This button allows the import of DXF lines into model view. These lines are not converted to airways during import.
Export to DXF	The user can export the ventilation model centerlines to a DXF file. To export fist display any parameters or text that should be included in the export. Select the branches to put into the file.
Import from DXF	VNet allows the user to import a network or level from a CAD or mine planning program using a DXF file to transfer the data.
Parameters	This button is used to display input and results data in model view. This is done by displaying text above the branches and/ or coloring branches based on a range of data.
Execute Hardy Cross Simulation	This button will perform the Hardy Cross calculations for the model. This needs to be performed for the model's results.
Execute Contaminant Simulation	This button will perform the calculations for a contaminant simulation. Contaminants can be entered into a branch using Branch Data dialog.

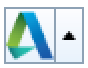
	User Preferences	This button will bring up the Preferences view. In Preferences view there are three tabs in the box to select from: Branch Display, Other Display and Miscellaneous. Under each one of the tabs are subset of boxes that can be used to change the display or setting of the program.

The Quick Access Toolbar has the following buttons and tools.

	Create New Model	This button will create a blank model in the model view and is called “newmodel” until the user saves and names the file.
	Open Model	This opens a window prompting the user to select a valid “.vds” file created by VNet.
	Save Model	This will save the current state of the model.
	Save As	This will save the model by a name the user specifies with a “.vds” extension.
	Undo	Allows the users to undo changes in the model.
	Redo	The data will be restored in each branch by using the redo button.

The icons Tray has the following buttons and tools.

	Branch Data Color	This button can be pressed to change the color of the branches.
	Branch Data Text	This button toggles the branch text data on and off. The displayed text is selected in the branch parameters view.
	3D Solids	This button toggles the branch 3D solids on and off. When the branch solids are turned off centerlines of the branches are still displayed.
	Show/Hide Symbols	This button toggles the display of symbols in the model view.
	Turn Animation On\Off	This button toggles the animation of airflow direction arrows on the branches and animated symbols.

	Show IR Branch Data	This button toggles the display of inject and reject branches on and off.
	Exclude Branch Data	This button toggles the display of excluded branches on and off.
	Show/Hide Junctions	This button toggles the display of junctions on and off.
	Show/Hide Relative Pressures	This button toggles the display of relative pressures on and off.
	Show/Hide Labels	This button toggles the display of labels on and off.
	Show/Hide the Grid	This button toggles the display of the grid on and off.
	DXF Reference	This button allows layers from a DXF import to be turned on and off and colored by layer and as a whole.
	Ortho or Perspective	This button toggles model view between orthographic and perspective view.
	Plan View	This button locks the view into the XY plane.
	XZ View	This button locks the model to the XZ plane.
	YZ View	This button locks the model to the YZ plane.
	Isometric View	This button allows the model to be rotated in isometric view.

7. Appendix B: Quick Reference and Glossary

VNet is designed to assist mine engineers in the planning of subsurface ventilation layouts. Given data that describes the geometry of the subsurface network, airway resistance or dimensions, and the location and characteristic curves of fans, the program will provide detailed listings and graphical representations of the desired parameters. The following Quick Reference and Glossary are meant to assist the user in ventilation planning and design. These references were not intended to be comprehensive guides, but rather clarify some general ventilation principles and concepts.

7.1 Quick Reference

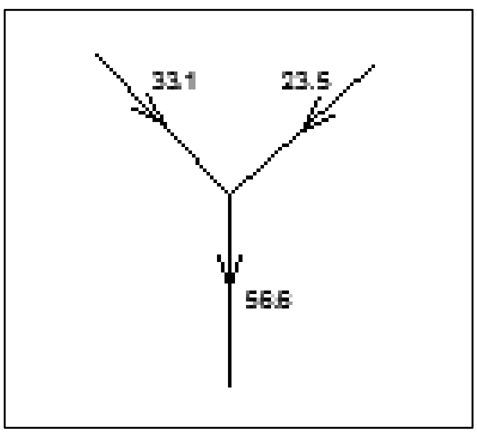
7.1.1 Background Theory

The VNET program has been developed based on the assumption of incompressible flow and on Kirchhoff's Laws: (1) - The algebraic sum of the volume flow rates entering and leaving each junction equals zero. Pseudo - compressible flow can be simulated by fixed quantity injections or rejections of air at any junction. (2) - The algebraic sum of pressure drops along any closed circuit equals zero.

The code utilizes an accelerated form of the Hardy Cross iterative technique to converge to a solution. The procedure is as follows:
1) The code scrutinizes the geometry of the ventilation network and constructs a number of closed meshes, the minimum number being equivalent to the number of branches minus the number of junctions plus one. Each branch in the network is represented in at least one mesh and, in order to minimize computing time, each mesh contains no more than one high resistance branch.
2) For every mesh, an airflow quantity correction factor is calculated using airway resistances and fan pressures. The program estimates an initial airflow and the simulation is initiated.
3) The airflow correction factor is applied to the flows of all the branches in the mesh. This is performed for each mesh in the network.
4) This process is repeated iteratively until Kirchhoff's Second Law holds to a prescribed level of accuracy for every mesh in the network. The resulting network is then balanced.

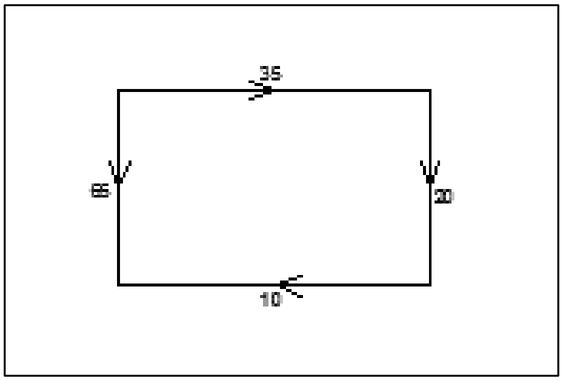
7.1.2 Kirchhoff's Laws

- The algebraic sum of the volume flow rates entering and leaving each junction equals zero.
- Pseudo compressible flow can be simulated by fixed quantity injections or rejections of air at any junction.



Example: 33.1 + 23.5 - 56.6 = 0.0

- The algebraic sum of pressure drops along any closed circuit equals zero.



Example: 10 + 20 + 35 - 65 = 0

7.1.3 Units and Conversions

The following table provides a list of basic conversions between Imperial and SI units for parameters commonly found in Ventilation analyses.

Imperial System		**SI System**	
Value	Units	Value	Units
1.0 (ft)	feet	0.3048 (m)	meter
1.0 (ft^2)	square feet	0.0929 (m^2)	square meter
1.0 (ft/s)	feet per second	0.3048 (m/s)	meter per second
1.0 (ft/min)	feet per minute	0.00508 (m/s)	meter per second
1.0 (ft^3)	cubic feet	0.02832 (m^2)	cubic meter
1.0 (ft^3/s)	cubic feet per second	0.02832 (m^3/s)	cubic meter per second
1.0 (ft^3/min)	cubic feet per minute	0.000472 (m^3/s)	cubic meter per second
1.0 lb (mass)	pound mass	0.453592 (kg)	kilo-gram
1.0 (lbf/ft^2) (psf)	pound per square foot	47.880 (N/m^2) (Pa)	Pascal
1.0 (lbf/in^2) (psi)	pound per square inch	6894.76 (N/m^2) (Pa)	Pascal
1.0 (inch w.g.)	inch water gauge	249.089 (N/m^2) (Pa)	Pascal
1.0 (inch w.g.)	inch water gauge	0.249089 (kPa)	kilo-Pascal
1.0 (ft. w.g.)	feet water gauge	2989.07 (N/m^2) (Pa)	Pascal
1.0 (mm w.g.)	milli-meter water gauge	9.807 (N/m^2) (Pa)	Pascal
1.0 (inch Hg)	inch mercury	3386.39 (N/m^2) (Pa)	Pascal
1.0 (mm Hg)	milli-meter mercury	133.32 (N/m^2) (Pa)	Pascal

1.0 (P.U.)	Resistance	1.1183 (Ns^2/m^8)	Resistance
1.0 (lbf min^2/ft^4)	Atkinson's (k-factor)	1.8554 x 10^6 (kg/m^3)	Atkinson's (k-factor)
1.0 (lb/ft^3)	density	16.0185 (kg/m^3)	density
1.0 (hp)	horse power	745.7 (W)	Watt

7.1.4 K-Factors

The following table lists commonly used friction factors for various types of mine entries. The list is by far not complete; however, it covers a broad spectrum of the airways likely to be found in a mine. The friction factors listed are the result of actual measurements taken in mines throughout the world. It is left to the user's discretion to choose the most appropriate k-Factor to be incorporated into the model.

Description of Airway	(SI)	(Imperial)
Coal or Bedded Deposit Mines		
Rectangular Entry - Good Condition	0.00753	40.6
Rectangular Entry - Fair Condition	0.00872	47.0
Rectangular Entry - Poor Condition	0.01133	61.1
Rectangular Belt Entry	0.01058	57.0
Metal Mines		
Single Drift - Average Condition	0.00879	47.4
Single Drift - Poor Condition	0.01284	69.2
Single Ramp	0.01158-0.01579	62.4-93.7
Single Belt Entry	0.01399-0.01664	75.5-89.7
Single Smooth Lined Drift	0.00440-0.00560	23.7-30.2
Bored Raise	0.00466-0.00698	25.1-37.6
Alimak Raise	0.01126-0.01579	60.7-85.1

The SI friction factors are given in kg/m^3, the imperial friction factors are given in lbf*min^2/ft^4 x 10^10.

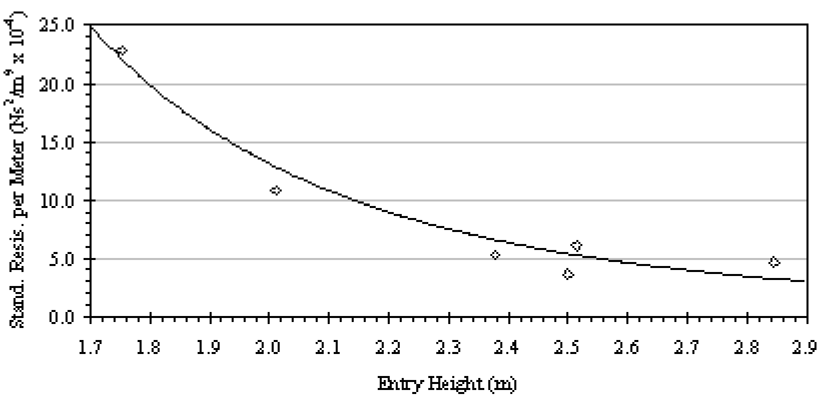
Note: Mine Ventilation Services, Inc. does not make any representations as to the correctness of the provided k-Factor data. This data should be used only for initial planning purposes, and every effort should be made to accurately measure the actual friction factors and resistances encountered at the mine.

7.1.5 R/L Factors

The VNet program can utilize standard resistance per length data to calculate airway resistance throughout the ventilation network. It has been established that when modeling bedded deposits where entries are kept fairly uniform, resistance per unit length data can be successfully used. The following charts and figures based upon measured field data help the user identify the most appropriate friction data.

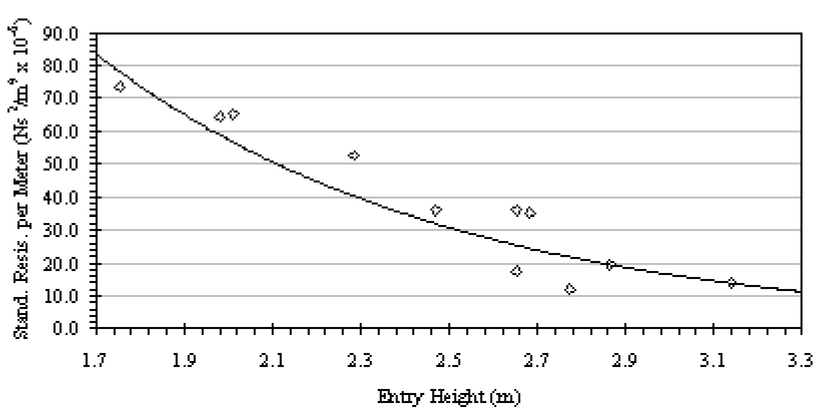
7.1.5.1 Resistance per Length for Tailgates

This graph shows tailgate resistances measured at several mines, and can be used for initial ventilation planning. However, no two tailgate entries will deteriorate and act in the same manner, so these resistances must be field verified when available. These resistances are based upon two rows of 1.2 m wide cribs placed on 2.4 m centers. In order to provide an estimate for the average resistance per length for this timber cribbing, a graph has been plotted of resistance per length against entry height.



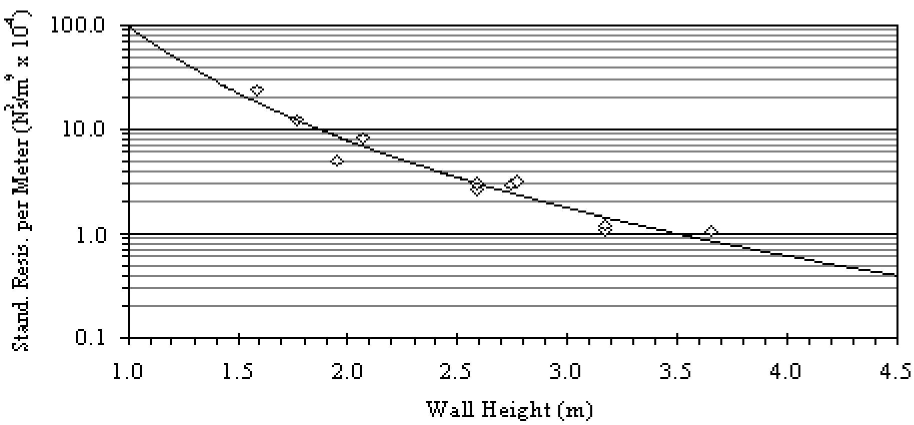
7.1.5.2 Resistance per Length for Intake Gate Roads

This chart can be used to determine the resistance per unit length for longwall, or miner section gate roads. The chart reads the standardized resistance per meter value vs. average entry height for single airways in SI units. The resistance per unit length value for multiple entry gate roads can be calculated by dividing the resistance per length value by the square of the number of entries.



This chart was established as the result of field measurements taken at various mines with different mining heights.

7.1.5.3 Resistance per Length for Longwall Faceline
This chart can be used to determine the resistance per unit length for a longwall faceline. The chart reads the standardized resistance per meter value vs. average wall height for single airways in SI units. The resistance per unit length value for multiple entry gate roads can be calculated by dividing the resistance per length value by the square of the number of entries.



Note: Mine Ventilation Services, Inc. does not make any representations as to the correctness of the provided resistance data. This data should be used only for initial planning purposes, and every effort should be made to accurately measure the actual friction factors and resistances encountered at the mine.

7.1.6 Velocity Limitations
Particular attention should be paid to the velocity of the air as it travels through each airway. Excess velocities can actually reduce the effectiveness of the ventilation system by liberating larger quantities dust, and can result in very high operating costs. The following table shows some recommended maximum velocities for various airways in mines.

Airway Description	m/s	ft/min
Working Faces	4.0	790.0
Conveyor Drifts	5.0	985.0
Main Haulage Routes	6.0	1180.0
Smooth Lined Main Airways	8.0	1575.0
Hoisting Shafts	10.0	1970.0
Ventilation Shafts	20.0	3940.0

It should be noted that along with maximum air velocity considerations there are minimum air velocities dictated by various governing bodies. One such limit is that a minimum air velocity of 0.3 m/s or 60 ft/min be maintained throughout the mine.

7.1.7 Data Preparation for Modeling
When modeling a mine ventilation system. It is always best to start from measured resistance data. This data can be obtained by conducting either a full or partial ventilation survey. If current measured resistance data is not available then empirical data obtained from one of many ventilation

texts may be used. The data required to model a ventilation system with the VNet program includes:

1) A schematic representation of the ventilation system. The schematic (Model view) consists of junctions (also referred to as nodes) and delineating branches. The network schematic must represent a closed circuit of interconnected branches. Each branch should represent a single airway, a group of airways, or leakage paths that can be combined into a single equivalent path. It is important to remember to identify all portals and surface connections as in atmosphere by checking the appropriate box. By identifying them as a surface opening the program will automatically connect them to atmosphere.

2) Numerical data is used to define each branch of the system. Branch resistance data may be entered in any combination of four forms. Each branch entry automatically assigns junction numbers to each newly created branch.

3) Data defining the location and characteristics of each fan or fixed quantity in the system. The fan data required consists of a fan location, flow direction, fan type (fixed pressure, or with characteristic curves) and a defined operating point (or set of points for fan curves). A fan may be located in any branch that does not have a fixed quantity associated with it. The order in which the junction numbers are entered defines the direction of the fan.

4) Descriptive data for both user preferences and model documentation. It is necessary to choose either SI or Imperial units, provide an average air density and power cost, and identify the surface reference node number.

7.1.8 General Guidelines for CAD Developed Networks

The use of AutoCAD, or other mine planning software to develop the ventilation model is an important and powerful tool included in VNet. In order to successfully use this tool, certain guidelines should be kept in mind.

- All lines drawn in the graphics program need to be joined, meaning that one line begins where another ends (not just close to it), unless the open end represents a portal, or top of a shaft.
- When drawing airways in AutoCAD overlaying a mine map, it is important to ensure that the airways are drawn on their own layer separate of the mine map.
- When using mine planning software the "center-line" layer is often useful for model generation.
- Try to keep networks simple, and limit the amount of branches in the network to minimize the possibility for errors and omissions. This may require the use of filters to reduce the number of line segments, particularly when curved entries are encountered.

The model will not initially be ready for execution. All branches require that a resistance be assigned to them. Don’t forget to identify the in atmosphere surface branches.

7.1.9 Possible Design Criteria

The purpose behind manipulating the ventilation model is to establish the total mine-wide requirements to meet certain design criteria. The design criteria are usually based upon the minimum amount of airflow required for the operation of equipment and to provide for comfortable working conditions for personnel underground. Each piece of equipment operated underground should be examined to establish exactly how much airflow will be required by law for that equipment. Every area of possible gas emission should be examined and estimates of the emission made to establish a minimum safe operating airflow to dilute that gas. Predicted temperatures and relative humidity should be examined to ensure personnel are working in a safe environment. Current regulations should be examined to determine these parameters, along with good engineering judgment.

7.1.9.1 Example Design Criteria

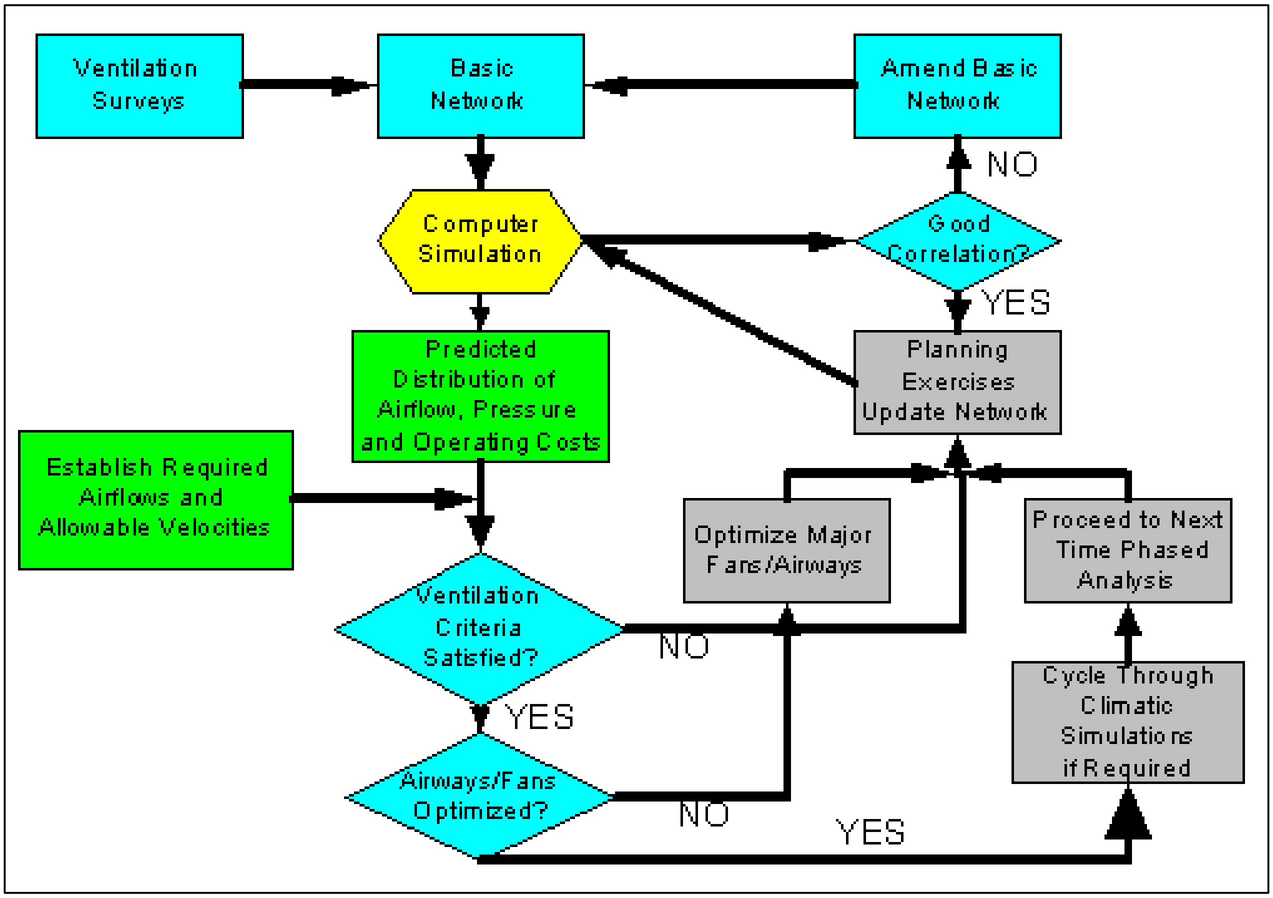
The following is an example of elements which might be included for consideration in design criteria:

- Dilution of hazardous gases to concentrations below statutory or administrative concentrations.
- The oxygen content in any airway accessible to personnel should not contain less than 19.5%.
- The carbon dioxide content of the air in any airway accessible to personnel should not contain more than 0.5%.
- The minimum air velocity experienced at any place in the mine should be such that turbulent flow is maintained.
- Identify maximum air velocity based on airway types and economic considerations.

7.1.9.2 Suggested Maximum Airflow Velocity

- Provide sufficient air to working faces (and last open cross-cut) to exceed statutory minimums and to meet actual needs (these are usually greater than the statutory minimums).
- Underground shops, compressor stations, and battery charging stations should all be ventilated directly to an exhaust airway.
- For generalized planning where particulate emissions are not of concern diesel equipment should be ventilated with at least 125 cubic feet per minute of air (standardized) per brake horsepower.

The actual elements of the design criteria will vary with respect to the mine type, mine layout and method, types of equipment, and a host of other special considerations. Local laws, regulations, and practices can also become factors in the design criteria. The following flowchart, illustrates a typical approach to integrating design and modeling into developing a mine ventilation plan.


Ventilation Surveys
Basic Network
Amend Basic Network
NO
Computer Simulation
Good Correlation?
YES
Predicted Distribution of Airflow, Pressure and Operating Costs
Planning Exercises Update Network
Establish Required Airflows and Allowable Velocities
Optimize Major Fans/Airways
Proceed to Next Time Phased Analysis
Ventilation Criteria Satisfied?
NO
YES
Cycle Through Climatic Simulations if Required
Airways/Fans Optimized?
NO
YES

7.2 Glossary of Terms

Air Power	The power required to overcome the resistance of an airway, or series of airways. This does not include any fan or motor efficiency. -Air Horse Power = cfm x inch w.g. x 52 / 33,000 -Air Power = cubic meters per second x kPa
Airflow	Measurement of air quantity per unit time through an airway. Given as; Imperial Unit = cubic feet per minute, or SI = cubic meters per second.
Anemometer	An instrument used to measure air velocity. The instrument normally uses rotating vanes, hot-wire, or ultrasonic type sensors.
Area	The cross-sectional area is defined as the area of the drift perpendicular to the direction of airflow.
Atkinson	John Job Atkinson wrote the classic paper "On the Theory of the Ventilation of mines", presented in 1854, in which he derived what is now known as the Atkinson's equation p =k*l*per*v^2 /A, and the Atkinson's friction factor (k).
Balanced network	A ventilation model in which both airflow and pressure distributions follow both of Kirchhoff's first and second laws.
Bleeder	This is a term applied to airways specifically designed to ventilate gob areas or abandoned workings. This type of airway removes the highly contaminated air and places it directly into the exhaust.
Booster Fan	This type of fan installation acts in conjunction with a main fan installation. This is used mainly for district ventilation, or expansion projects.
Bore hole	A small ventilation shaft usually installed with either a drill or raise bore machine. This type of shaft is usually used for ventilation purposes only, and is most often too small for equipment usage.
Branch	A single segment of a network model representing an airway or series of airways.
Brattice	A wall usually constructed of cloth or plastic which is installed to stop airflow in an airway. Generally more temporary than a stopping/bulkhead.
Equivalent Length	This is used to add "shock losses" to an airway. The additional airway length is equal to the resistance of the loss.

Exhausting ventilation	This term is generally applied to ventilation systems operating under an induced negative pressure. This has the effect of pulling air out of the mine using a suction fan type system.
Fan Characteristic Curve	The operation of a fan is defined by the curve plotted by the pressure/quantity's achieved in operation. This curve can be modified by either changing the fan rotational speed, blade angle, or inlet-vane pitch.
Fan efficiency	This term defines the amount of wasted energy used to achieve the desired airflow exerted by a fan. A fan that is 80% efficient is applying only 80% of the total work to the air, and wasting the remaining 20%.
Forced ventilation	This term is generally applied to ventilation systems operating under an induced positive pressure. This has the effect of pushing air into the mine using blowing fans.
Junction	A junction is a point where branches meet. VNet adheres to Kirchhoff's Laws regarding junctions.
Kcfm	The standard of airflow measure in the imperial basis of units. (Thousand cubic feet per minute)
K-Factor	The Atkinson friction factor describes the airway roughness. It is a function of air density, and is computed as the product of the Chezy-Darcy coefficient of friction and the air density, divided by a factor of 2.
Milli-inch	The unit of pressure used to calculate airway resistance in VNet. It is not practical to measure differential pressures below 1 milli-inch water gauge. 1 milli-inch = 0.001 inch w.g.
Network	The series of branches that make up a ventilation model is referred to as a network.
NVP	The ventilating pressure induced by the heating or cooling of air as it circulates through mine workings. This can be a significant factor; however, it is heavily dependent upon outside atmospheric conditions.
Operating Cost	The annual cost of running a fan, or ventilating an airway.
Perimeter	

	The distance as measured around the outside edge of an airway perpendicular to the direction of airflow.
Practical Unit	The practical unit or PU is defined by k*L*P / 52*A^3. It is the imperial equivalent of the Ns^2/m^8 unit of resistance.
Raise	An internal vertical or inclined airway used to ventilate between levels.
Shaft	A large vertical or inclined airway used for ventilation, and/or materials/men haulage.
Shock loss	Losses in kinetic energy of air due to obstructions in an airway.
Stall	A condition encountered by a fan usually associated with a sharp drop in airflow, increase in pressure, and excessive cavitation at fan blades that can cause serious vibration and structural damage. This occurs when a fan is operating above its characteristic curve.
Stopping/Bulkhead	A wall constructed usually of metal or wood to stop airflow in an airway. Generally more permanent than a brattice.
Ventilation	A key component of a mining system is bringing sufficient air into the mine, and then distributing it through the workings in an adequate quantity to support both workers and equipment.
Volumetric Efficiency	A unit of measure to identify the general efficiency of a ventilation system. It is defined as the sum of all air usefully employed in the ventilation system divided by the total amount of air provided by the main fans.