NAIMA

NORTH AMERICAN INSULATION MANUFACTURERS ASSOCIATION

# 3E plus®

# User Guide

## Version 4.1

Compatible with Windows® XP, Vista and Windows 7 Operating Systems

# Insulation Thickness Computer Program

## FEATURES:

- Able to retain user installed data when updating the program
- Contains updated thermal data for insulation materials
- Exports data to spreadsheets for further analysis
- Automatically calculates thickness tables
- Simple payback calculations
- New user interface
- Improved report formats
- Calculates in both metric and inch-pound units
- Ability to add custom fuels
- Calculates multiple insulation layers

**Calculates The Savings For A Range of Insulation Thicknesses**

Energy Savings • Economic Savings • Environmental Savings

www.PipeInsulation.org

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NORTH AMERICAN INSULATION MANUFACTURERS ASSOCIATION

# 3E Plus®

## Version 4.1 Users Guide

August 2012

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# Chapter 1
# Introduction

## GETTING STARTED

### Program Installation

If you have previous versions of 3E Plus® on your computer, you must:

- Save all user installed data available in your "Options" menu – see ***Uninstalling 3E Plus®*** below.
- Uninstall the previous version,
- Have "administrator privileges."

On most home computers this is not an issue, but many corporate/business computers that are on a network have restrictions that may prevent you from downloading or installing this software. Please contact your computer administrator or IT department and attempt to resolve any installation issues prior to contacting NAIMA. **ALL installation issues to date have been on the user end and not software related.**

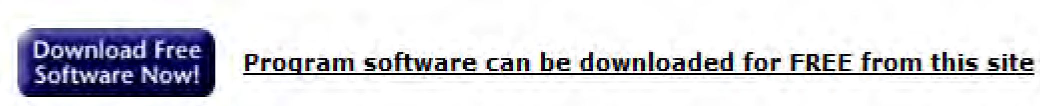
**If you've previously installed earlier versions of 3E Plus®, please follow the directions in the *Uninstalling 3E Plus®* section to uninstall your current program before you run the setup program.**

If you encounter any problems during installation, retry the installation procedure. **NOTE: To date – all installation issues have been caused by either not following the program installation instructions, the user does not have administrative rights to install software or the user's settings are not set correctly. Please do not contact NAIMA until checking with your IT support.**

If you continue to have problems, please contact technical support at 3EPlus@naima.org.

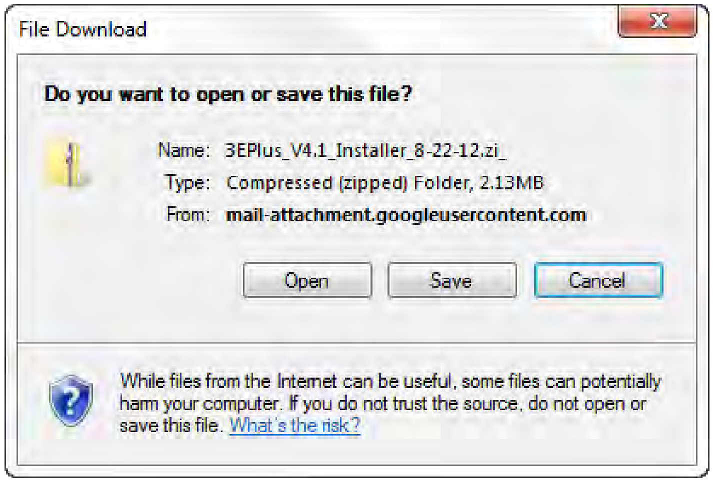
This program is named 3E Plus® V4.1 and can be downloaded from this Website: www.pipeinsulation.org.
The default location for program installation is C:\Program Files\NAIMA\3EPlusV4.1. It is highly recommended the user use this default location.

1. Go to www.pipeinsulation.org on the Internet.
2. Click on the button **Download Free Software Now** to navigate to the registration page

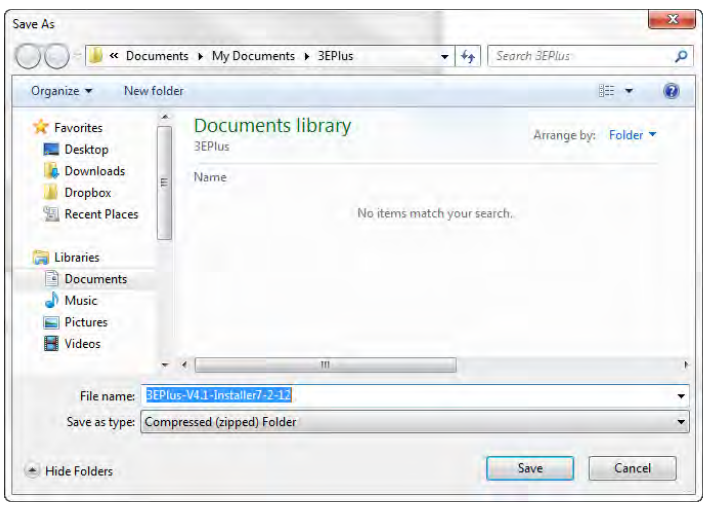



3. Follow the instructions to register (or re-register) the program
4. When registration is complete, you will be directed to the **3E Plus® Download Page**
5. Follow the instructions on that page and then left click on "**Click Here to Download the 3E Plus® Installer**".

6. You will see the File Download dialog box

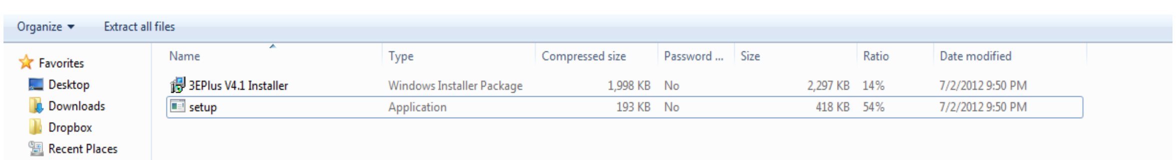



7. Click on **Save** to save the install folder to your hard drive and the **Save As** dialog box will appear.

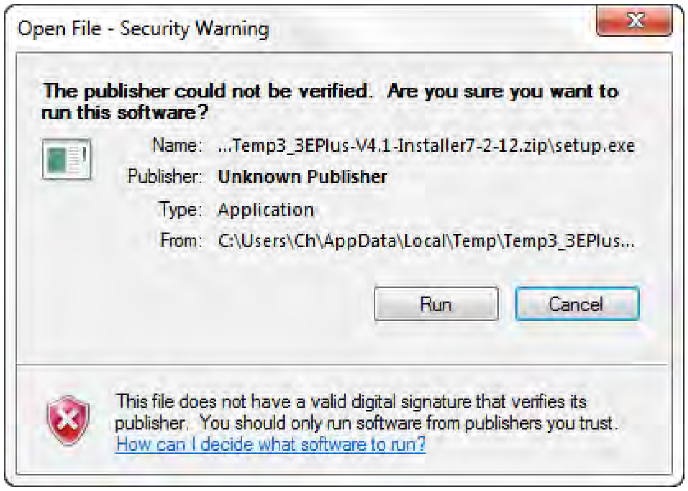



8. Select a location where you wish to save the install folder and then click **Save** to initiate the download. **It is highly recommended you install the program to the default directory.**

9. When the download is complete, navigate to the location you specified and open the folder (it should look like this):



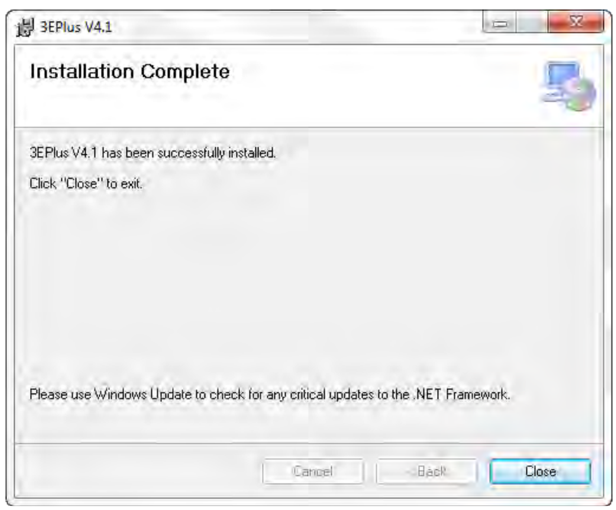
10. Double click on either the **3EPlusV4.1 Installer** or **setup** to start the install. You should then see an Open File – Security Warning like this:




11. Click **Run** to initiate the Setup Wizard

12. Follow the Instructions in the Setup Wizard to Install 3E Plus® V4.1

13. When the Installation has completed, you will see the following:

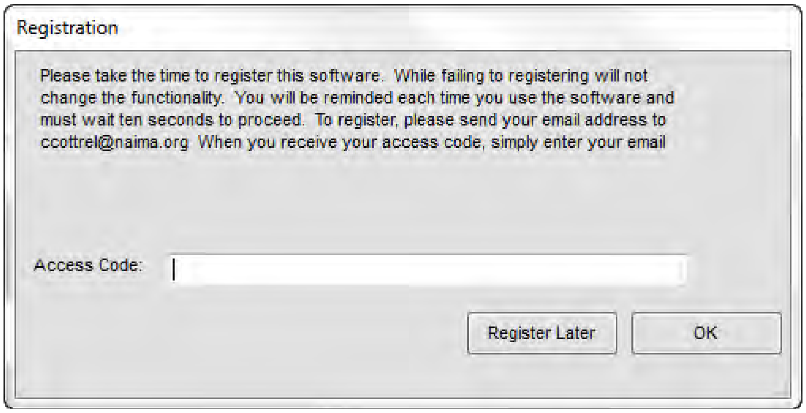



14. Click Close to complete the installation.

15. The **3E Plusv41** program should now appear on your **Programs Menu**

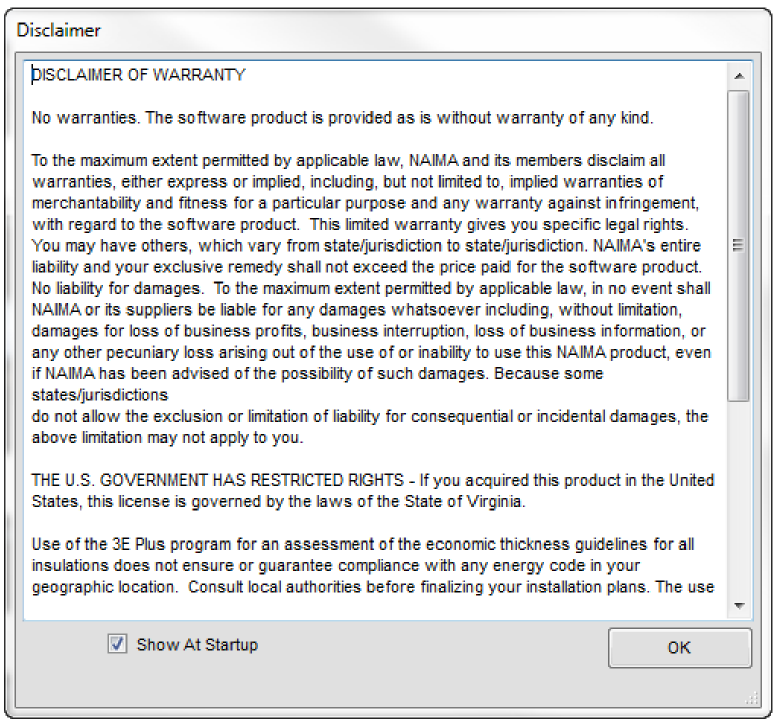
16. Start the 3E Plus® program by clicking **Start** >> **Programs** >> **3E Plusv41**

17. On initial startup, a registration box will appear




18. The access code is **3EPlus4.1** (case sensitive – no spaces). Enter the Access Code and left click on "**OK**".

19. The 3E Plus® program will then start with a disclaimer page.




20. After reviewing this disclaimer you may choose to uncheck the **Show At Startup** box.

21. The **Main Page** will then appear and you may begin using the 3EPlus® program.

# 3E Plus® 4.1 Verification

To verify the program has been properly installed the correct version, please follow these directions:

.

1. Start the 3E Plus® computer program by clicking **Start** >> **Programs** >> **3E Plusv41**.

2. The disclaimer window will appear – clear the check in the "show at start-up box" unless you want to review this every time the program starts.

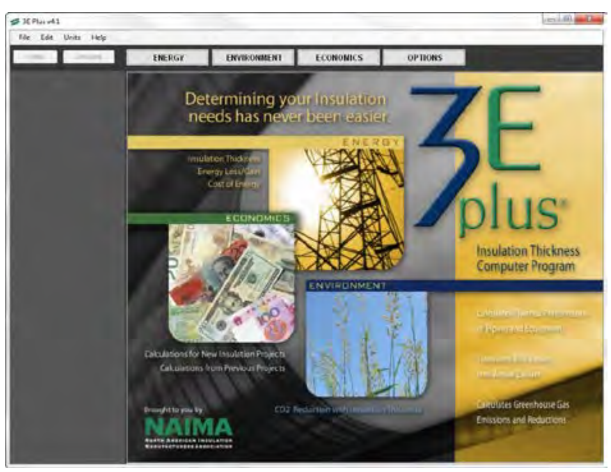
3. Left click on "**OK**"

4. If the "Access Code" window appears, enter the access code (**3EPlusv4.1**) that was sent in your registration confirmation e-mail. Without the access code you will be required to wait 10 seconds every time the program is started. Otherwise left click "Register Later"

5. Once the program is running, click **Help** >> **About**

6. You should see the following information box. The important part is **Version 4.1**


7. Click **OK** to get back to the **Main Page**. You are now ready to run 3E Plus® 4.1.



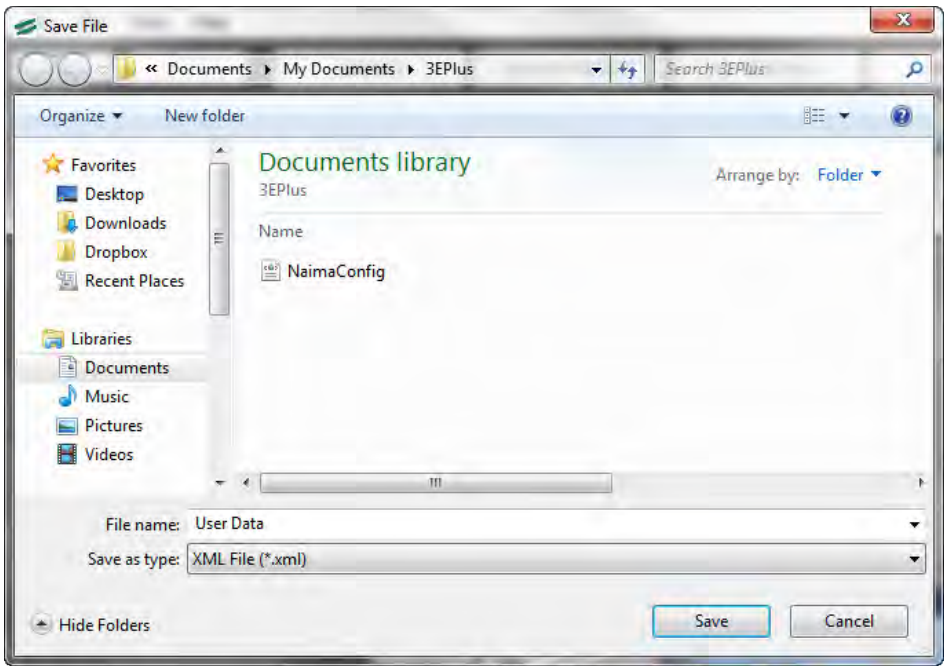
# Uninstalling 3E Plus®

If you are installing a new version of 3E Plus® it is important to uninstall any previous versions that may be on your computer. To uninstall the 3E Plus® program follow these steps to make sure all components are uninstalled.

If you have entered user defined materials in your previous version of 3E Plus® you will want to save that information so that it may be reentered in the new version.

For 3E Plus® **versions 4.0 and earlier**, this may be done by navigating to the **Options** section of the program, selecting the user defined materials (from Insulation Materials, Fuels Types, Jacket Materials, and/or Base Metals) and using **Print Screen** or a screen capture program to preserve the data previously entered.

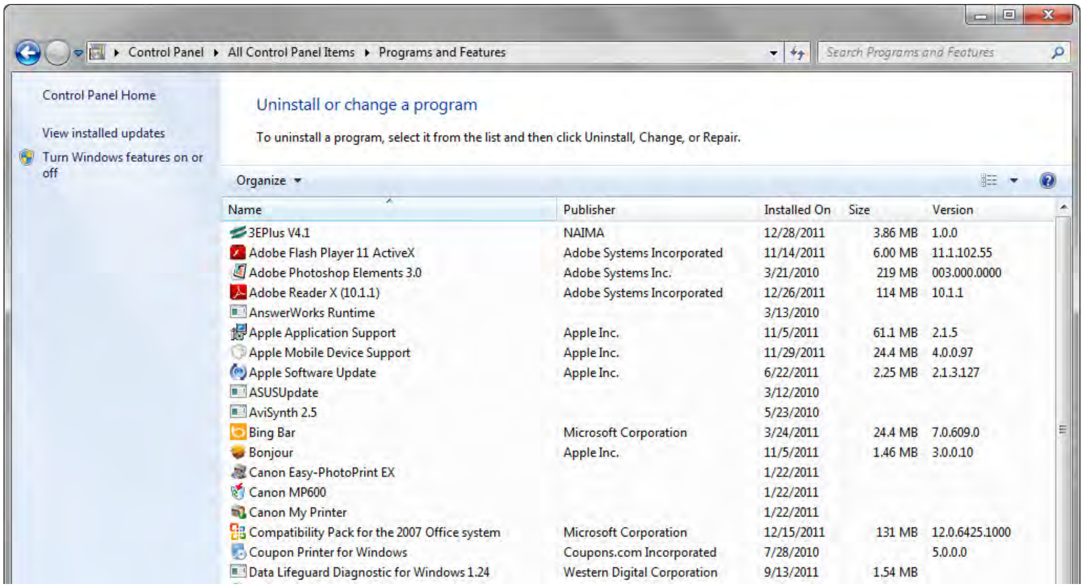
For 3E Plus® **version 4.1 and later**, this process has been automated. On the **File Menu**, select **Export User Data**. A Save File dialog box will open to allow specifying the name and location where user data will reside.




It is recommended that the default location be retained. After installation of the new version is complete, the user data may be imported by selecting **File Menu> Import User Data** and identifying the previously exported file.

After any user data has been secured, we can proceed to uninstall the earlier version of 3E Plus®

1. Click on **Start** >> **Control Panel** >> **Programs.** You will get the following window (you may get a different view than this depending on your computer settings or operating system).




2. Right click on the “3E Plus Vx.x” program (it is usually at the very top of the list) and left click “Uninstall.”

   **NOTE: If you see more than one listing of 3E Plus if you’ve installed the program more than once. This may or may not be an issue. If you select one, and uninstall doesn’t work, try the other one in the list. Unless you know how to edit (and it’s highly recommended you don’t) your Windows® registry, you won’t be able to remove the item from the list. It’s not a problem, but it can be confusing.**

3. Once you click Add/Remove, a dialog box will appear, and you will be prompted to confirm your intentions. Click **Yes** to uninstall the program.

4. Next, you **may** see the Shared File prompt. ***It’s strongly suggested you keep shared files by clicking* Keep*, unless you’re absolutely sure no other program is using them.***

5. After the program is uninstalled you may be notified, depending on your operating system, that some components could not be removed. This isn’t a problem. All the uninstall program is telling you is there are files (e.g. your personal configuration info, saved economics jobs) in the program directory which weren’t part of the original installation. Since the uninstall program doesn’t know what to do with them, it notifies you so you can take care of them. After the program is uninstalled, you can delete the 3E Plus directory if you have no use for the extra files. Uninstall should complete after you answer the aforementioned dialog, and you should see the following notification. Click **OK**

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6. Click **OK** in the confirmation dialog, and the program will return to the same dialog shown in step 2 except 3E Plus Vx.x has been removed from the list.

# Network Users

This version of 3E Plus® will not work on a network file server. You can print to a network printer, but the program must be resident on the user's PC in to obtain correct operation.

# Installation Problems

When the setup program is initialized, setup cannot install system files or update if they are in use. Before proceeding, it is strongly recommended you close any applications you may be running. If you encounter any problems during installation, retry the installation procedure. If you continue to have problems, please contact technical support

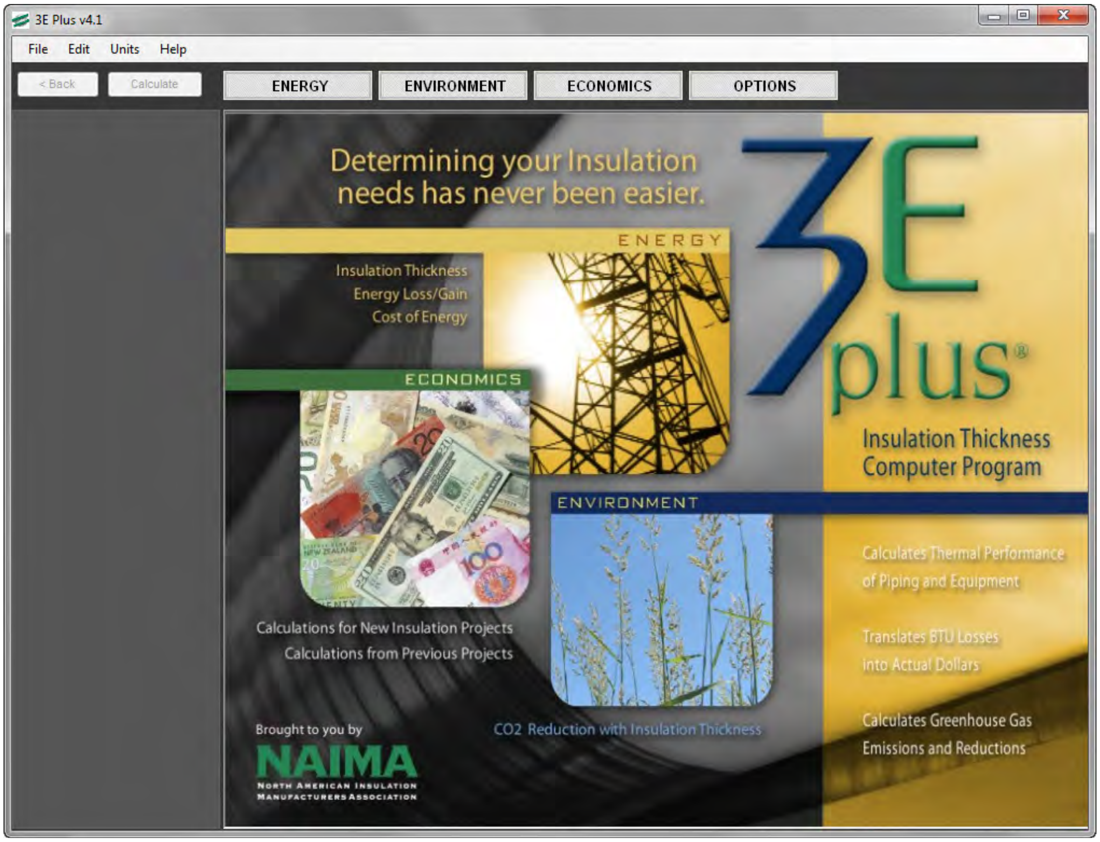
# Technical Support

Technical support is available from the North American Insulation Manufacturers Association (NAIMA). To get support; send an e-mail message to 3EPlus@naima.org detailing the problem encountered.

**NOTE: To date – all installation issues have been caused by either not following the program installation instructions, the user does not have administrative rights to install software or the user's settings are not set correctly. Please do not contact NAIMA until checking with your IT support.**

# USING THE PROGRAM

**Start > Programs> 3EPlusv41** brings up the **Main Page**




This screen has a top Menu bar containing **File, Edit, Units, and Help** buttons in the upper left corner.

1. Clicking on the **File** button creates a drop down menu with 8 choices: **Open Job, Save Job, Calculate, Export Report, Print Report, Export User Data, Import User Data,** and **Exit;**
   a. Clicking on the **Open Job** allows the User to open up a previously saved job whereas the command **Save Job** will allow him to save the input information for a job he's working on. This enables the user to modify the information as necessary.
   b. The **Calculate** item instructs the program to perform calculations (same as the Calculate Button)
   c. The **Export Report** item exports a report in htm Format
   d. The **Print Report** item generates a printed report
   e. The **Export User Data** selection writes user supplied data (custom conductivity data or other) to a file for later use.
   f. The **Import User Data** selection reads user supplied data (custom conductivity data or other).
   g. Clicking on the **Exit** button terminates the application.

2. Clicking on the **Edit** Button creates a drop down menu with 2 choices: **Save as Default** or **Load Defaults.**
   The default values are the input values that load on start-up. The user may use these features to save time when doing repetitive analyses on common materials and systems.

3. Left clicking on **Units** allows the User to select Inch-Pound (I-P) units or SI, or System International, which is the accepted system of metric, units. The default setting is inch-pound (I-P) units.

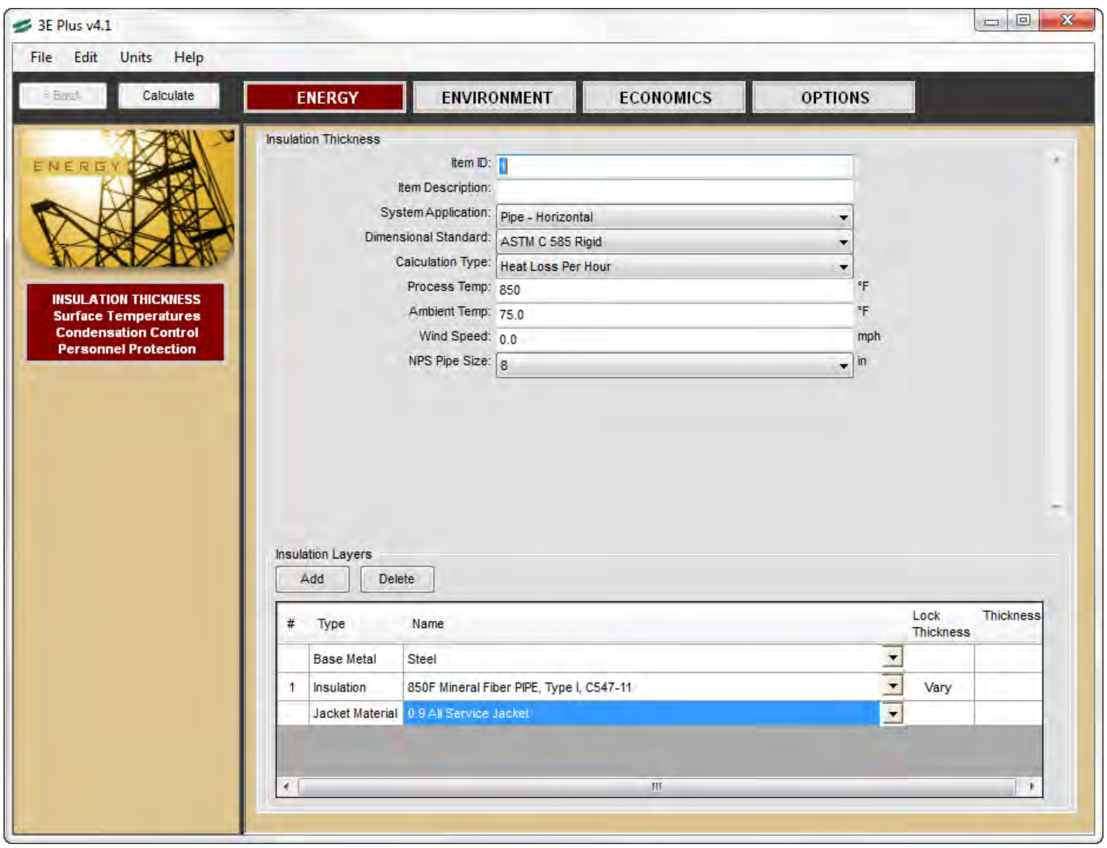
4. Clicking on the **Help** button generates a drop down menu with two Choices: **Disclaime**r and **About.**
   a. Clicking on **Disclaimer** brings up the same Disclaimer you have already seen.
   b. Clicking on the **About** button generates the About screen which identifies the program, version, sponsor, Web address, Copyright. Clicking on the **OK** box returns the user to the Main Menu. When this screen is closed, the user is returned to the **Main Menu**.

This Main Menu will remind you why the program is called 3E Plus: there's an "E" for Energy, for Environment, and for Economics. Details on using the 3E Plus® program will be covered in the following chapters. Before moving on, let's get a taste of the power of 3E Plus by working through an example problem...

# Example Problem No. 1 – Insulation Thickness Calculation

**NOTE to Previous Users: All calculations involving economic calculations ($) have been moved to the "ECONOMICS" section.**

Left click on the box at the top labeled "Energy". The following screen will appear:

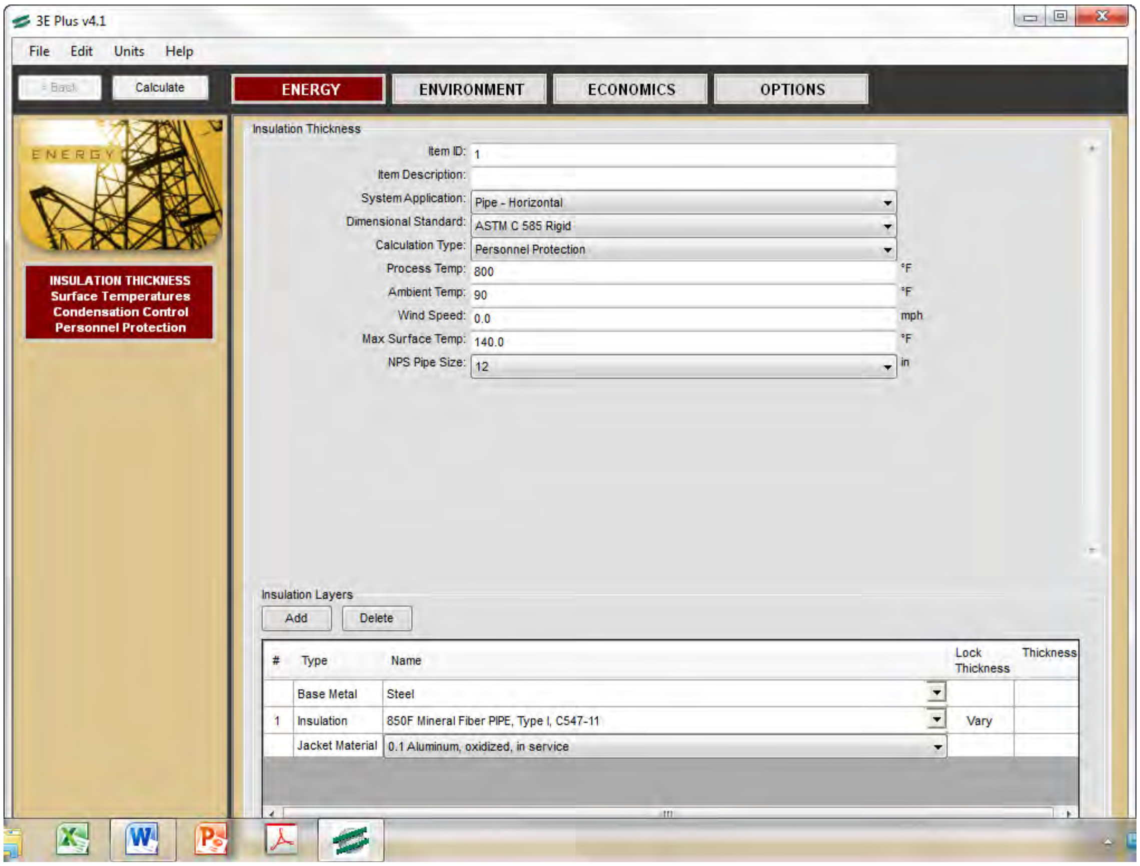



**Note: As is normal for Windows® based software, the windows used in 3E Plus® may be adjusted in size to accommodate video displays and user preferences. In some cases, this may "hide" some areas of the input and/or results and requires users to use the scroll bars to view all of the information available.**

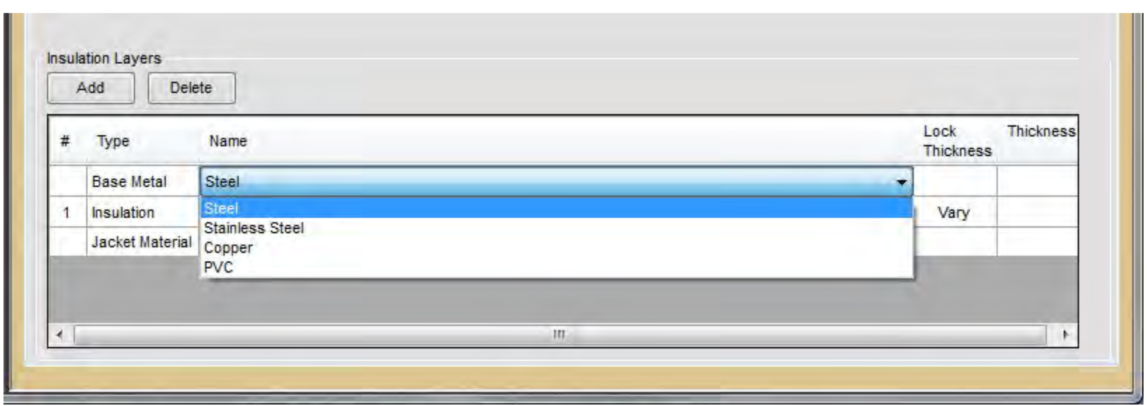
For this first example, say we want to determine the minimum insulation thickness required for personnel protection, defined as a maximum external surface temperature of 140° F, for a horizontal 12-inch NPS, 800° F steel pipe insulated with ASTM C547

Type 1 mineral fiber insulation and weathered aluminum jacketing. The design ambient air temperature is 90° F with zero wind speed.

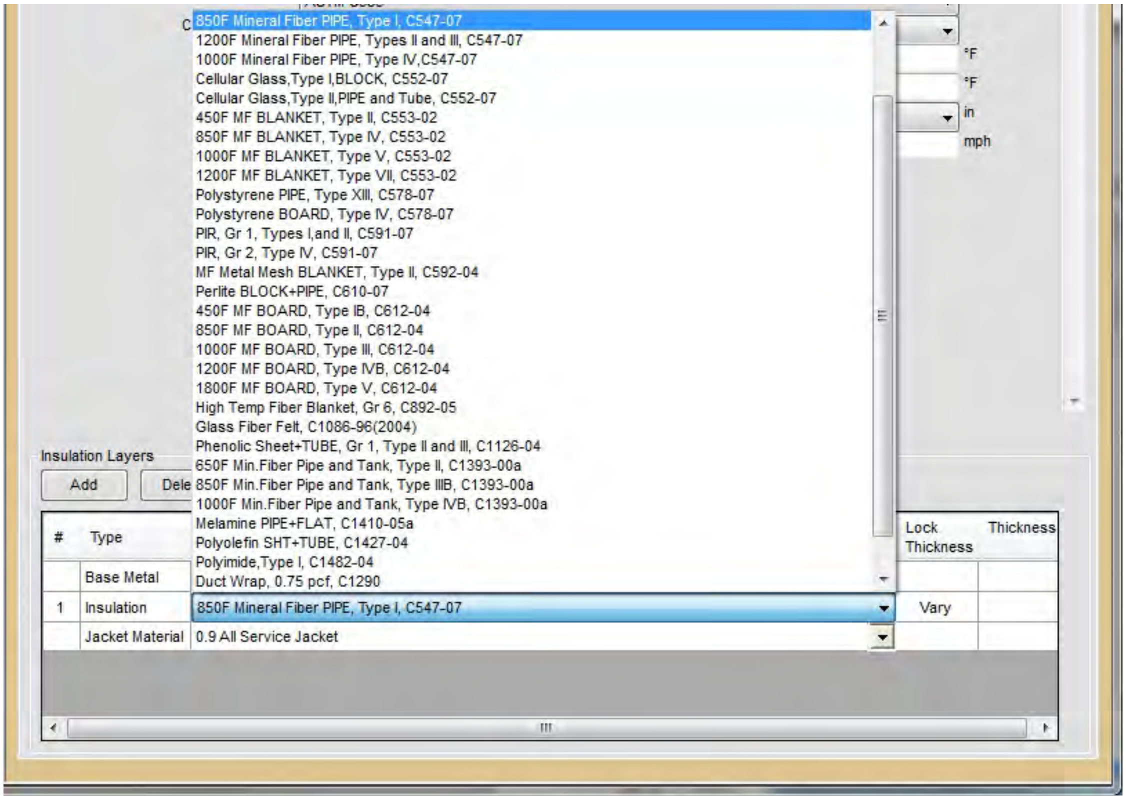
Fill in or select information in the input area so it appears as follows:



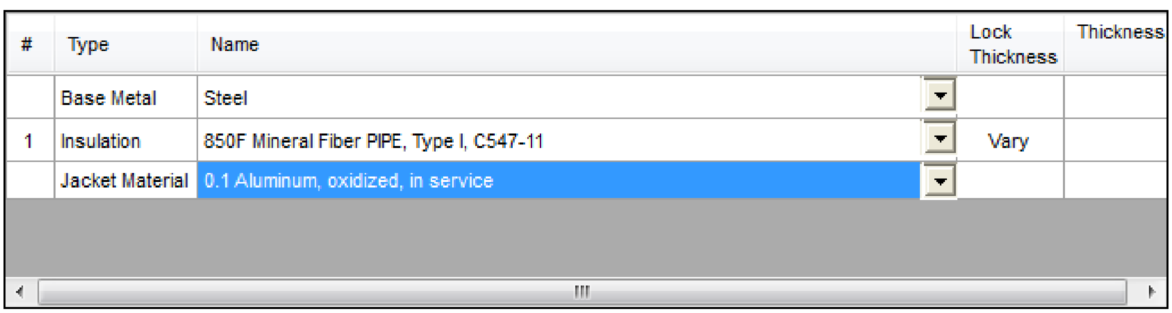

Next go to "Insulation Layers" area to designate the **Base Metal**, (in this case, the pipe wall material): Select "Steel", then go the second drop down menu:



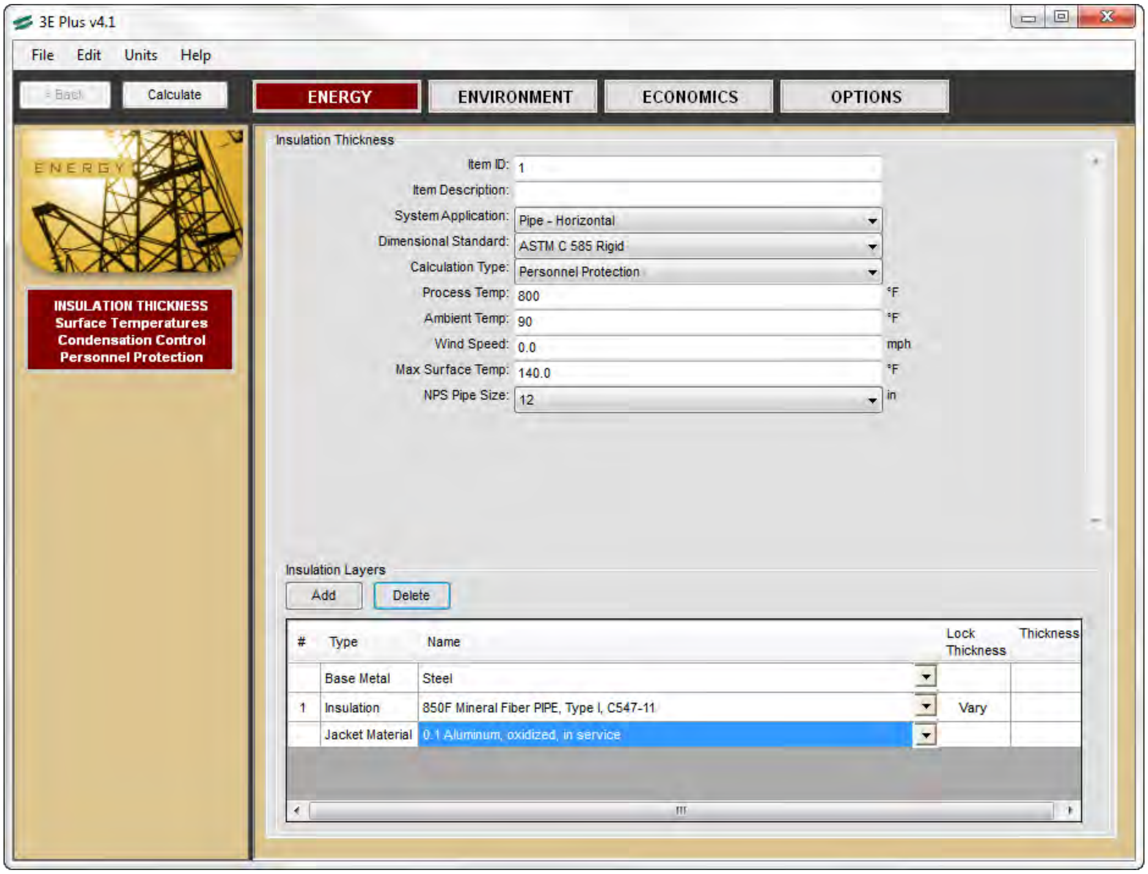
Next designate the **Insulation** as Type 1, C547-07 Mineral Fiber pipe insulation.



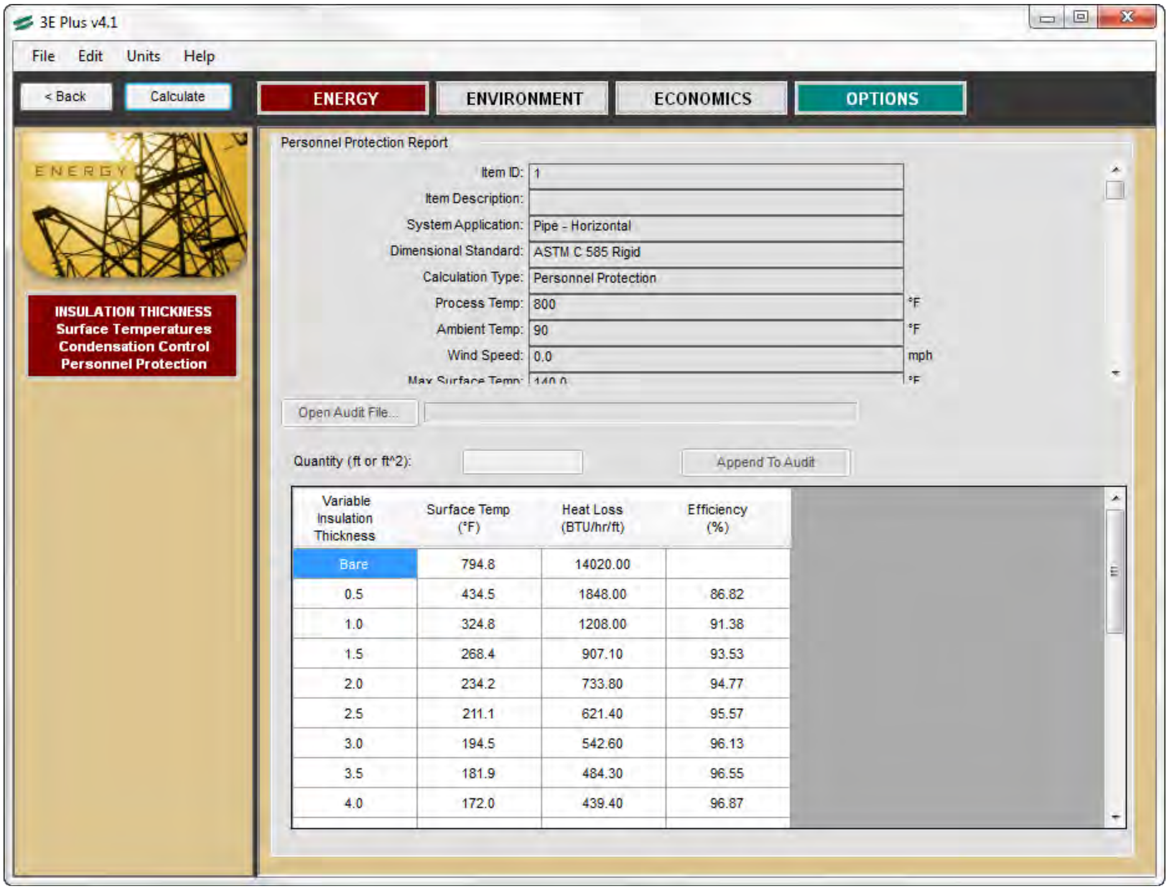

Finally, go the third drop down menu for **Jacket Material** to select the 0.1 (emissivity) Aluminum, oxidized (weathered) jacketing:




Next perform a calculation by clicking on the **Calculate** box on the upper left. Before doing so, the screen should look like this:

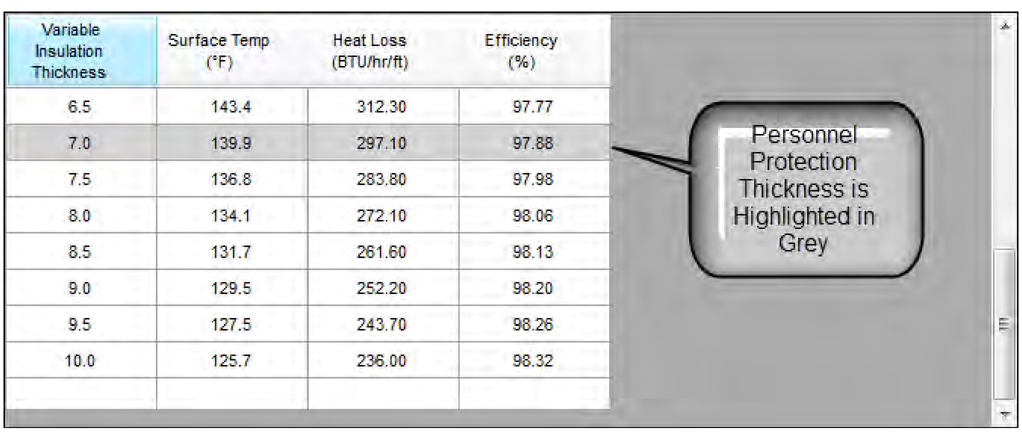



After clicking on **Calculate**, the results should look like the following:




| Variable Insulation Thickness | Surface Temp (°F) | Heat Loss (BTU/hr/ft) | Efficiency (%) |
|---|---|---|---|
| Bare | 794.8 | 14020.00 | |
| 0.5 | 434.5 | 1848.00 | 86.82 |
| 1.0 | 324.8 | 1208.00 | 91.38 |
| 1.5 | 268.4 | 907.10 | 93.53 |
| 2.0 | 234.2 | 733.80 | 94.77 |
| 2.5 | 211.1 | 621.40 | 95.57 |
| 3.0 | 194.5 | 542.60 | 96.13 |
| 3.5 | 181.9 | 484.30 | 96.55 |
| 4.0 | 172.0 | 439.40 | 96.87 |

Note the input information is all reprinted at the top of the computer screen (such as System Application, Calculation Type, pipe orientation, Nominal Pipe Size, Process Temp., etc.). Also note that you may (depending on your window size) need to scroll down to see the calculation results for Surface Temp, Heat Loss, and Efficiency for the Bare Pipe and all the way down to a pipe with 10.0 inches of insulation thickness, in 0.5 inch increments.




| Variable Insulation Thickness | Surface Temp (°F) | Heat Loss (BTU/hr/ft) | Efficiency (%) |
|---|---|---|---|
| 6.5 | 143.4 | 312.30 | 97.77 |
| 7.0 | 139.9 | 297.10 | 97.88 |
| 7.5 | 136.8 | 283.80 | 97.98 |
| 8.0 | 134.1 | 272.10 | 98.06 |
| 8.5 | 131.7 | 261.60 | 98.13 |
| 9.0 | 129.5 | 252.20 | 98.20 |
| 9.5 | 127.5 | 243.70 | 98.26 |
| 10.0 | 125.7 | 236.00 | 98.32 |

This calculation shows to attain a surface temperature of less than 140° F an insulation thickness of 7.0 inches is the minimum required and is highlighted in grey:

The calculated surface temperature of 139.9° F is less than the maximum specified of 140.0° F. The program also gives you the heat loss as 297.10 Btu/hr/ft (of pipe length) with an efficiency of 97.88%.

The efficiency here is defined as the percent reduction in heat loss and is calculated by dividing the Heat Loss through 7.0 inches of insulation (297.10 Btu/hr/ft) by the Heat Loss for the Bare pipe (14020.00 Btu/hr/ft), you get 0.0212. Multiply by 100 to convert this to 2.12% and then subtract from 100.00%, to get 97.88%. This is the Efficiency of the insulated pipe with 7.0 inches of mineral fiber insulation compared to the heat loss from a bare pipe, with no insulation at all, under the same conditions.

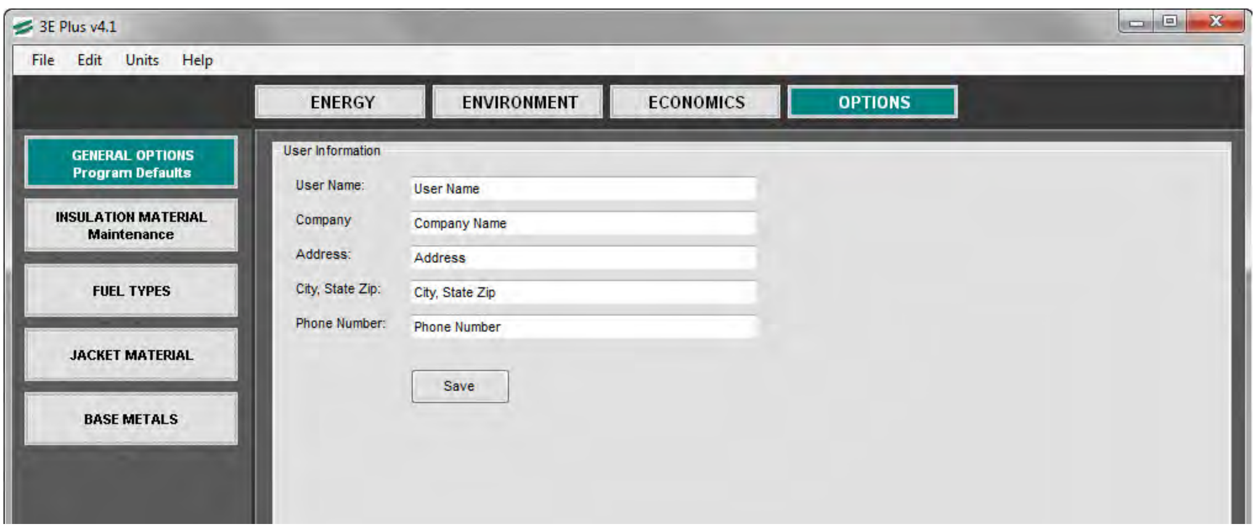
# Chapter 2
# Options

There are five options available under the button labeled **Options:**

1. **General Options**
2. **Insulation Material**
3. **Fuel Types**
4. **Jacket Material**
5. **Base Metals**

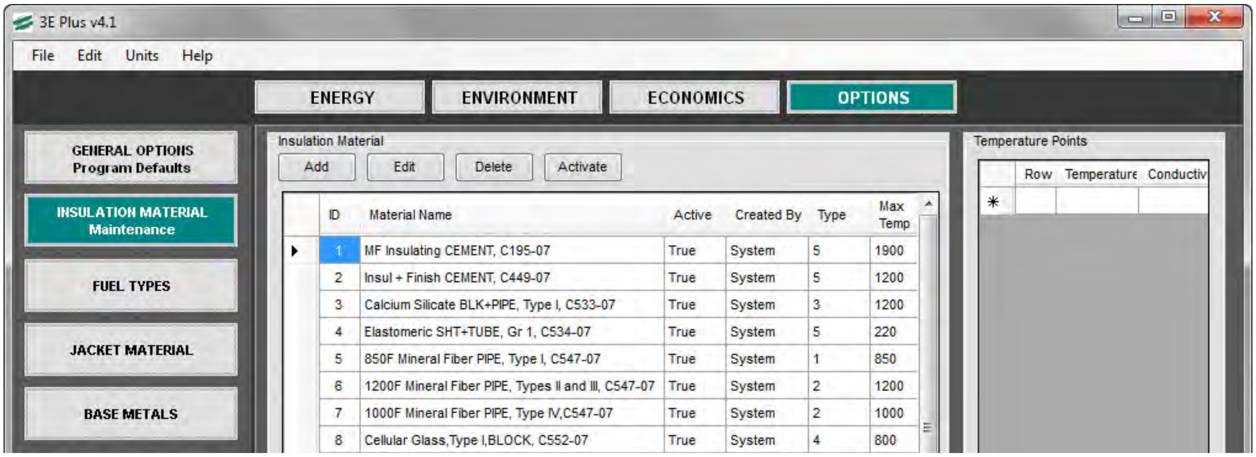
The **General Options** provides the opportunity for the User to add information about himself (name, company's name, address, phone number). This information is simply repeated in any printed reports. Option 2, **Insulation Material**, gives the User the opportunity to supply thermal conductivity data for insulation materials that are not preloaded in the library. Option 3, **Fuel Types**, gives the User the opportunity to edit or add other fuels. Option 4, **Jacket Material**, gives the User the opportunity to define other jacketing materials in addition to those provided by the program. . Option 5, **Base Metals** allows the user to define additional substrate materials.

Click on the **GENERAL OPTIONS** tab and the following screen will appear where the user enters information that appears on printed reports.



# INSULATION MATERIALS

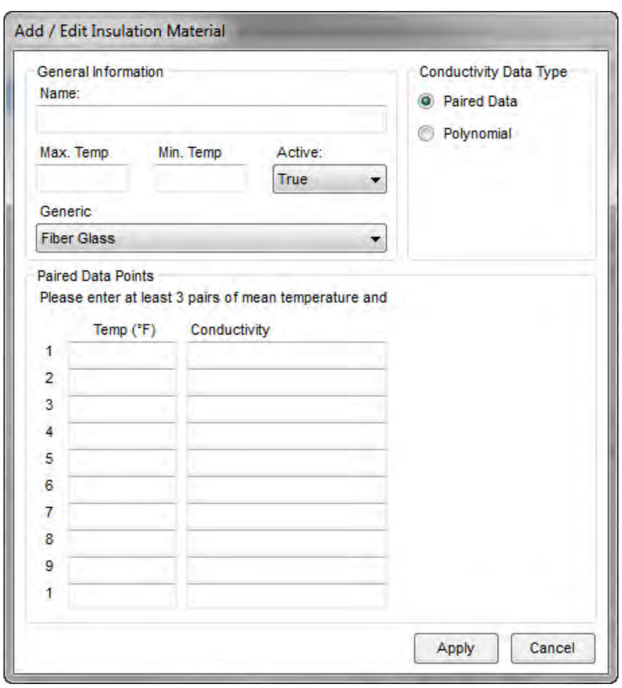
Select **INSULATION MATERIAL** and the following screen will appear:




This menu contains a large number of different insulation materials, each with the Material Name (per the appropriate ASTM material standard), whether it is Activated for use or not (True means that it is Active; False means that it is Inactive), Created by (either System or User), the type or class of the insulation material, and the Max Temp Limit for the material. The section in the upper right hand corner displays the corresponding pairs of temperature - thermal conductivity values used to represent the thermal performance of the selected material. The user may notice that the ASTM values for thermal conductivity are typically higher than those reported by manufacturers of materials that comply with these particular standards. This is typical as the ASTM material standards specify maximum values of thermal conductivity allowable. If you wish to use values for a specific commercially available insulation material, thermal data may be available from insulation manufacturers, or from test data reported in the literature.

## Add a New Insulation Material to the Program

Use the **ADD** button to generate the **Add/Edit Insulation Material box.**..

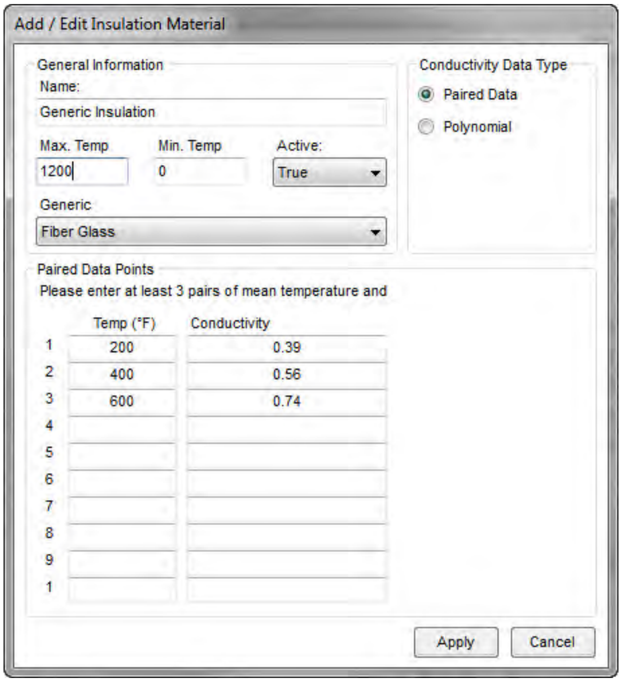



Next, give a name to the insulation material which is different than the generic names in the program. Second, add the Maximum and Minimum service temperatures (supplied by the manufacturer). Third, select "True" for Active. Finally, supply at least 3 pairs of temperature - conductivity data over the temperature range of interest.

For example, to add a material which called Generic Insulation, you must have at least three pairs of temperature – thermal conductivity data. Let us assume that these pairs are as follows:

| Temp, ° F | Thermal Conductivity, Btu-in/hr-ft$^2$ - °F |
|---|---|
| 200° | 0.39 |
| 400° | 0.56 |
| 600° | 0.74 |

Assuming this Generic Insulation has a maximum use temperature of 1200° F and a minimum use temperature of 0°F - input the values as shown in the following diagram.



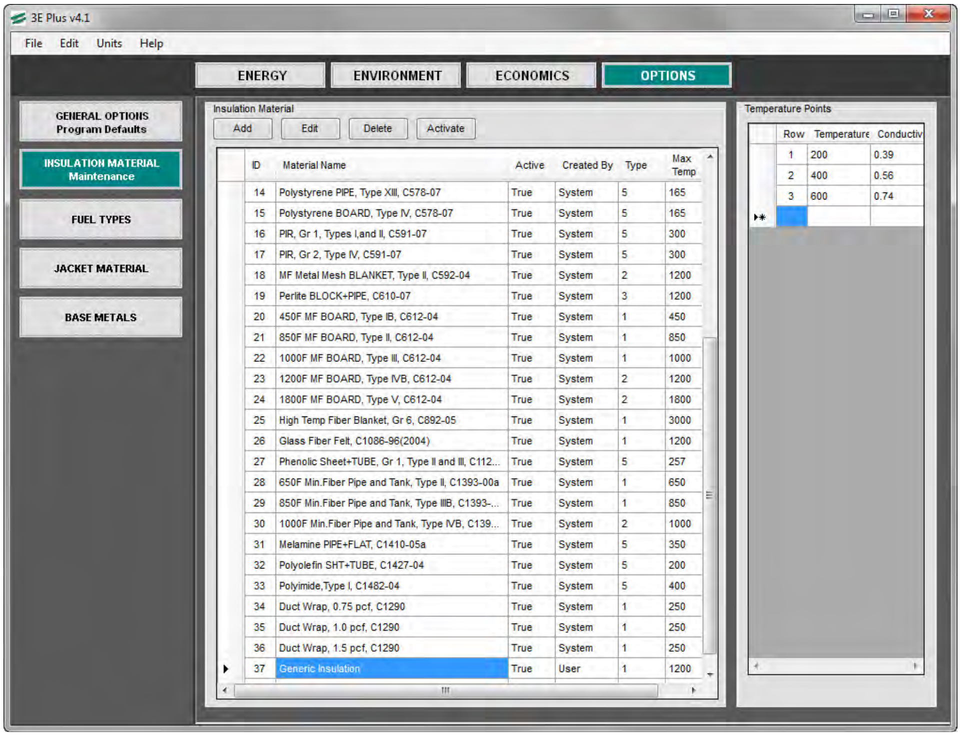

The next step is to fill in the spaces with the appropriate information. Select the Paired Data option (unless you have an equation, rather than temperature conductivity data), as shown above. Note this example uses 3 pairs of temperature - thermal conductivity data for the Generic Insulation although there are spaces for ten pairs of data.

Next, click on the **Apply** button. This makes Generic Insulation, as well as any of the System supplied materials, available for your calculations.

It is only possible to **Edit** the data for User supplied materials. You cannot **Edit** Conductivity, Maximum Temp, or Minimum Temp for any of the "System" materials (which come preinstalled with the program) since those values are established by the particular referenced ASTM material standard.

# Display a List of Insulation Materials

Scrolling to the bottom of the insulation material list, you will see the new material which was just added.
Notice that in the upper right hand corner of the screen are the three pairs of temperature - conductivity data just added. Notice also that you can scroll back through the entire list of available insulation materials and check the data used for those materials.

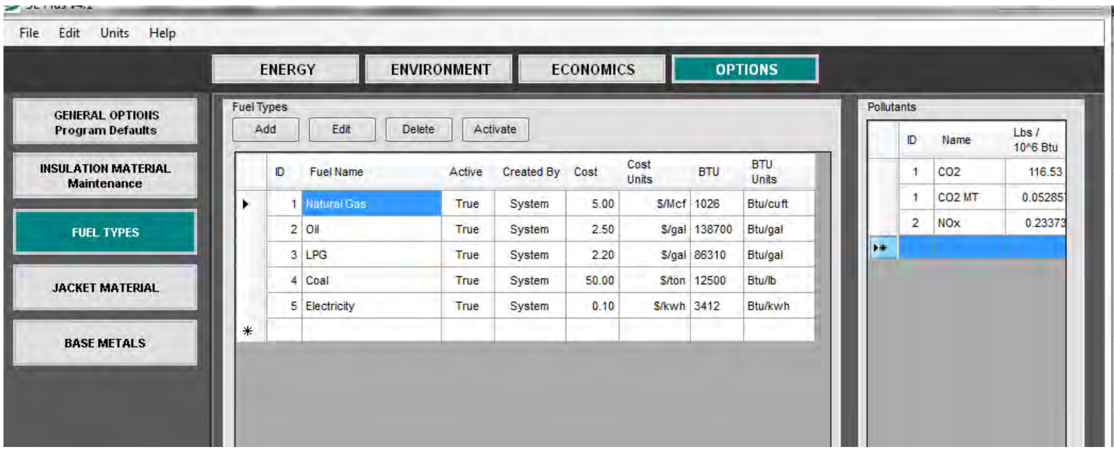



# Delete an Existing Insulation from the Program

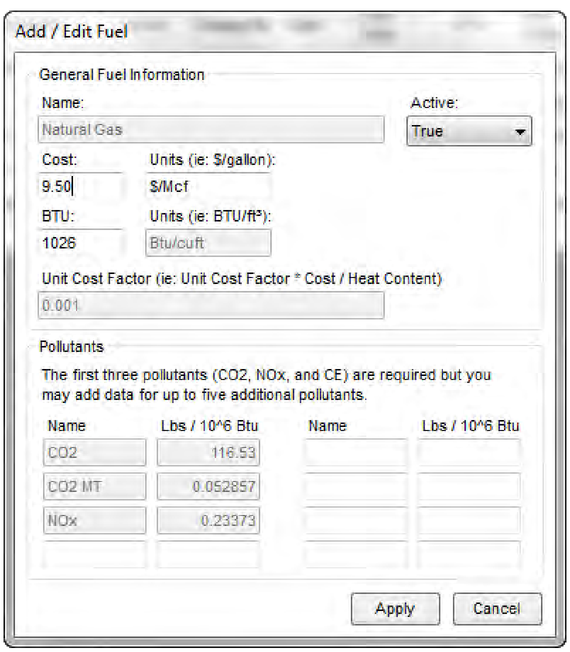
Click on the Generic Insulation material which just added. Then, click on the **DELETE** button. This deletes this material. You cannot delete or change the properties of "System" materials provided in the program. However, materials can be turned off by selecting the material, clicking on the **Activate** button, and thereby changing **True** to **False.** This option is useful in eliminating from view those insulation materials not routinely used, thereby shortening the viewed list thereby making the program more user-friendly. However, should you ever wish to use those deactivated materials, simply change **False** back to **True**.

# FUEL TYPES

Click on **Fuel Types** and you will see a new screen. When you do, select one of the fuels. For illustration purposes, we'll select the first one on the list, namely **Natural Gas**:




Several common fuels come preinstalled by the SYSTEM and appear with **True** under the **Active column.** The default cost of those fuels is shown in the **Cost** column. The **Cost Units** used are indicated in the next column. For natural gas, the default cost is $5/Mcf (thousand cubic feet). Default energy content is given in the **BTU** column followed by the **BTU Units**. The default energy content for natural gas is 1026 Btu/cu ft. In the upper right hand corner are the default pollutants data for that particular fuel (this is the number of pounds of each pollutant per $10^6$ Btu of energy content. With **Natural Gas** highlighted the pollutant values are for that fuel used in a gas burner. Some modern "low-NOX" burners produce less $NO_X$ so different values can be inserted by the User to replace the default values.

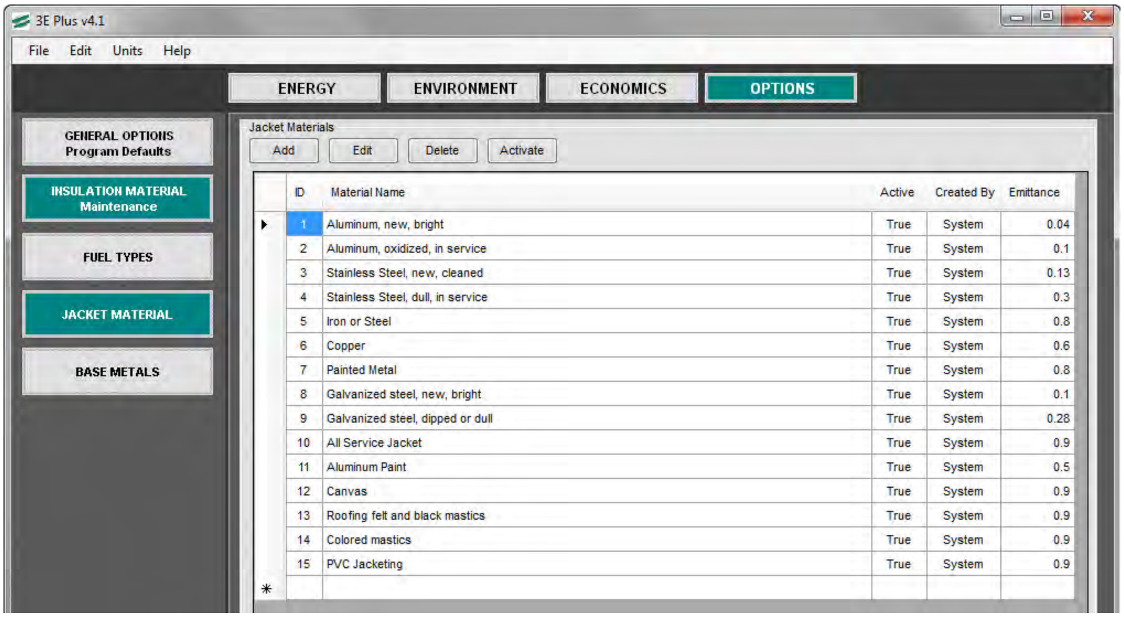



The default values for both the **Cost** value and the **BTU** value can be changed, should you have better data. With energy costs constantly changing and varying from one location to another, these values should be updated to reflect the cost of fuel you are routinely using. For example, the default cost of **Natural Gas** is $5.00 per Mcf. If your actual local cost is $9.50 per Mcf, then it would be appropriate to change to that value as shown below.

Note it is also possible to add other fuel types, should they be required. The process is similar to that shown for adding an insulation material except you'll need a **Cost** for the fuel, **Cost Units**, the **BTU** content of the fuel, and the **BTU Units**.

# JACKET MATERIALS

Next, click on the **JACKET MATERIAL** button and you'll get a list of 15 materials, used for jacketing, on your screen (which will look like the following):



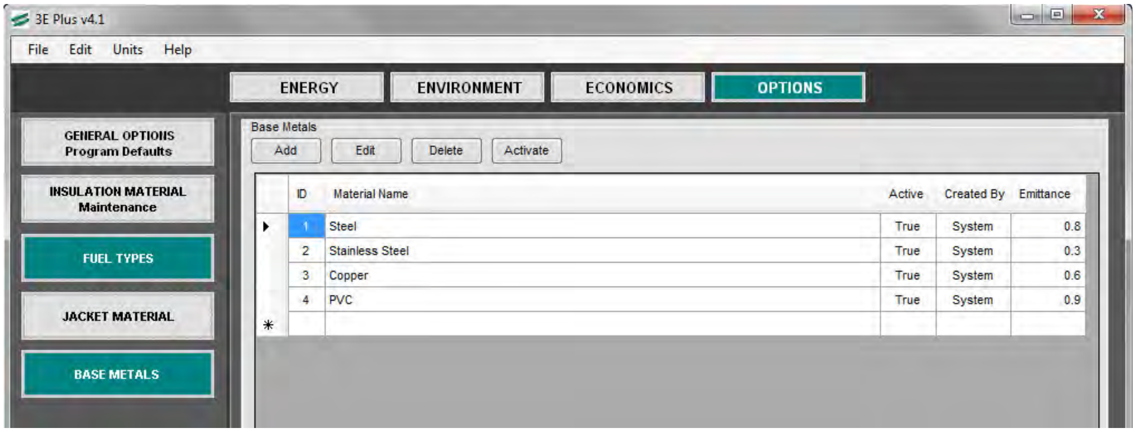

| ID | Material Name | Active | Created By | Emittance |
|---|---|---|---|---|
| 1 | Aluminum, new, bright | True | System | 0.04 |
| 2 | Aluminum, oxidized, in service | True | System | 0.1 |
| 3 | Stainless Steel, new, cleaned | True | System | 0.13 |
| 4 | Stainless Steel, dull, in service | True | System | 0.3 |
| 5 | Iron or Steel | True | System | 0.8 |
| 6 | Copper | True | System | 0.6 |
| 7 | Painted Metal | True | System | 0.8 |
| 8 | Galvanized steel, new, bright | True | System | 0.1 |
| 9 | Galvanized steel, dipped or dull | True | System | 0.28 |
| 10 | All Service Jacket | True | System | 0.9 |
| 11 | Aluminum Paint | True | System | 0.5 |
| 12 | Canvas | True | System | 0.9 |
| 13 | Roofing felt and black mastics | True | System | 0.9 |
| 14 | Colored mastics | True | System | 0.9 |
| 15 | PVC Jacketing | True | System | 0.9 |

As with the **Insulation Materials**, new jacket materials can be added and can be made Inactive (**False**) or Active (**True**). However, the "System" jacket materials that are provided in the program cannot be edited or deleted. The forth column has the value of emittance associated with that jacketing material**.** The value of **emittance** is particularly important when doing any calculations where surface temperature is the design criteria, namely for Personnel Protection or Condensation Control. You can **Add** a new jacket material and insert the value of **emittance** you wish to use.

.

# BASE METALS

Selecting the **BASE METALS** button displays the list of the materials commonly used for pipes and equipment. The **emittance** values of associated with these base materials is used to calculate the radiant component of heat transfer for bare surfaces. While no base metal values may be eliminated or edited, new materials may be added when desired:




As with **INSULATION MATERIALS, FUEL TYPES, and JACKET MATERIALS**, the User can **Add** other base materials if the thermal conductivity and surface emittance of the materials are known.

# Chapter 3
# Energy Calculations

As shown in Example 1 in the Introduction, the Energy Calculations are accessible from the **MAIN PAGE**. Calculation Types available in this section include:

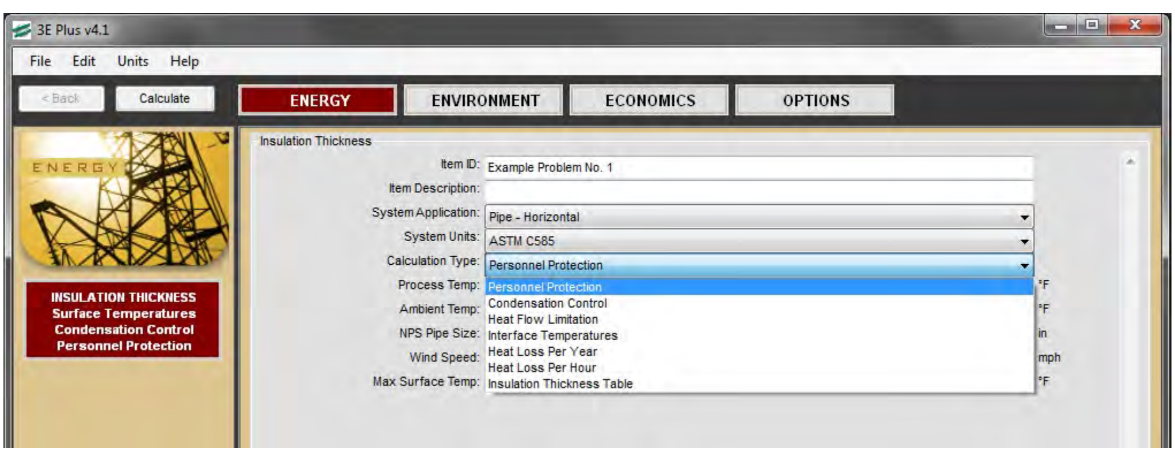
1. Control of the surface temperature to provide **Personnel Protection** in hot service,
2. Control of surface temperature so as to control **Condensation** in cold service;
3. Control of **Heat loss / Heat gain** per unit outer surface area based on some maximum allowable value;
4. Calculation of **Interface Temperatures** at various locations within the insulation assembly
5. Calculation of **Heat Loss / Heat Gain** either per hour or per year, and finally
6. Generation of **insulation thickness tables** for control of surface temperature.

# SURFACE TEMPERATURES

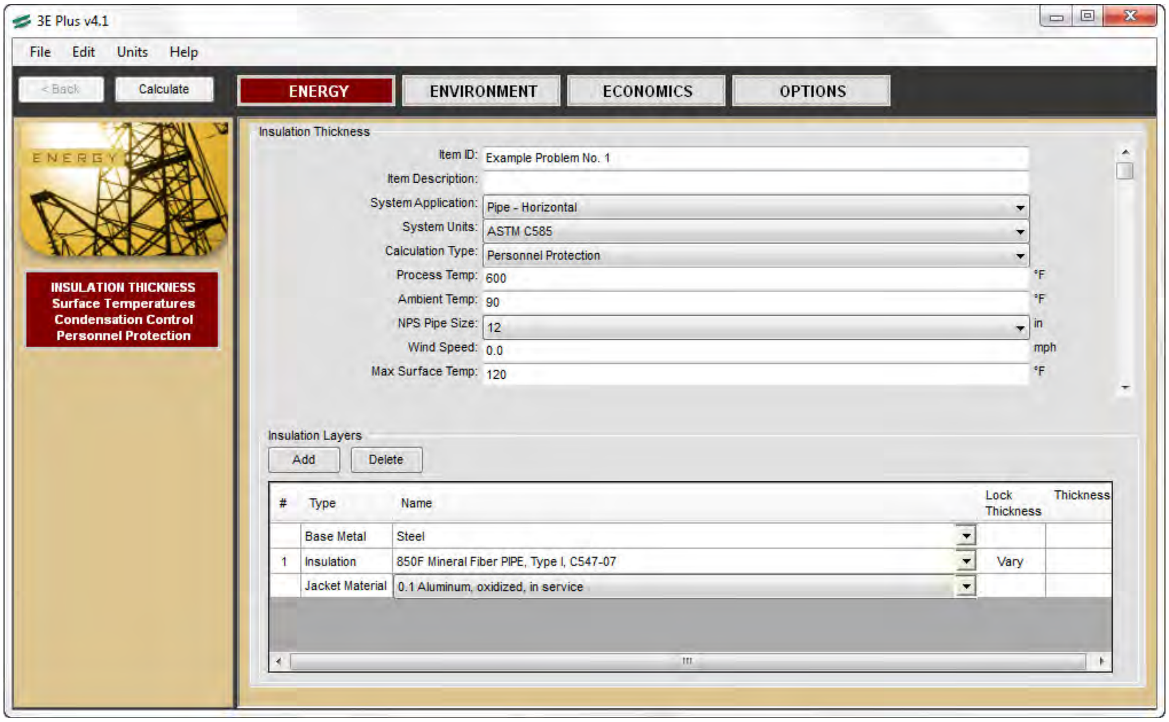
From the Main Menu, first click on **Energy**. The use of a single insulation material on a surface is most common. Two layers on a surface apply to applications such as "Retrofit" when a new insulation is to be applied over insulation already in place, or for new installations where multilayer applications are desired. There may be very rare cases where the job requirements may need three or more different insulations on the surface. There may be occasions when tabular presentations are helpful to evaluate surface temperatures over a range of service temperatures. Click on the box that describes the calculation type.


## Surface Temperatures – Personnel Protection
## 1 Insulation Material – Example Problem No. 1

Click on the **ENERGY** box of the Main Menu that opens up the screen with a "calculation type" option to select **Personnel Protection, Condensation Control, Heat Flow Limitation, Interface Temperature, Heat Loss Per Year, Heat Loss Per Hour, or Insulation Thickness Table**. These choices are shown on the following screen image:

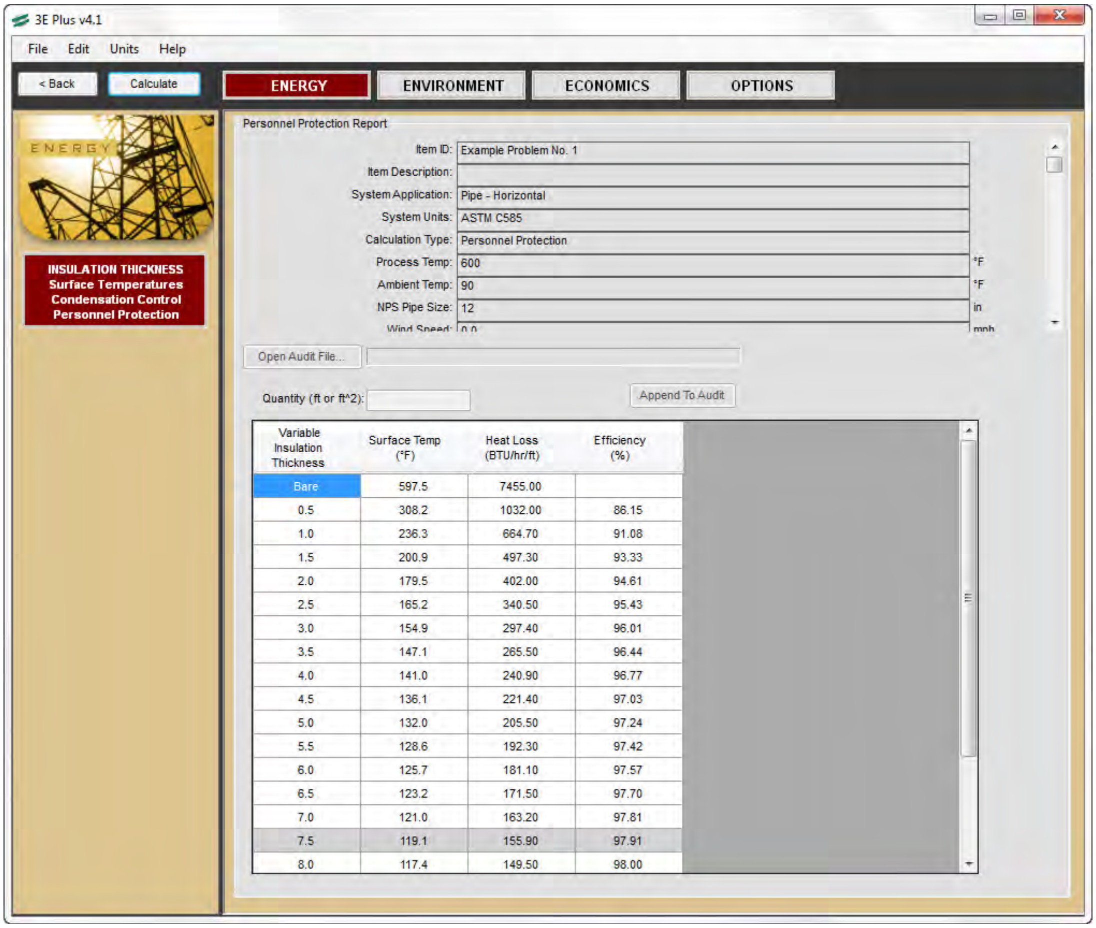



The User must select the appropriate input for each of the boxes on this screen. The default inputs will be used in the calculations unless the user changes it. Drop down menus appear for the boxes with Down Arrows on the right side. Click on the appropriate Down Arrow, point to the desired input and click on it. The boxes on the right side of this screen require selection of the appropriate inputs for Process Temperature, Ambient Temperature, and Wind Speed.  Other named boxes may appear depending on the calculation type or inputs selected.



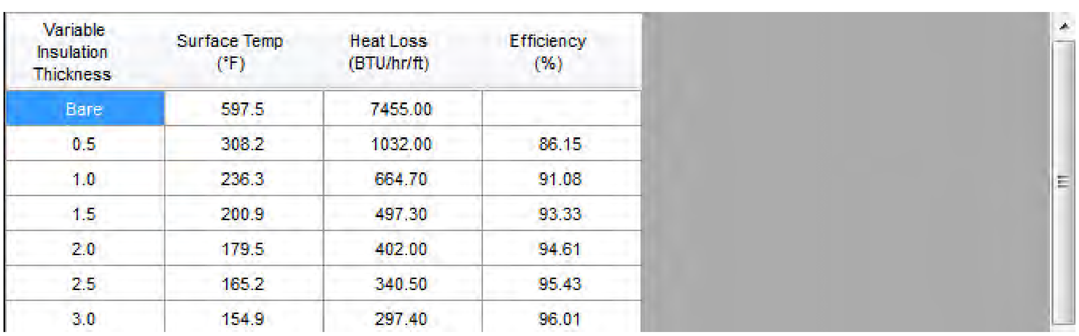

When the Personnel Protection is selected, a box is provided for the user to input the maximum allowable surface temperature.

Once the inputs are entered, click **Calculate** to generate the Report shown below. Note the minimum insulation thickness required to keep the jacket temperature below the desired temperature of 120°F is highlighted in grey.  The user may need to use the scroll bar to find the highlighted line as shown.




| Variable Insulation Thickness | Surface Temp (°F) | Heat Loss (BTU/hr/ft) | Efficiency (%) |
|---|---|---|---|
| Bare | 597.5 | 7455.00 | |
| 0.5 | 308.2 | 1032.00 | 86.15 |
| 1.0 | 236.3 | 664.70 | 91.08 |
| 1.5 | 200.9 | 497.30 | 93.33 |
| 2.0 | 179.5 | 402.00 | 94.61 |
| 2.5 | 165.2 | 340.50 | 95.43 |
| 3.0 | 154.9 | 297.40 | 96.01 |
| 3.5 | 147.1 | 265.50 | 96.44 |
| 4.0 | 141.0 | 240.90 | 96.77 |
| 4.5 | 136.1 | 221.40 | 97.03 |
| 5.0 | 132.0 | 205.50 | 97.24 |
| 5.5 | 128.6 | 192.30 | 97.42 |
| 6.0 | 125.7 | 181.10 | 97.57 |
| 6.5 | 123.2 | 171.50 | 97.70 |
| 7.0 | 121.0 | 163.20 | 97.81 |
| 7.5 | 119.1 | 155.90 | 97.91 |
| 8.0 | 117.4 | 149.50 | 98.00 |

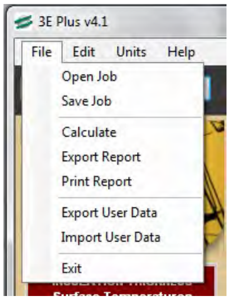
The User will note that there are columns labeled **Surface Temp (°F)**, **Heat Loss (BTU/hr/ft)** and **Efficiency (%)**. For the Bare case, note that the temperature is nearly the same as the process temperature and the heat loss is approximately 11 times greater than the same pipe with 1" of insulation (7455 ÷ 664.70 = 11.2).



| Variable Insulation Thickness | Surface Temp (°F) | Heat Loss (BTU/hr/ft) | Efficiency (%) |
|---|---|---|---|
| Bare | 597.5 | 7455.00 | |
| 0.5 | 308.2 | 1032.00 | 86.15 |
| 1.0 | 236.3 | 664.70 | 91.08 |
| 1.5 | 200.9 | 497.30 | 93.33 |
| 2.0 | 179.5 | 402.00 | 94.61 |
| 2.5 | 165.2 | 340.50 | 95.43 |
| 3.0 | 154.9 | 297.40 | 96.01 |

This program also checks that the Process Temperature is within the range of upper and lower temperature limits for the insulation material selected. If the Process Temperature exceeds the material limits (either above or below), a warning message will appear. The calculations may still be performed but the User is cautioned when a possible problem exists with the choice of the insulation material for the given conditions.

The user may generate a printout and/or save these results by clicking on the **File** button on the menu bar.




Clicking on **Save Job** opens the Save Menu. **Save Job** saves the input information used to a file so it can be retrieved at a later time. It is recommended that the files be stored in a job folder with a descriptive name so that it may readily be accessed in the future.

Click on the **<Back** button to exit the report screen and return to the **Insulation Thickness** input screen. The User may select another set of inputs and repeat the operations above, or select the **Environment**, **Economics**, or **Options** buttons.

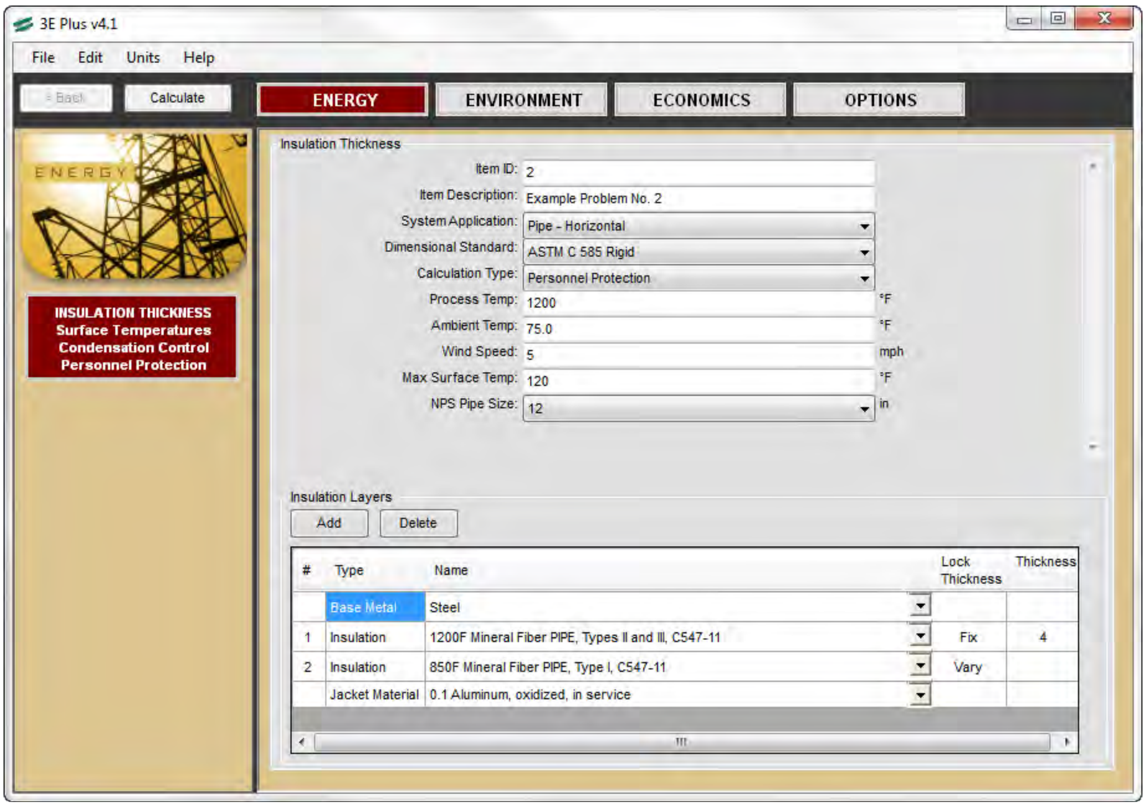
# Surface Temperatures, 2 Layers – Example Problem No. 2

3E Plus® has the capability to have more than one layer of insulation material. Let us say that our pipe temperature is now 1200°F. We still want to use as much of the 850°F Mineral Fiber PIPE, Type 1, C547 as possible. However, it is limited to 850°F service temperature and our pipe is operating at 1200°F. Therefore, one option is to have an inner layer consisting of a higher temperature rated insulation, such 1200°F Mineral Fiber Pipe, Type II, ASTM C547, and the outer layer of 850°F Mineral Fiber insulation. To evaluate insulating with two different layers, do the following:

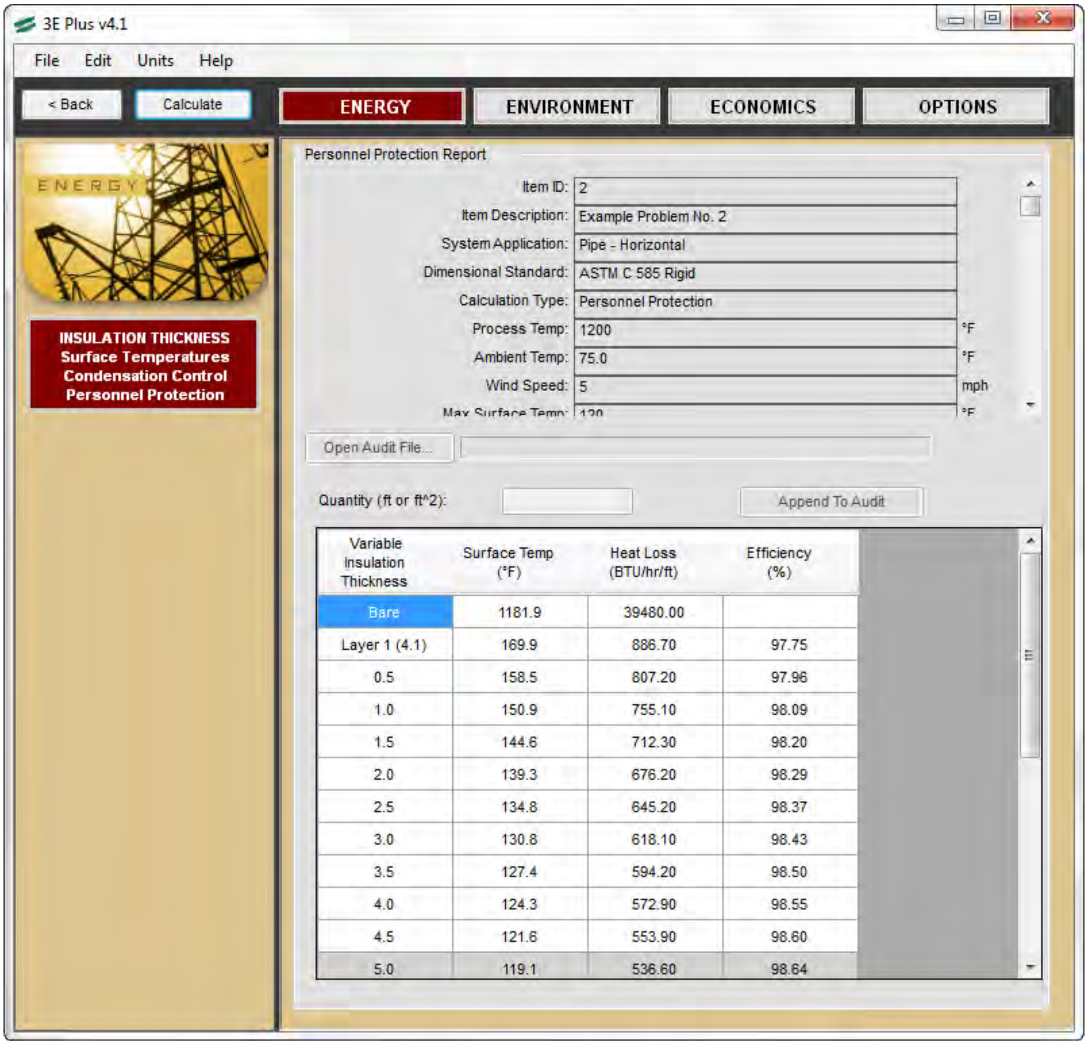
Click on the **Back** button in the upper left corner of your screen to take you back to the input page.

First designate this as Example Problem No. 2. Next, change the **Process Temp** to 1200°F. Also change the **Ambient Temperature** to 75°F and the **Wind Speed** to 5 mph. Keep the **Personnel Protection** option and leave the **Max Surf Temp** criteria as 120°F.

Then, click on the **Add** box below the **Insulation Layers**. This adds another drop down menu for insulation materials. The first material, which is the inner layer, will already be the 850F Mineral Fiber PIPE, Type 1, C547 insulation that you last used. Change the inner layer to 1200F Mineral Fiber Pipe, Type II C547, and the outer layer to be the 850F Mineral Fiber PIPE, Type 1, C547 insulation, (note that the materials are all listed in ascending order of their ASTM specification number). The results will only be generated for a single thickness of the Inner Layer which we will input as 4.0 inches of 1200 F Mineral Fiber Pipe. The outer layer (850°F Mineral Fiber PIPE, Type 1, C547) insulation will be allowed to vary. This is done with the third column called **Lock Thickness**. Lock the inner layer to have only a 4" thickness and allow the outer layer to **vary** in 0.5" increments. The input screen should appear as shown below:



Click **Calculate** to generate the **Personnel Protection** results for the use of two insulation materials.   The screen will look like this:




This second row shows the results for Layer 1.  The results show that the Surface Temp would be 169.9°F if only the 4.0 inch layer of the 1200 F Mineral Fiber Pipe insulation were installed on the pipe. Adding the second layer of insulation, the surface temperature will decrease incrementally, as shown, for thicknesses up to 10.0 inches.  To reduce the surface temperature below 120°F requires an additional 5 inches of 850F Mineral Fiber PIPE, Type 1, C547 insulation.

Note that the program also checks the Process Temperature against the maximum recommended upper temperature limit for the insulation material selected. If the Process Temperature exceeds the upper limit, an error message will appear on the screen. The calculations may still be performed, but the user is cautioned that a problem exists with the choice of the insulation material for the given conditions. For multi-layer situations, an Interface Temperature calculation should be performed to verify acceptability of the design.

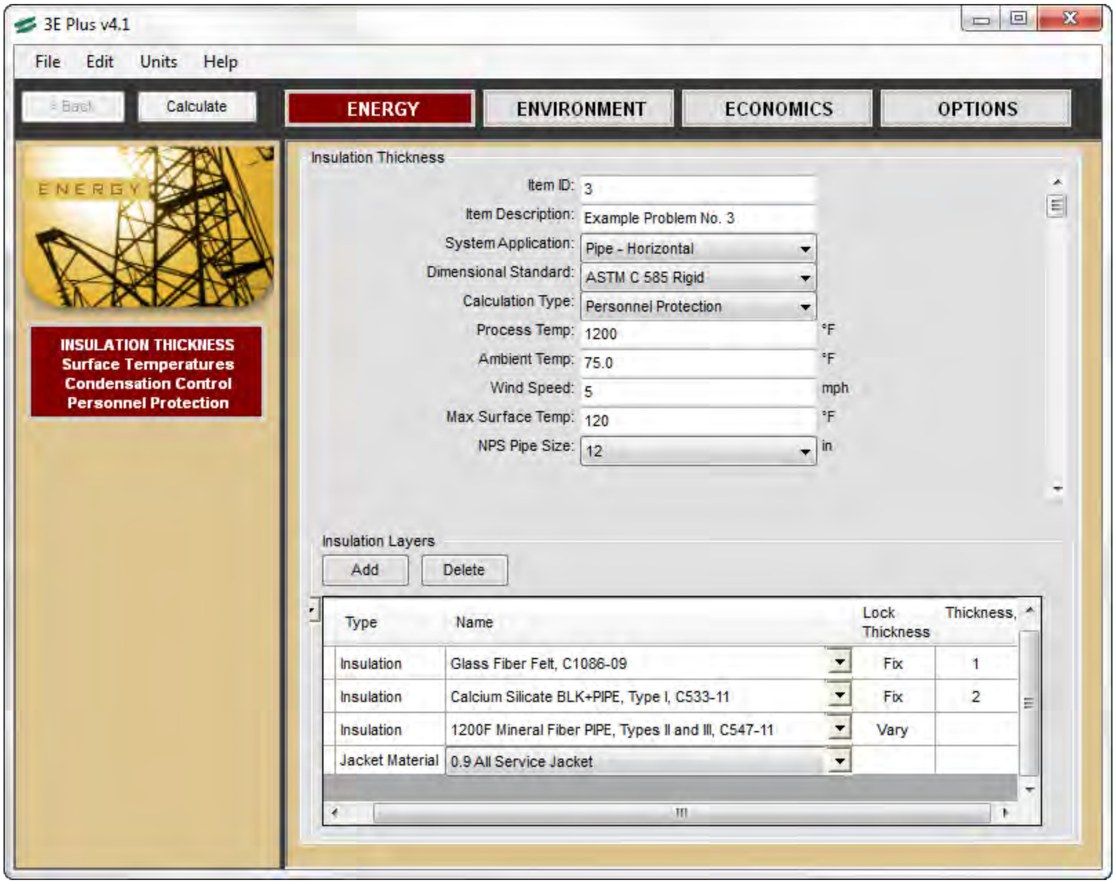
The user may generate a printout and/or save the results by clicking on the **File** button on the menu bar. Clicking on **Print** initiates the printing.

Clicking on **Export Report** generates the Save As box and allows users to save a copy of the printed report as an htm file that may be retrieved and edited at a later time. It is recommended the files be stored in a job folder with a descriptive name so it may readily accessed in the future.

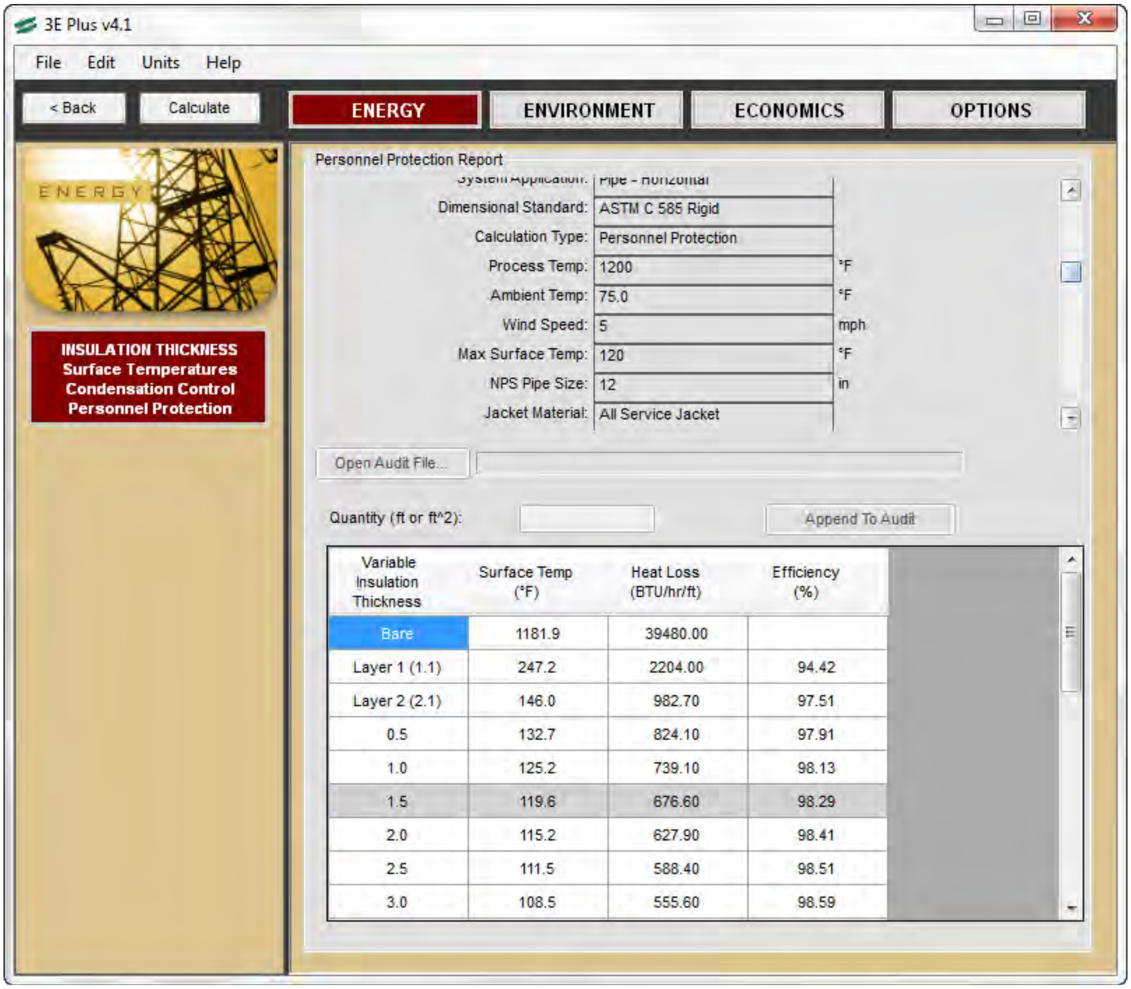
# Surface Temperature - Up to 5 Materials
# Example Problem No. 3

Click on the **Insulation Layers – Add** box, and the user can continue adding new insulation materials up to a total of five. The user must select the appropriate input for each of the boxes on this screen. The default inputs will be used in the calculations unless the user changes it.

The following screen shows the program set to use 3 layers - 1” of Glass Fiber Felt insulation, 2” of Calcium Silicate BLK+PIPE (i.e., block and pipe) insulation, 1 and a varying thickness of 1200F Mineral Fiber PIPE Insulation. Jacketing will be selected as All Service Jacket (ASJ). The input screen should look like this:



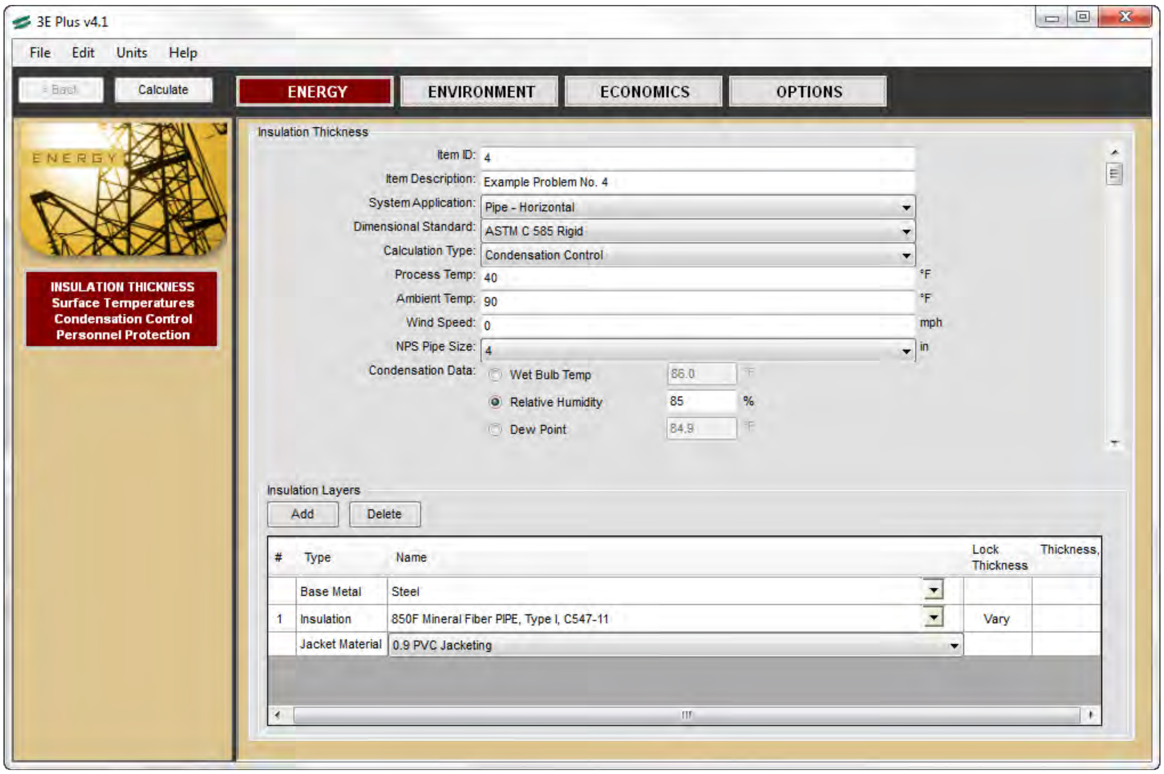
We're not recommending this combination as being practical but simply are illustrating the capabilities of 3E Plus® V4.1. The next screen shows what the output would look like after you click on **Calculate**:



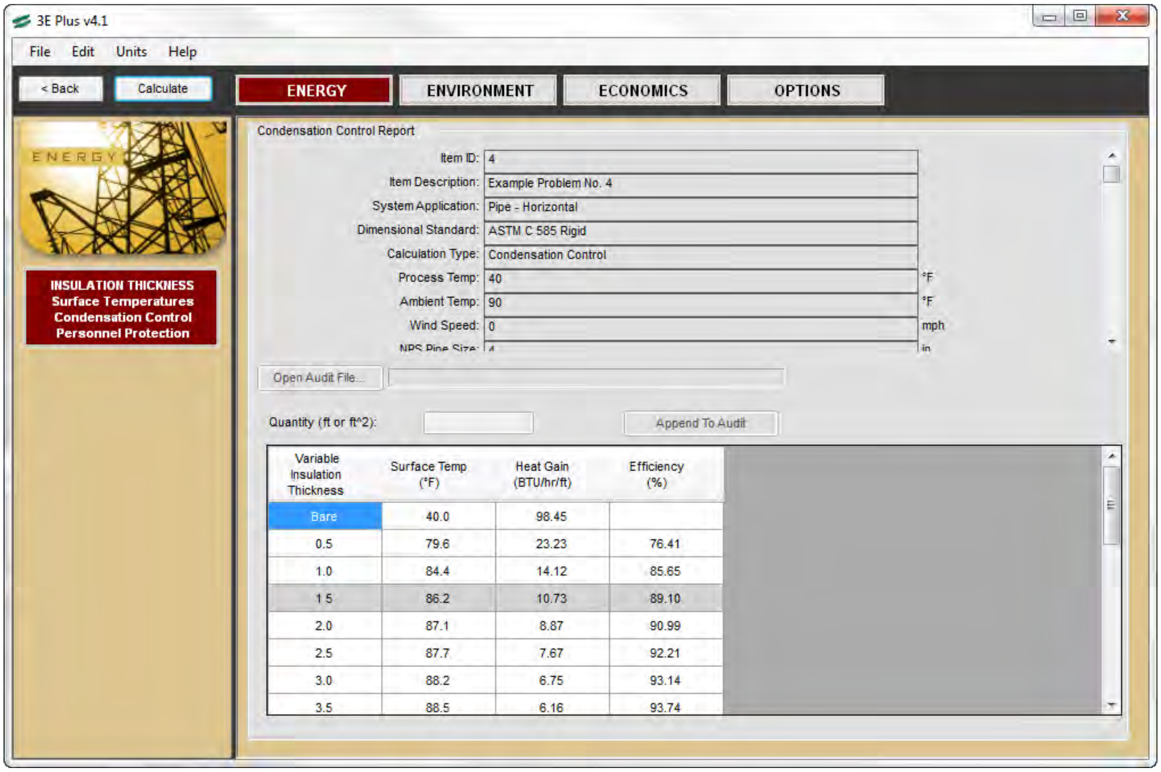

Click on the < **Back** button to exit this screen and return to the **Input** screen. The User may select another set of inputs and repeat the operations above, or return to the **INSULATION THICKNESS** menu.

# Surface Temperatures – Condensation Control Example Problem No. 4

Example Problem No. 4 below is a condensation control design problem. With a 4 inch NPS, horizontal chilled water pipe, operating at 40°F, in a 90°F ambient with 85% relative humidity and no wind. We'll select an insulation material of 850°F Mineral Fiber PIPE, Type 1, C547 and PVC jacketing over it for protection. Note that here we chose to input relative humidity in % by selecting the appropriate button. The program calculates the dew point temperature of 84.9°F (we also have the option of supplying dew point or wet bulb temperature). The input screen for this example should look like this:



After clicking on the **Calculate** box, your screen should look like this:



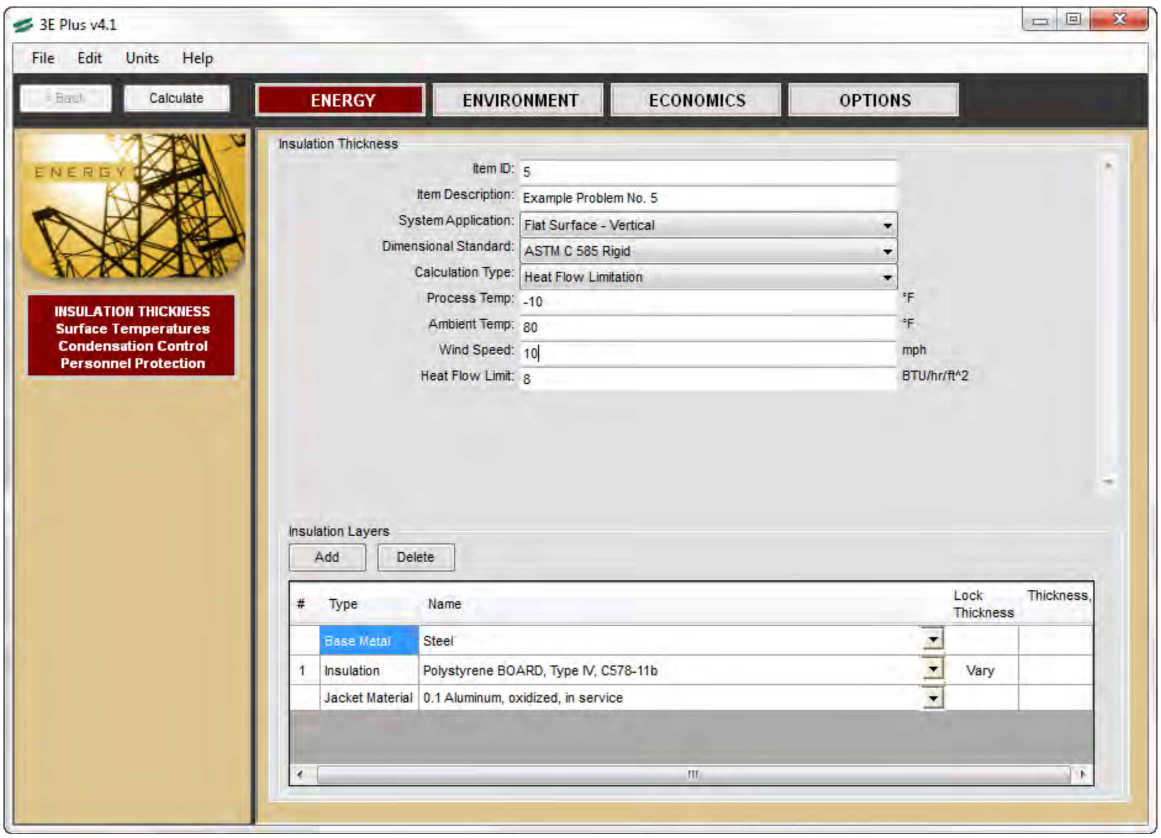

Notice the insulation thickness of 1.5 inches is highlighted in gray, indicating that this is the minimum thickness to achieve condensation control. At this thickness, the Surface Temp is 86.2°F which is above the dew point of 84.9 °F. Since 86.0 > 84.9, condensation should not occur on the surface with 1.5 inches of pipe insulation with 0.9 PVC Jacket. Notice with only 1 inch of insulation, the calculated Surface Temperature is predicted to be 84.1°F, but that 84.1° < 86.0° (the Dew point) so this does not meet the criteria for condensation control under these conditions. Hence, with only 1.0 inches of insulation, condensation would likely occur. The condensation control thickness is the thickness which yields a surface temperature of at least 0.75°F greater than the dew point temperature.

# Heat Flow

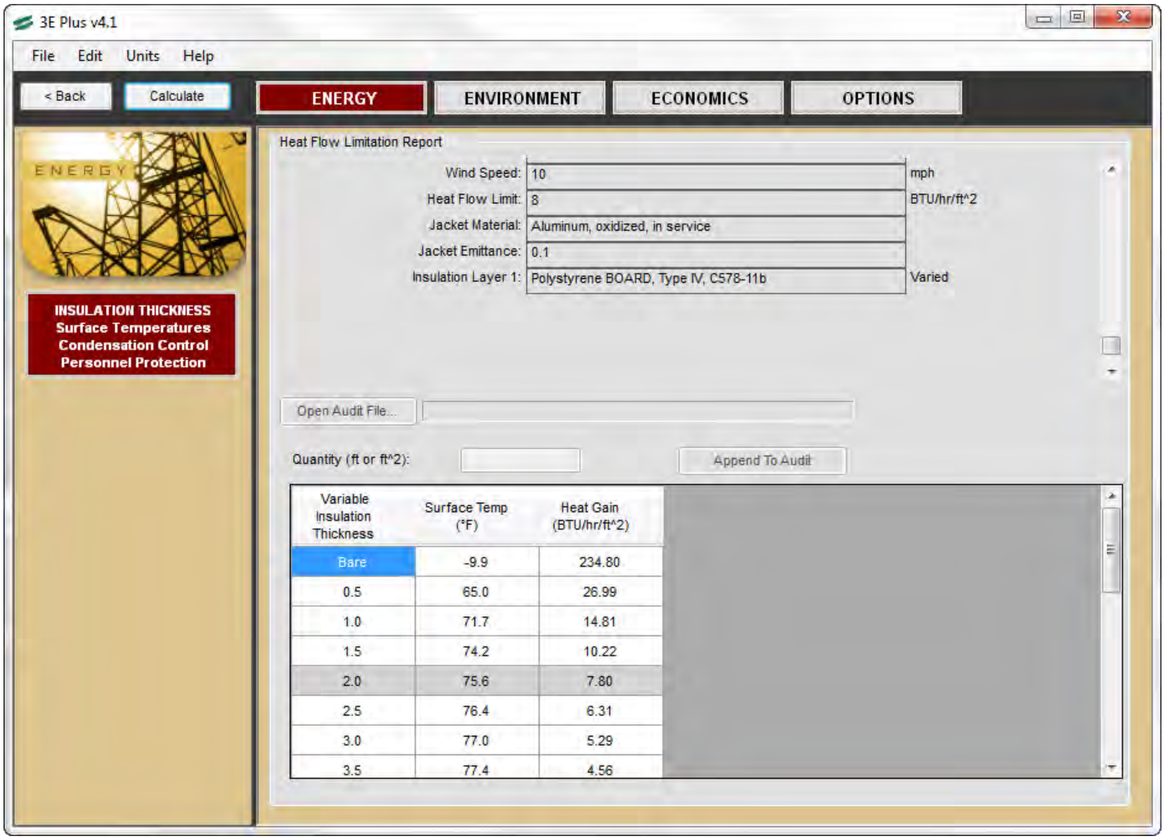
## Heat Flow Limitation – Example Problem No. 5

For Example Problem No. 5, consider the case of using 3E Plus® to determine the minimum insulation thickness required to meet a particular heat flow limitation. This problem is to determine the minimum required thickness of Polystyrene Board, Type IV, C 578, covered with Aluminum, oxidized lagging, on a flat, vertical surface of a tank containing a fluid at -10°F. The ambient conditions are 80°F and 10 mph of wind. We want to limit the heat gain to 8 Btu/h/sq. ft.

Under the **Calculation Type** select Heat Flow Limitation as the type of problem. Next, select the **System Application** as Flat Surface – Vertical and input the Process Temp, Ambient Temp, Wind Speed, and Heat Flow Limit. The input screen should look like this:

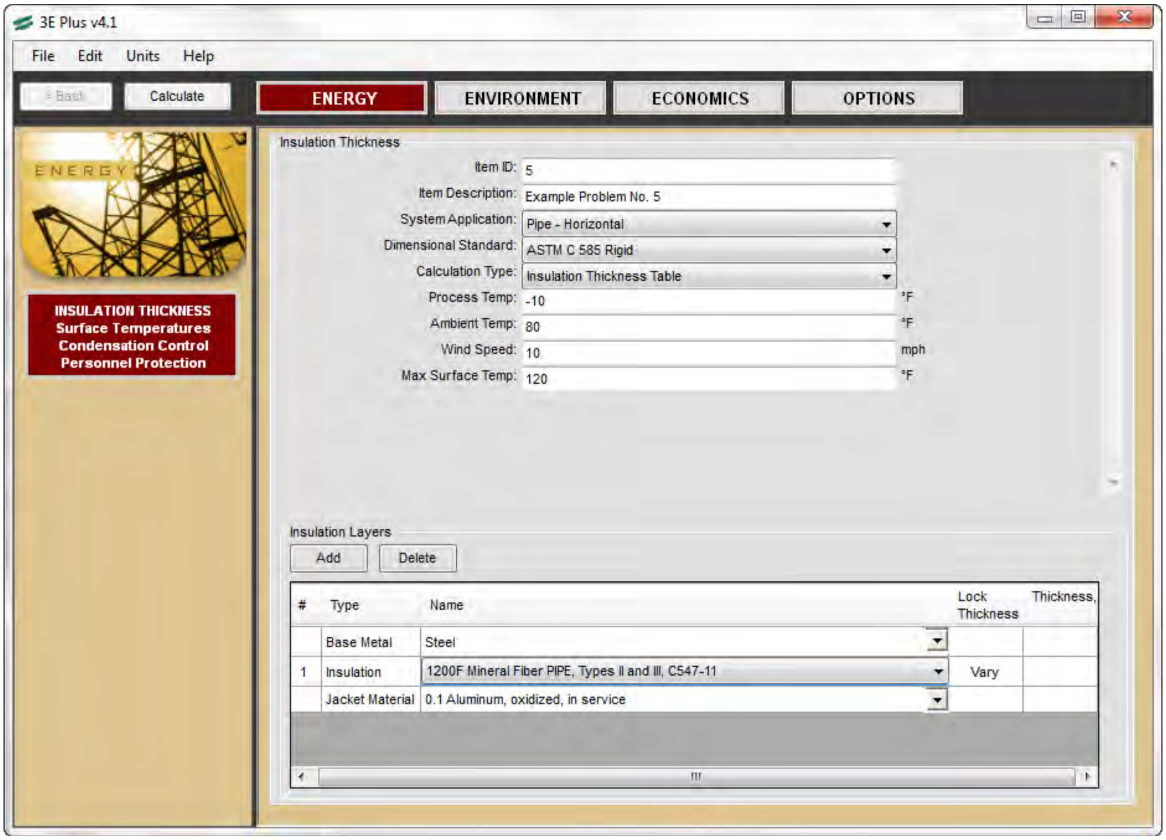


Click the **Calculate** box and scroll through the different insulation thicknesses, and 2.0 inches which is highlighted in gray is the minimum thickness to limit the heat loss to a maximum of 8 Btu/h/sq ft. At that thickness, the Heat Loss is predicted to be 7.8 Btu/h/sq ft, which is less than the maximum allowable of 8 Btu/h/sq ft.

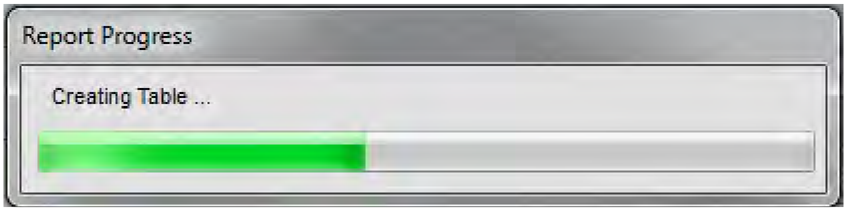


# Insulation Thickness Table for Max Surface Temp Example Problem No. 6

For Example Problem No. 6, click the **Back** box, and then change the **system application** from a vertical flat surface to a horizontal pipe. For **Calculation Type**, select **Insulation Thickness Table.** Change the insulation type to 1200°F Mineral Fiber PIPE, Types II and III, C547 and a max surface temperature of 120°F. Note- although there is a place to input the process temperature the program will automatically conduct the calculations at 200°F through 1200°F in 100°F increments. The input screen will look like this:




Click on the **Calculate** and a box (shown below) will appear for approximately 10 seconds,



After completing the calculations a table which looks like this:

NAIMA 3E Plus 4.1

Company Name
Address
City, State Zip
Phone Number

Item ID = 5
Item Description = Example Problem No. 5
System Application = Pipe - Horizontal
Dimensional Standard = ASTM C 585 Rigid
Calculation Type = Insulation Thickness Table
Ambient Temperature = 80
Wind Speed = 10
Max Surface Temp = 120
Bare Metal = Steel
Bare Surface Emittance = 0.8
Insulation Layer 1 = 1200F Mineral Fiber PIPE, Types II and III, C547-11, 9.955
Outer Jacket Material = Aluminum, oxidized, in service
Outer Surface Emittance = 0.1

| Size | 200 °F | 300 °F | 400 °F | 500 °F | 600 °F | 800 °F | 1000 °F | 1200 °F |
|---|---|---|---|---|---|---|---|---|
| 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 1.0 | 1.0 | 2.0 | 2.5 |
| 0.75 | 0.5 | 0.5 | 0.5 | 0.5 | 1.0 | 1.5 | 2.0 | 2.5 |
| 1 | 0.5 | 0.5 | 0.5 | 0.5 | 1.0 | 1.5 | 2.0 | 3.0 |
| 1.25 | 0.5 | 0.5 | 0.5 | 1.0 | 1.0 | 1.5 | 2.5 | 3.5 |
| 1.5 | 0.5 | 0.5 | 0.5 | 1.0 | 1.0 | 1.5 | 2.0 | 3.0 |
| 2 | 0.5 | 0.5 | 0.5 | 1.0 | 1.0 | 1.5 | 2.5 | 3.5 |
| 2.5 | 0.5 | 0.5 | 0.5 | 1.0 | 1.0 | 1.5 | 2.5 | 3.5 |
| 3 | 0.5 | 0.5 | 1.0 | 1.0 | 1.5 | 2.0 | 3.0 | 4.0 |
| 3.5 | 0.5 | 0.5 | 0.5 | 1.0 | 1.0 | 2.0 | 3.0 | 4.0 |
| 4 | 0.5 | 0.5 | 1.0 | 1.0 | 1.5 | 2.0 | 3.0 | 4.5 |
| 4.5 | 0.5 | 0.5 | 0.5 | 1.0 | 1.0 | 2.0 | 3.0 | 5.0 |
| 5 | 0.5 | 0.5 | 1.0 | 1.0 | 1.5 | 2.5 | 3.5 | 5.0 |
| 6 | 0.5 | 0.5 | 1.0 | 1.0 | 1.5 | 2.5 | 3.5 | 5.0 |
| 7 | 0.5 | 0.5 | 1.0 | 1.5 | 1.5 | 2.5 | 3.5 | 5.5 |
| 8 | 0.5 | 0.5 | 1.0 | 1.5 | 1.5 | 2.5 | 4.0 | 5.5 |
| 9 | 0.5 | 0.5 | 1.0 | 1.5 | 1.5 | 2.5 | 4.0 | 6.0 |
| 10 | 0.5 | 0.5 | 1.0 | 1.5 | 1.5 | 3.0 | 4.5 | 6.0 |
| 12 | 0.5 | 0.5 | 1.0 | 1.5 | 2.0 | 3.0 | 4.5 | 6.5 |
| 14 | 0.5 | 1.0 | 1.0 | 1.5 | 2.0 | 3.0 | 5.0 | 7.0 |
| 16 | 0.5 | 1.0 | 1.0 | 1.5 | 2.0 | 3.5 | 5.0 | 7.0 |
| 18 | 0.5 | 1.0 | 1.0 | 1.5 | 2.0 | 3.5 | 5.0 | 7.5 |
| 20 | 0.5 | 1.0 | 1.0 | 1.5 | 2.0 | 3.5 | 5.5 | 7.5 |
| 24 | 0.5 | 1.0 | 1.5 | 1.5 | 2.5 | 3.5 | 5.5 | 8.0 |
| 30 | 0.5 | 1.0 | 1.5 | 2.0 | 2.5 | 4.0 | 6.0 | 8.5 |
| 36 | 0.5 | 1.0 | 1.5 | 2.0 | 2.5 | 4.0 | 6.0 | 9.0 |
| 48 | 0.5 | 1.0 | 1.5 | 2.0 | 2.5 | 4.5 | 6.5 | 9.5 |

Insulation Thickness Required For Surface Temperature <= 120

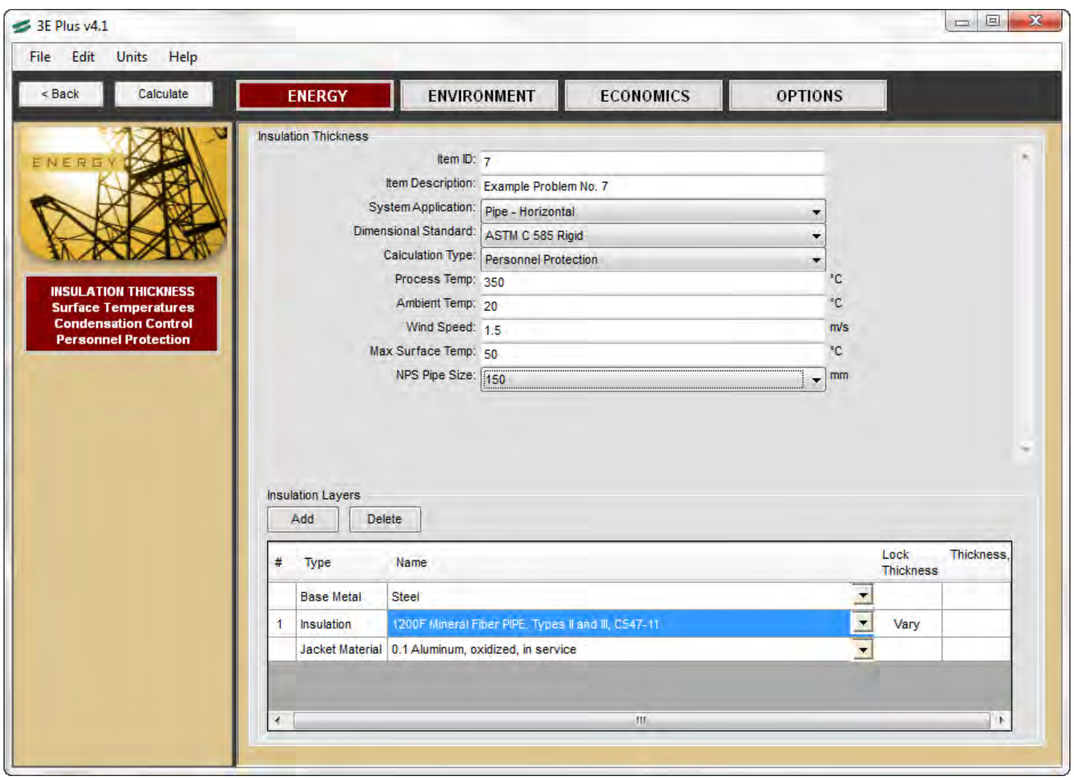
This **Calculation Type** generated the minimum insulation thicknesses required to limit the Surface Temperature to 120°F, for hot service temperatures of 200°, 300°, 400°, 500°, 600°, 800°, 1000°, and 1200°F for pipe sizes from 0.5 in to 48 inch, NPS, in all standard sized in between. It is easy to save this data by simply Saving it as it is or by doing a Copy, Paste of the data into an MS Word file or other type of file.

# Surface Temperatures – 1 Insulation Material Example Problem No. 7: Metric Units

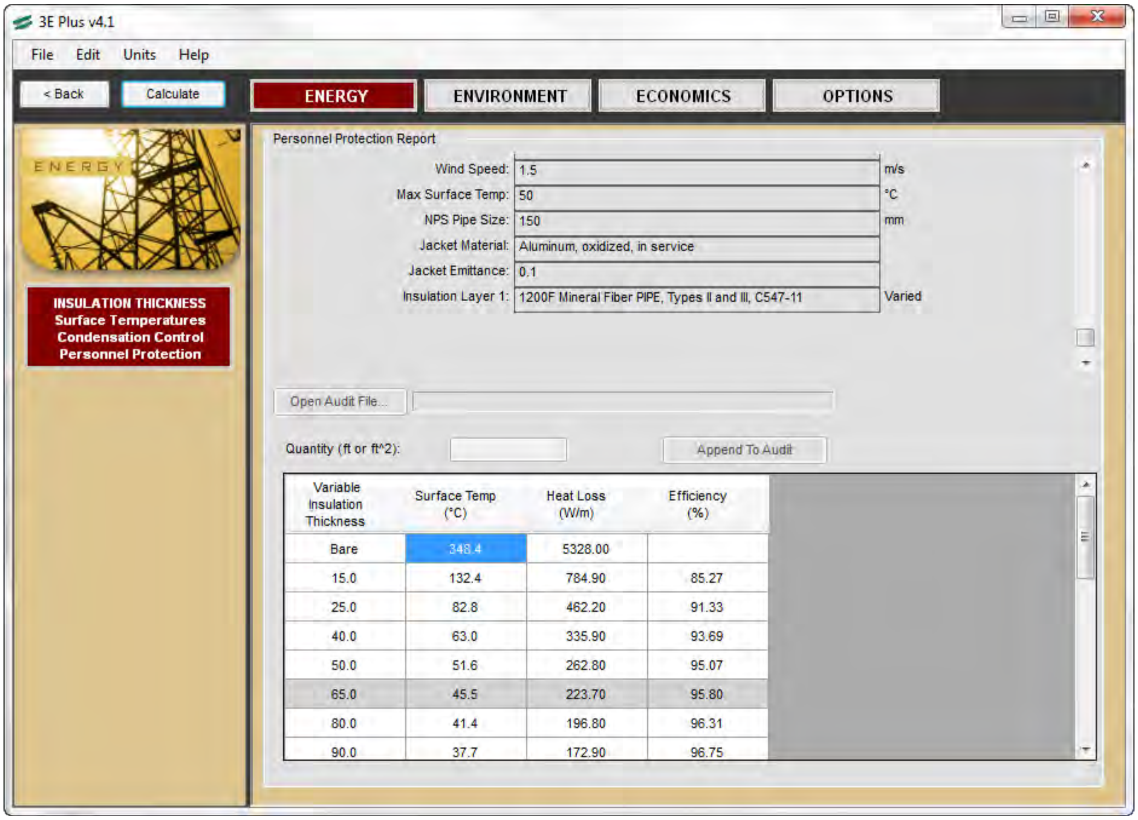
Running a surface temperature problem, or a heat loss/gain problem, in metric units is the same as those problems already shown. The only difference is that it's in metric units. Here is an example to illustrate. The first thing to do is change the units from English to SI (for Standard International) by going to the menu line, click **Units**, and select **SI**. The English Inch-pound units are the default units.

CAUTION: It is important to understand that the program does all the calculations using "soft" metric conversions for the pipe and insulation dimensions. This means when the user selects a 50mm pipe – the actual dimensions the program uses for calculations are the 2 inch NPS dimensions. Likewise a 25mm thickness of insulation is actually 1 inch. This follows the North American Convention where building materials in Canada and Mexico – for example are called 100mm are actually 4 inch products.

As in earlier Example Problem 1, the next step is to specify the various values for the **System Application** - Horizontal Pipe, **Calculation Type** - Personnel Protection, **Process Temp** - 350°C, **Ambient Temp** - 20°C, Pipe Size - 150 mm, **Wind Speed** - 1.5 m/s, Max Surface Temp - input 50°C (approx. 120°F) , select **Steel** as the base metal, **Mineral Fiber PIPE, Types II and III, C547** for the insulation, and **0.1 Aluminum, oxidized, in service** for the jacket. The input screen should look like the following:




The results of the calculation show that 65 mm of Mineral Fiber PIPE, Types II and III are required to keep the surface temperature less than the specified 50°C and thereby offer personnel protection with metal jacketing:



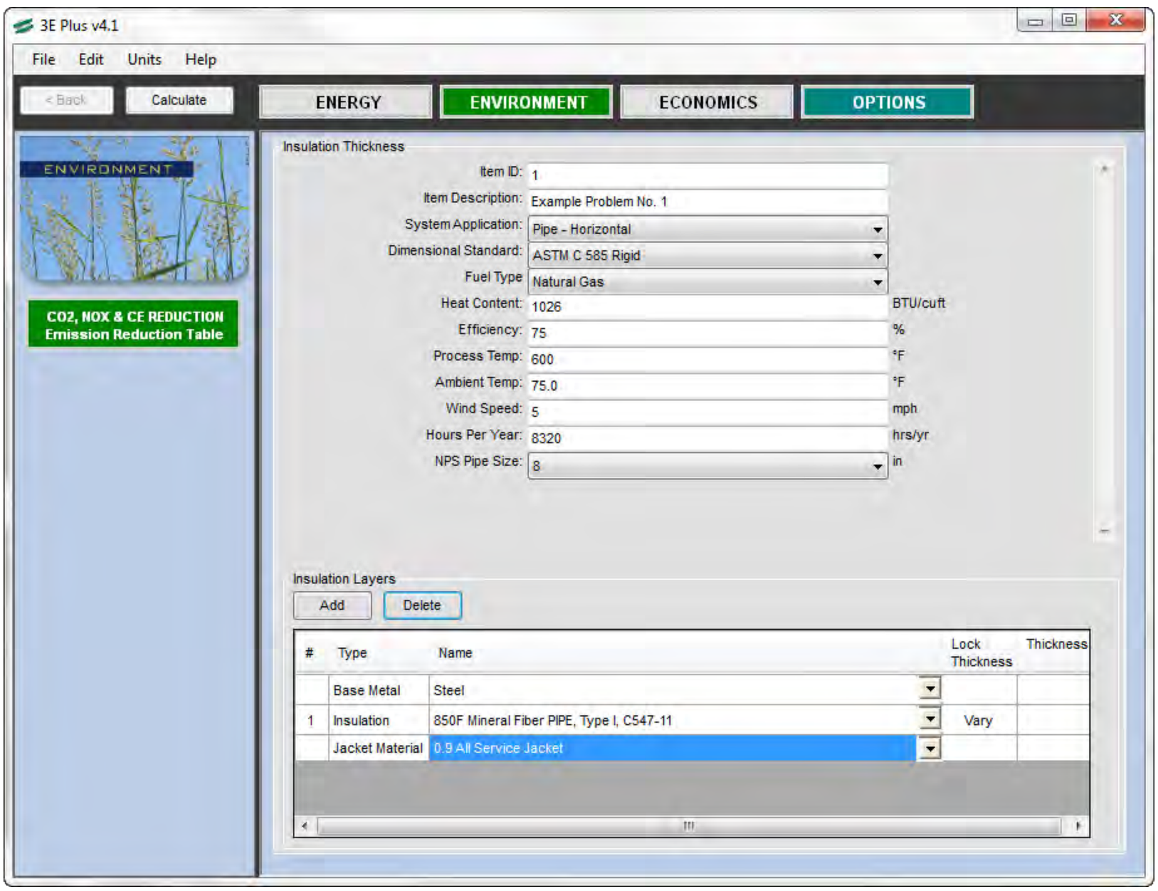

Notice also that all the other units are metric, such as the Surface Temp of 45.5° C and the Heat Loss of 223.70 W/m.

# Chapter 4
# Environmental Calculations

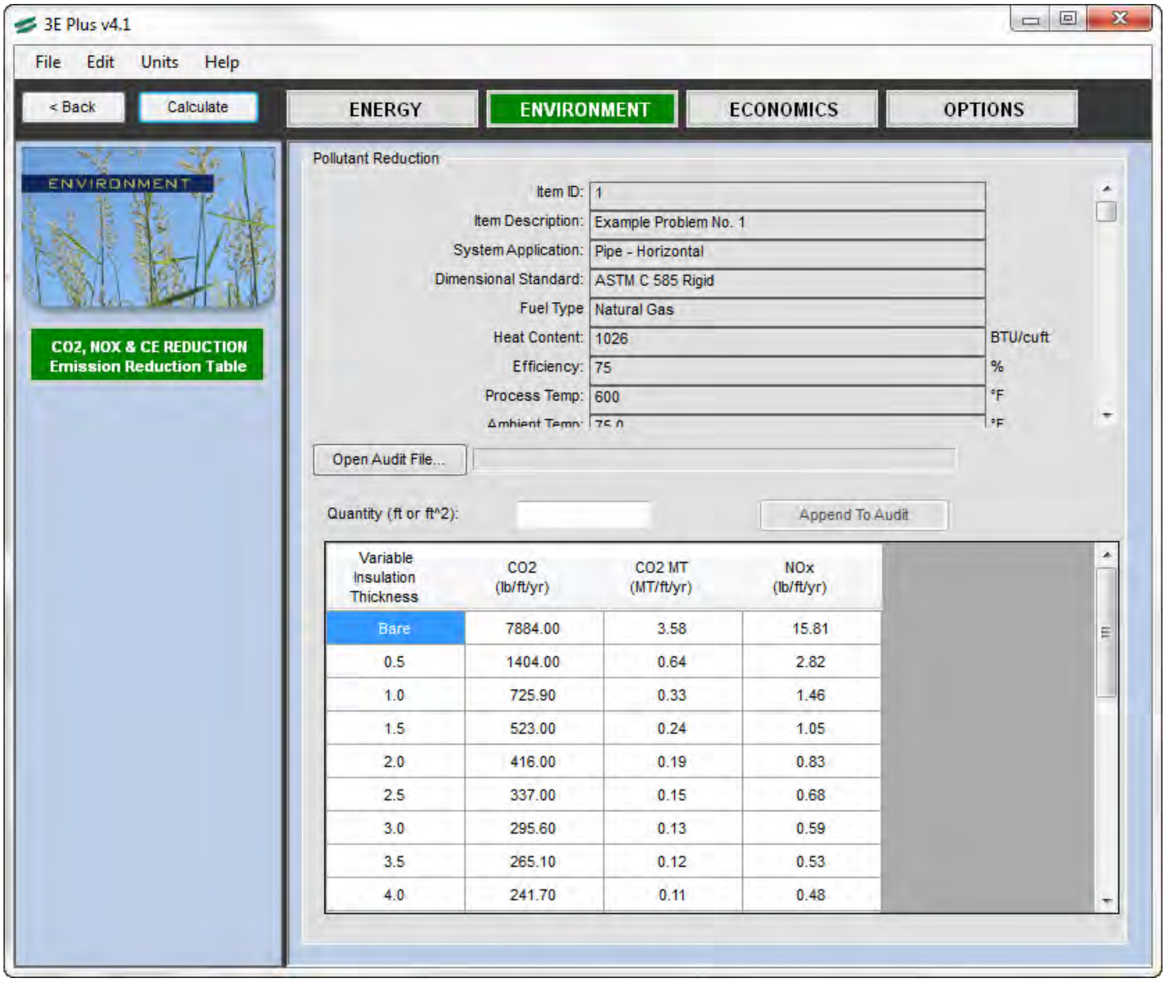
The Environment calculations are accessed by clicking the **ENVIRONMENT** tab of the 3E Plus® **MAIN PAGE**.

## Environmental, Reduction of Emissions Using 1 Layer of Insulation Material - Example Problem No. 1

Click on the button titled **ENVIRONMENT** to generate the screen shown below. Input "Example Problem No. 1" into the **Item Description** box. The inputs for this problem are: Pipe- Horizontal, Fuel type – Natural Gas with heat content of 1026 Btu/cuft at an efficiency of 75%, process temperature - 600°F, ambient temperature 75° F, NPS Pipe Size – 8 inches, Wind Speed – 5 mph and Hours Per Year – 8320. Select steel as the base metal and 850°F Mineral Fiber Pipe, Type 1, C547 with ASJ jacketing as the insulation. Below is the input screen with this data entered:




After the inputs are entered, click the **Calculate** button to generate the Report shown below:




This report gives estimates of the emissions associated with burning fossil fuels to generate the heat lost through the insulation assembly as a function of insulation thickness. Note that in this example, for bare pipe, the Carbon Dioxide ($CO_2$) emissions are estimated at 7,884 lbs/ft/yr. Adding 3.0 inches of 850°F Mineral Fiber PIPE Insulation reduces the $CO_2$ emissions to 295.6 lbs/foot/year, or 0.13 Metric Tonnes/ft/yr. The nitrogen oxides ($NO_x$) emissions at this insulation level are 0.59 lbs/foot/year. Each of these emission estimates could be used to determine the annual expected emission reductions associated with insulation upgrades.

Note that this estimate assumes that the combustion process (and the associated emissions) occurs on-site. The exception is for electricity, where it is assumed that the emissions are generated at the power plant. For electricity, a weighted national average fuel mix is assumed. Emission factors for electricity and for other default fuels may be viewed and/or edited in the **OPTIONS →FUEL TYPES** section of the 3E Plus® program. User defined fuels and pollutants may be added to the fuel library as well.

As would be expected, the greater the insulation thickness, the greater the reduction in polluting gasses. Hence, 4.0 inches will reduce the $CO_2$ emissions to 241.7 lbs/foot/year from 295.6 lbs/foot/year for only 3.0 inches of mineral fiber pipe insulation. The user may generate a printout and/or save these results by clicking on the **File** button on the menu bar.

It is strongly recommended that the files be stored in a job folder. Take care to select a descriptive name so that it may readily accessed in the future. Click on the **Back** button to exit this screen and return to the **Emission Reduction Input** screen. The user may select another set of inputs and repeat the operations above.

# Chapter 5
# Economic Calculations

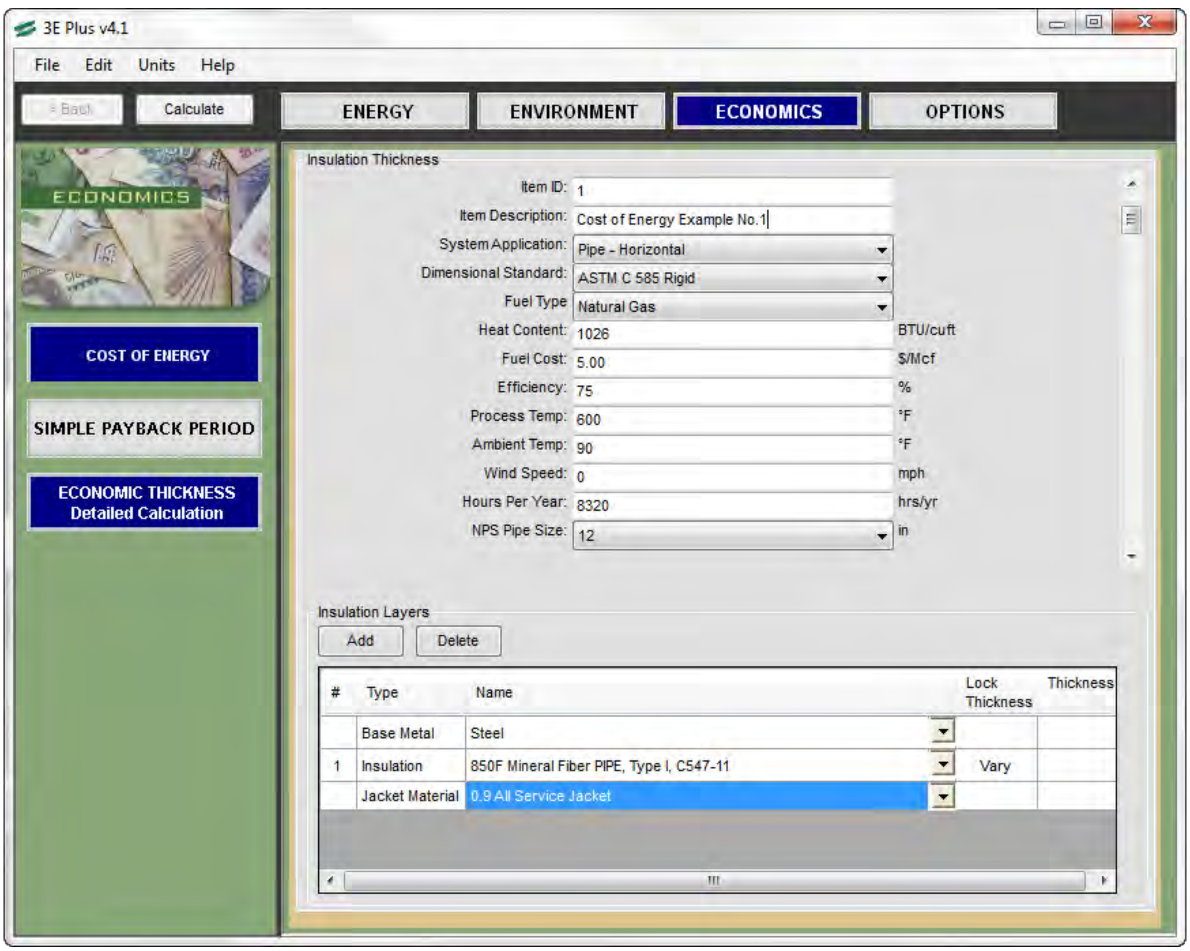
The **ECONOMICS** button on the **MAIN PAGE** allows access to three calculations:

1. Cost of Energy
2. Simple Payback Period
3. Economic Thickness (Detailed Calculation).

# COST OF ENERGY

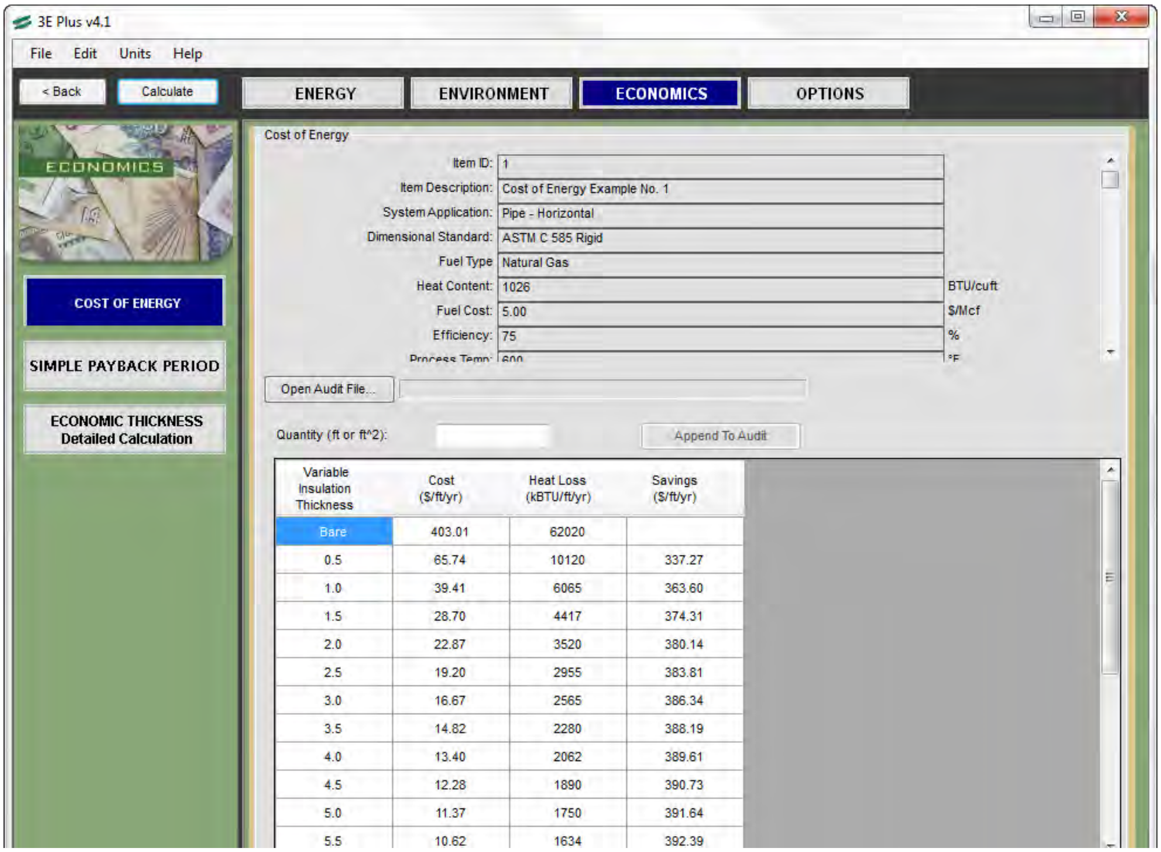
## Cost of Energy Example Problem No. 1

From the Main Menu, first click on **ECONOMICS**. Next, click on the **COST OF ENERGY** button to generate the input screen.



For this example, we have assumed a 12” NPS horizontal steel pipe operating at 600°F and insulated with a single layer of 850°F Mineral Fiber PIPE insulation. The jacketing is 0.9 (emittance) ASJ jacketing. Ambient air temperature is 90°F with 0 mph wind. We have also assumed that heat is supplied via a natural gas-fired boiler operating 8,320 hours per year (95% of the year) at an average efficiency of 75%. Cost of natural gas is assumed to be $5/thousand cubic feet (Mcf).

After clicking on the **Calculate** button, the report screen should look like this:



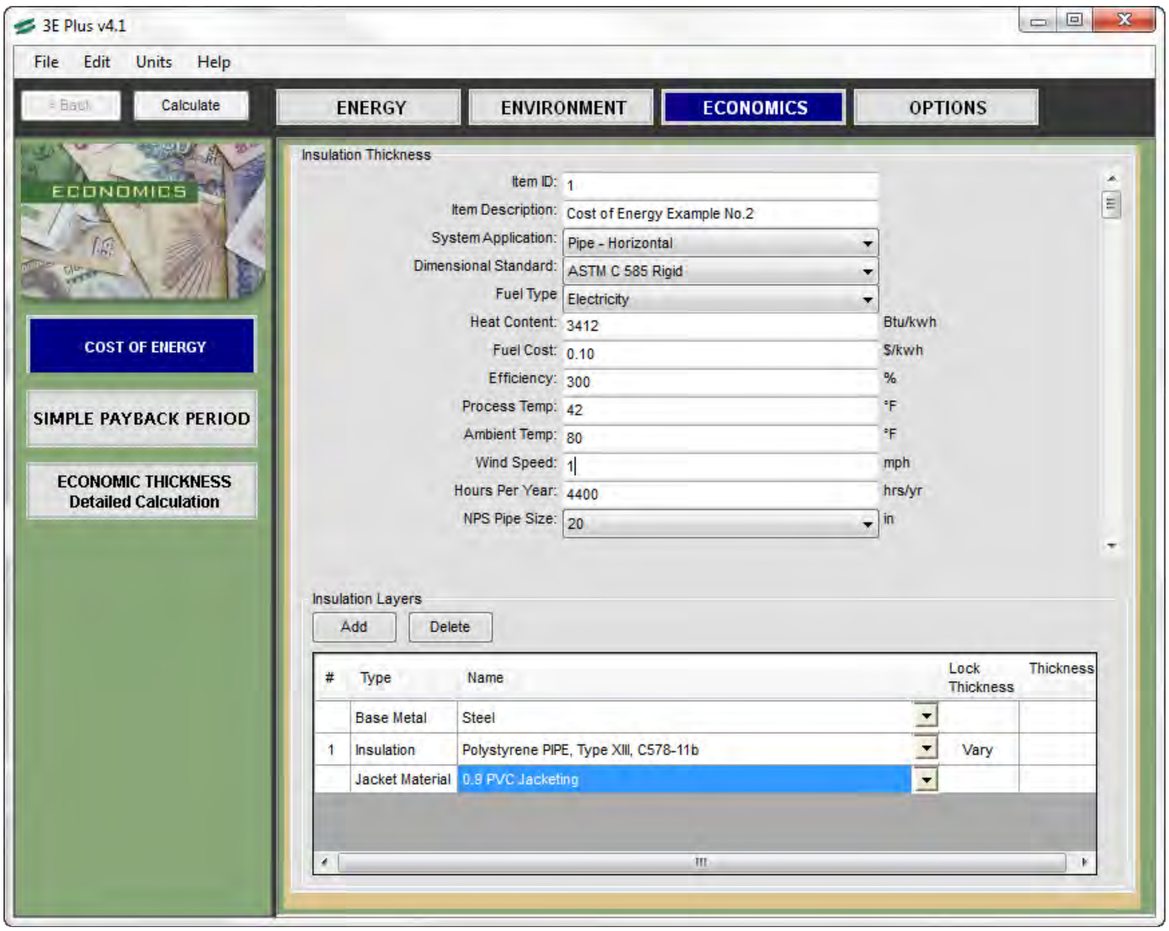

The User will note there is a column labeled “Cost ($/ft/yr)” which is the operating cost per foot of pipe length per year. The next column is labeled “Heat Loss (kBtu/ft/yr)” which is the annual heat loss per foot of pipe length in thousands of Btu/ft/yr. The third column is the labeled “Savings ($/ft/yr)” which is the annual savings in operating cost relative to the Bare case. For the Bare case, there is no savings since that is the reference case. At 3 inches of insulation, there is a savings of $386.34/ft/yr, which is the difference in operating cost between the 3” thickness and the bare case ($403.01-16.67 = $386.34).

Note that this cost of energy calculation assumes that all of the heat lost through the insulation system must be replaced by the energy source (in this example, the natural gas-fired boiler). In some applications, the heat loss through the insulation system may be beneficial (e.g. consider a hot water distribution system within a building during the heating season). In other situations, additional energy costs may need to be expended to remove the lost heat (e.g. a hot water distribution system within a building during the cooling season). In these situations, the calculated results will need to be adjusted accordingly.

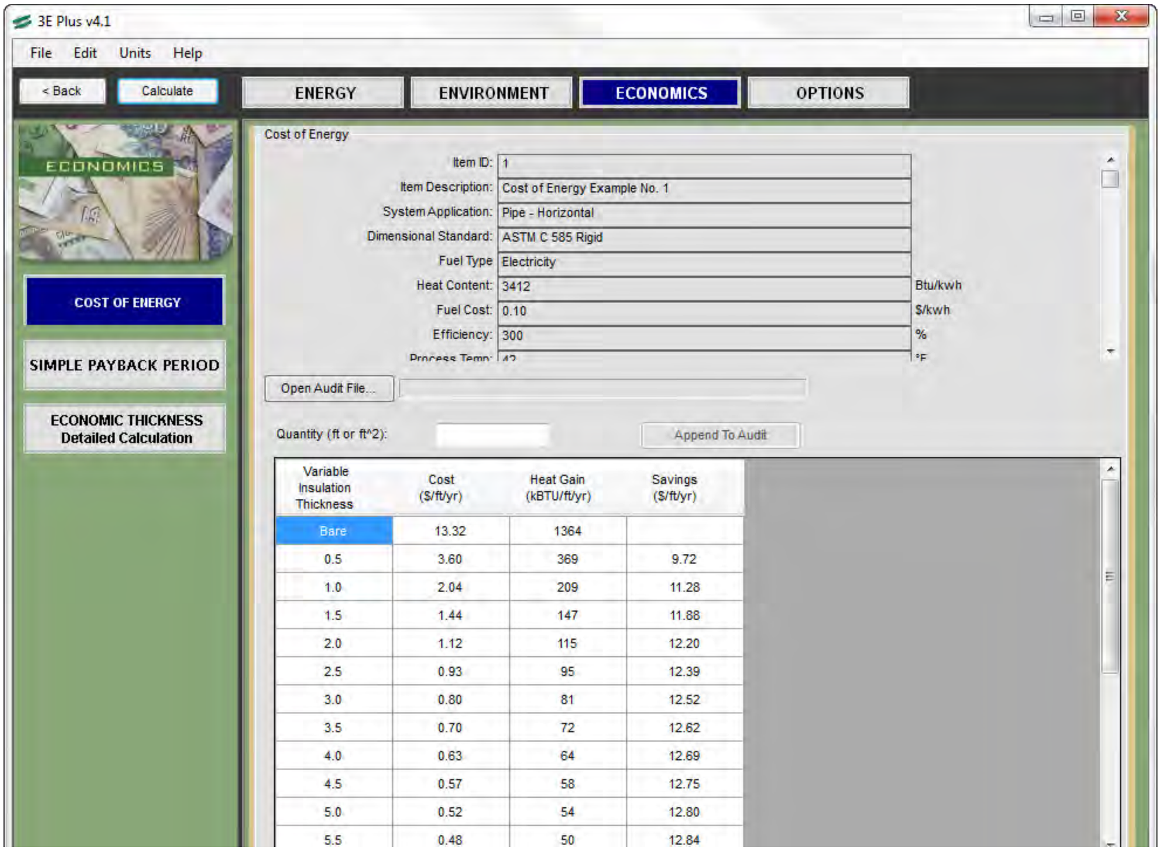
# Cost of Energy Example Problem No. 2

For this example, we will use the **COST OF ENERGY** calculation to estimate the savings associated with insulating chilled water distribution piping for a cooling system.

Assume a 20" NPS horizontal steel pipe operating at 42°F insulated with a single layer of Polystyrene PIPE insulation (Type IV, C578) and covered with PVC jacketing. Ambient conditions are 80°F air with 1 mph wind. We will also assume that heat gain to the piping system is removed by an electric-driven chiller operating 4,400 hours per year at an average coefficient of performance (COP) of 3.0 (or an efficiency of 300%). Average cost of electricity is assumed to be $0.10/kWh.
Using these assumptions the input screen will look like this:



Click the **Calculate** button, and the report screen should look like the following:




| Variable Insulation Thickness | Cost ($/ft/yr) | Heat Gain (kBTU/ft/yr) | Savings ($/ft/yr) |
|---|---|---|---|
| Bare | 13.32 | 1364 | |
| 0.5 | 3.60 | 369 | 9.72 |
| 1.0 | 2.04 | 209 | 11.28 |
| 1.5 | 1.44 | 147 | 11.88 |
| 2.0 | 1.12 | 115 | 12.20 |
| 2.5 | 0.93 | 95 | 12.39 |
| 3.0 | 0.80 | 81 | 12.52 |
| 3.5 | 0.70 | 72 | 12.62 |
| 4.0 | 0.63 | 64 | 12.69 |
| 4.5 | 0.57 | 58 | 12.75 |
| 5.0 | 0.52 | 54 | 12.80 |
| 5.5 | 0.48 | 50 | 12.84 |

Note that the column headings are similar to Example 1, except that the "Heat Loss" column is now labeled "Heat Gain" to reflect the direction of heat flow. In this example, insulating with 3" of Polystyrene insulation saves approximately $12.52/ft/yr relative to the bare (uninsulated) case.

# SIMPLE PAYBACK PERIOD

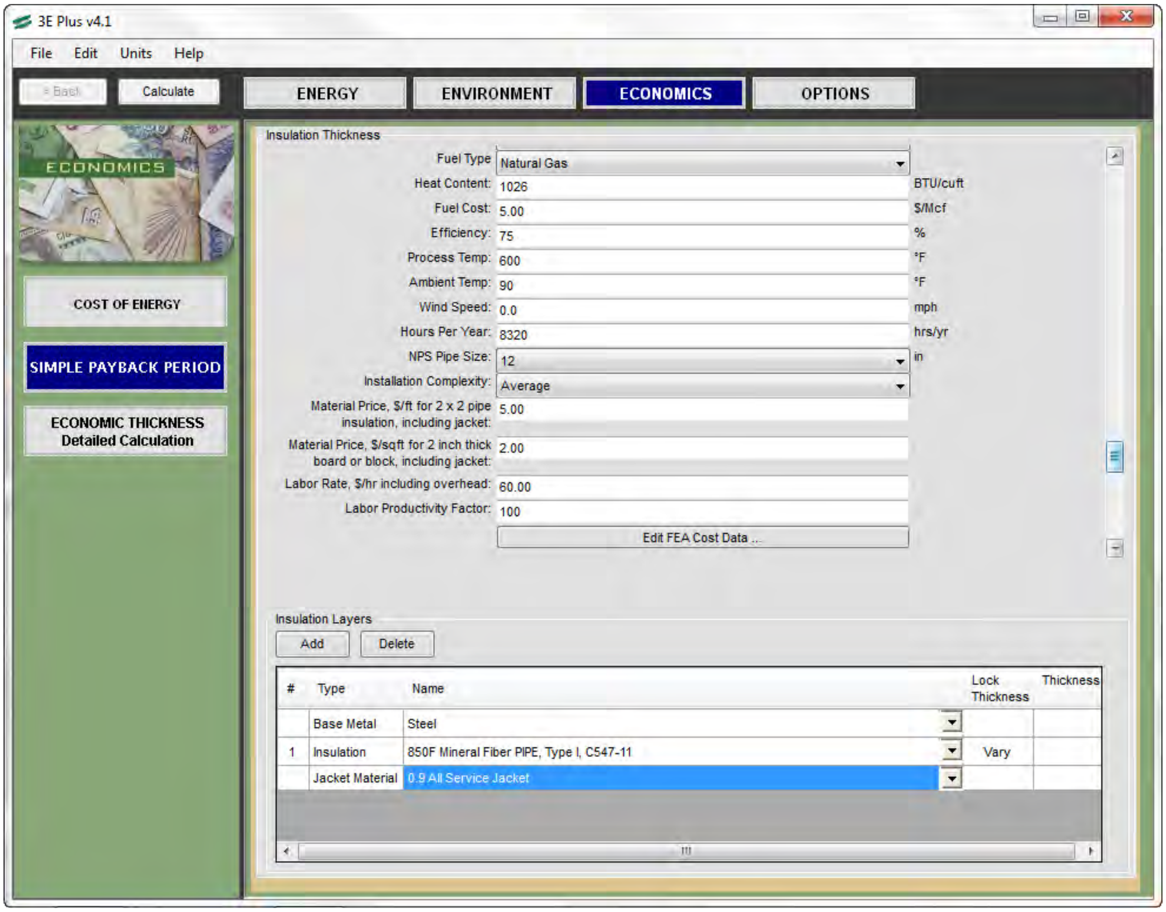
## Simple Payback Period Example Problem No. 3

From the Main Menu, first click on **ECONOMICS**. Next, click on the **SIMPLE PAYBACK PERIOD** button to generate the input screen.

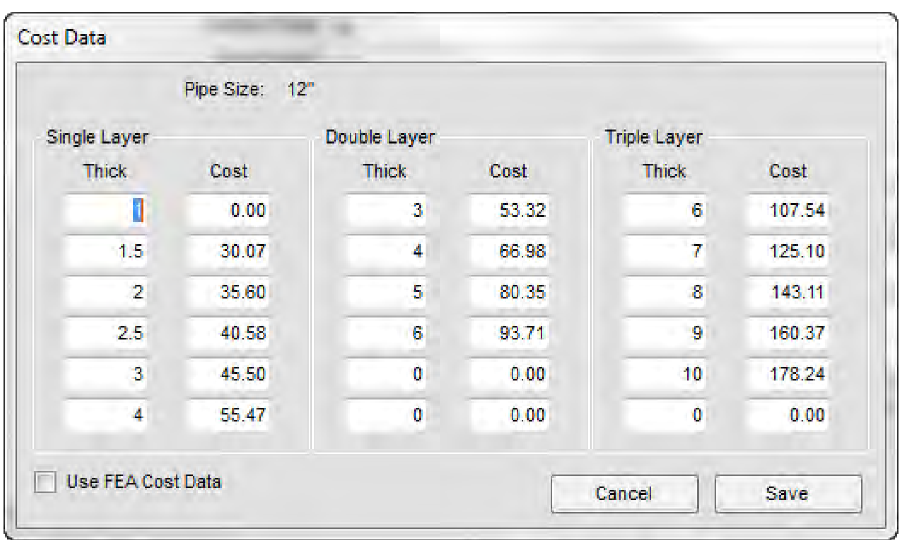
The simple payback period calculation is very similar to the Cost of Energy Calculation except that the installed cost of insulation systems is included. Simple Payback Period is defined as the installed cost of a project ($) divided by the annual savings ($/yr).

Installed costs are highly variable and dependent on the location of the job, project size and complexity, local labor rates and productivity, and market conditions. The 3E Plus® program contains an algorithm to estimate installed costs for a number of insulation materials. These algorithms were originally developed under a contract from the Federal Energy Administration (FEA), Office of Industrial Programs. However, these algorithms are intended as a guide. Users should supply their own estimates for installed costs if available.

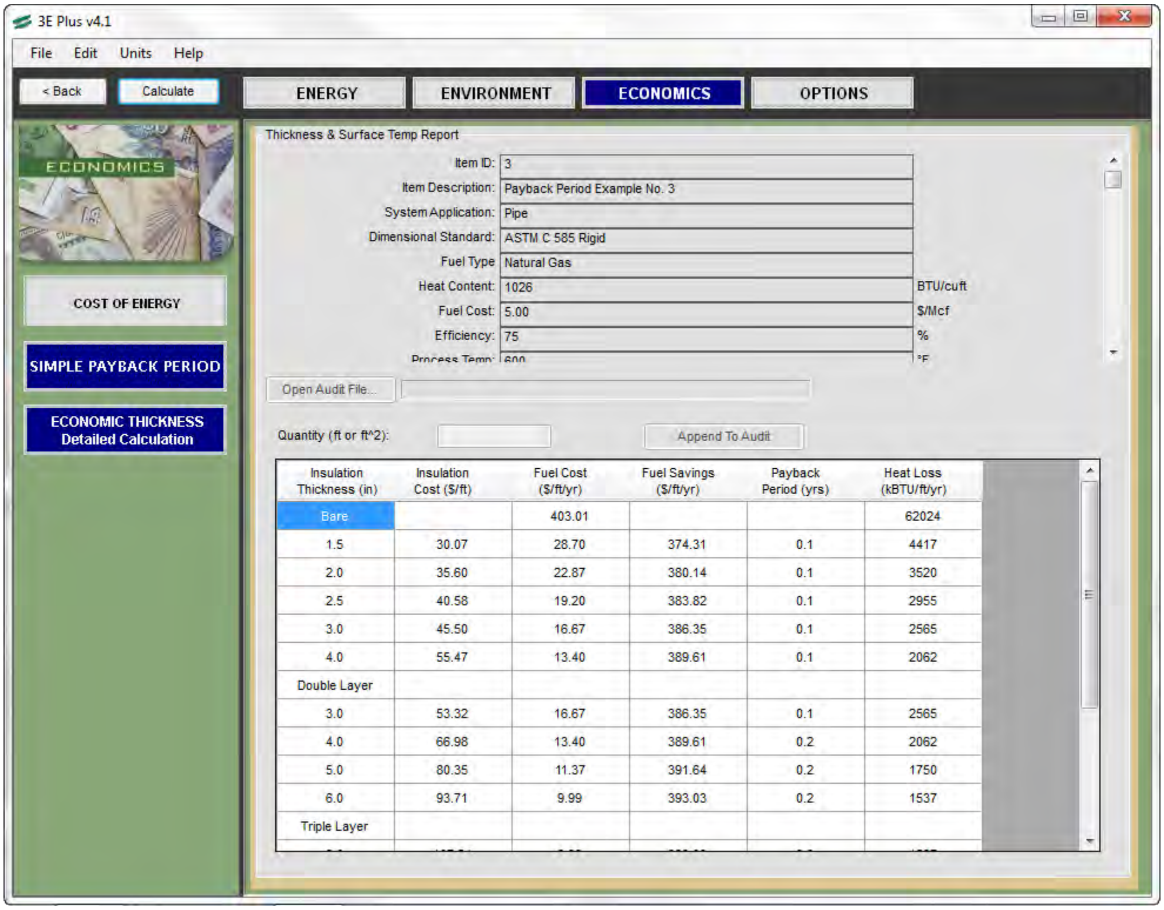
For Example 3, we will assume the same input information as for Example 1 (12" NPS pipe at 600F, 90F ambient with 0 mph wind, natural gas-fired boiler operating 8,320 hours per year at 75% efficiency). The input screen is shown below. Note that the input screen has been scrolled down to reveal some new input fields for supplying the information needed to estimate installed cost. **Installation Complexity** (complex, average, simple, or very simple) addresses the labor and material cost implications of installation complexity. **Material Price** is the cost (including contractor markup) of insulation material. Labor Rate ($/hr) includes the base labor rate, fringe benefits, per diem and travel expenses, and contractor markup. **Local Productivity Factor** is a multiplier on labor costs to reflect the variation in worker productivity, in percent (100 is average, 120 multiplies labor cost/foot by a factor 1.2).




Note that clicking on the **Edit FEA Cost Data** button generates the Cost Data box shown below. This box allows users to preview and/or edit the installation costs calculated by the FEA cost model if desired. The FEA Model generates cost estimates for single layer, double layer, and triple layer installations. Note that for this example, the FEA Model estimate for 2 inches of insulation on a 12" NPS pipe is $35.60/ft. Also note that 1inch thickness displays as $0.00/ft, which indicates that an estimate for this thickness is not available for this pipe size. The user may edit the displayed data if desired.



If the user is satisfied with the installed cost data, clicking on save closes the Cost Data box and returns the user to the input screen. Clicking the calculate button generates the report shown below:



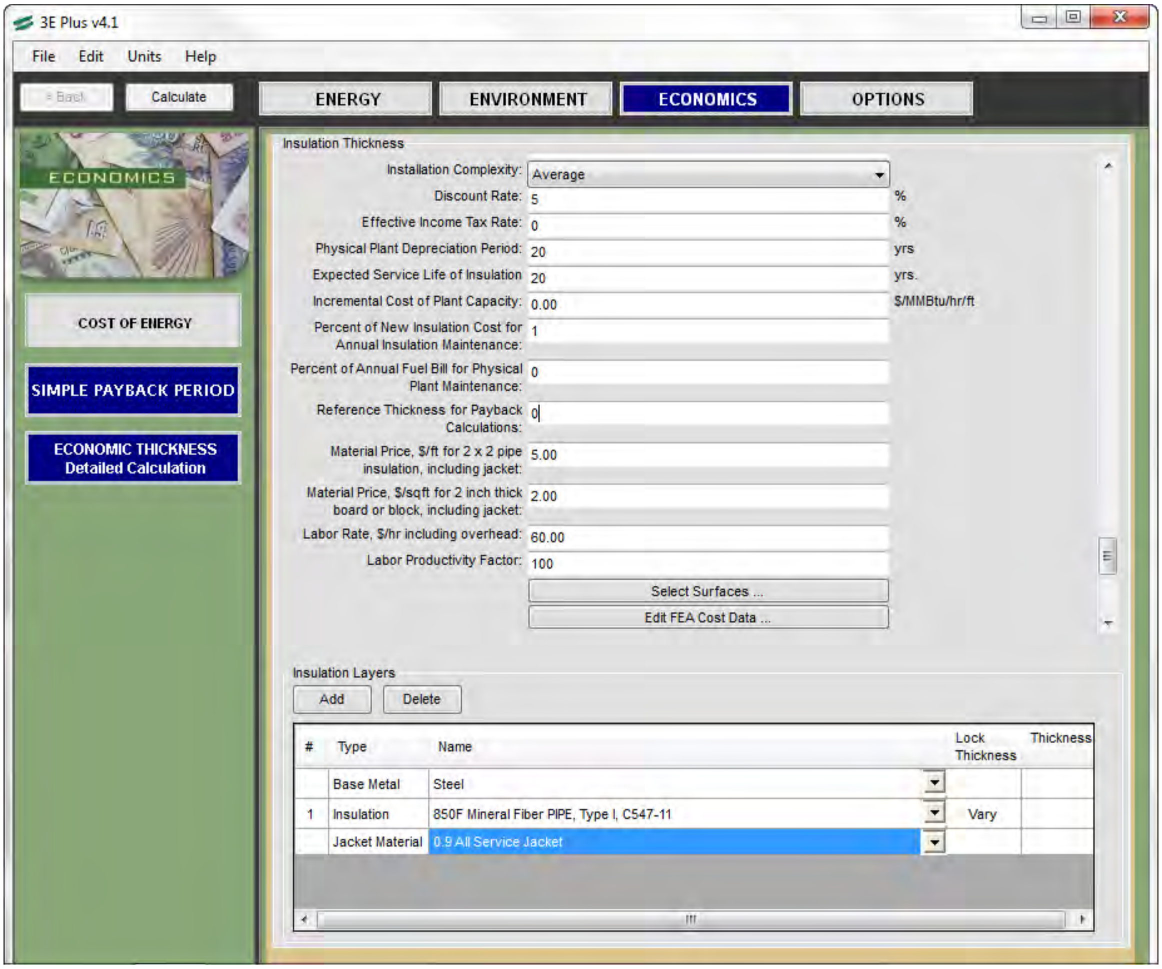

Note that the report contains columns for Installed Insulation Cost ($/ft), Fuel Cost ($/ft/yr), Fuel Savings ($/ft/yr) relative to bare pipe, Payback Period (yrs) relative to bare pipe, and Heat Loss (kBtu/ft/yr).

# ECONOMIC THICKNESS

## Economic Thickness Calculation Example Problem No. 4

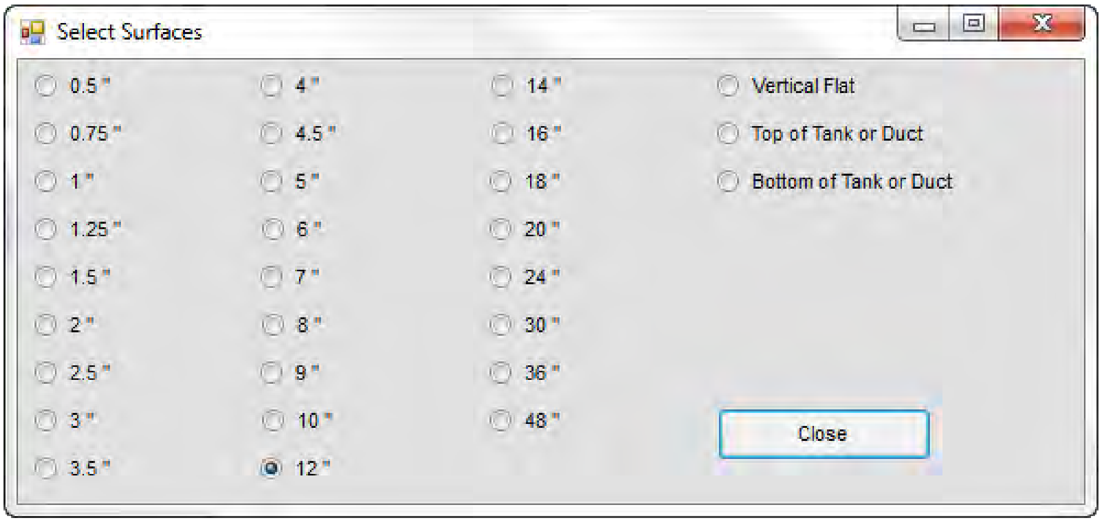
From the Main Menu, first click on **ECONOMICS**. Next, click on the **ECONOMIC THICKNESS Detailed Calculation** button to generate the input screen.

The **ECONOMIC THICKNESS** calculation attempts to identify the insulation thickness that minimizes the annualized cost of an installation considering the installed insulation cost, the economic life of the project, the annual cost of fuel, the fuel escalation rate, estimated cost of insulation maintenance, estimated income tax rates, and the time value of money. Additional input information is required and is viewed by using the scroll bar at the right side of the screen. For this example, we'll use the same basic input as Example Problem 3. Additional input information required is shown on the lower portion of the input screen as illustrated below:

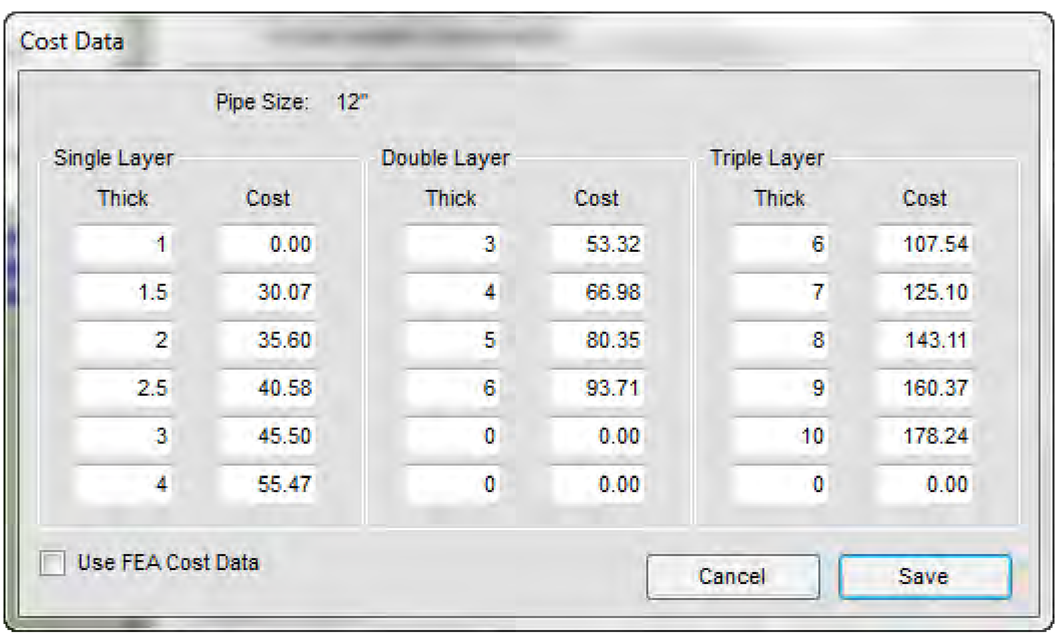



For this example, we have assumed a **Annual Fuel Escalation Rate** of 0%/yr, a **Discount Rate** of 5%, an **Effective Income Tax Rate** of 0%, an economic life of 20 years (for both the insulation and the physical plant), an **Incremental Cost of Plant Capacity** of $0/Million Btu/ft of pipe, **Annual Insulation Maintenance Cost** of 1% of the new insulation cost, and a **Physical Plant Maintenance Cost** of 0% of the annual fuel bill.

Click on the **Select Surfaces** button to select the pipe size of interest. For this example, we have selected 12” NPS. The program will also analyze Vertical Flat, Top of Tank or Duct, or Bottom of Tank or Duct.




As before, we can use the FEA Model to estimate costs by clicking on the **Edit FEA Cost** Data button. This brings up the Cost Data box as shown below. Note that the costs are the same as for Example 3.



Clicking on the **Calculate** button generates a report that reprints the input information and presents the following results:

| Insulation Thickness | Insulation Cost | Annualized Cost | Payback Period | Heat Loss | Surface Temp |
|---|---|---|---|---|---|
| Inches | $/ft | $/ft | Years | BTU/hr/ft | °F |
| 1.5 | 30.07 | 31.41 | 0.10 | 531 | 153 |
| 2.0 | 35.60 | 26.08 | 0.10 | 423 | 140 |
| 2.5 | 40.58 | 22.86 | 0.11 | 355 | 131 |
| 3.0 | 45.50 | 20.77 | 0.12 | 308 | 125 |
| 4.0 | 55.47 | 18.40 | 0.15 | 248 | 116 |
| Double Layer | | | | | |
| 3.0 | 53.32 | 21.48 | 0.14 | 308 | 125 |
| 4.0 | 66.98 | 19.44 | 0.18 | 248 | 116 |
| 5.0 | 80.35 | 18.62 | 0.21 | 210 | 111 |
| 6.0 | 93.71 | 18.44 | 0.25 | 185 | 108 |
| Triple Layer | | | | | |
| 6.0 | 107.54 | 19.69 | 0.28 | 185 | 108 |
| 7.0 | 125.10 | 20.27 | 0.33 | 166 | 105 |
| 8.0 | 143.11 | 21.12 | 0.38 | 152 | 103 |
| 9.0 | 160.37 | 22.07 | 0.42 | 141 | 101 |
| 10.0 | 178.24 | 23.19 | 0.47 | 131 | 100 |

The Economic Thickness is single layer 4.00 inches.

Annualized costs are presented in the third column. These annualized costs are the sum of the installed insulation costs, fuel costs, and maintenance costs, all spread over the assumed economic life of the project. The minimum annualized cost for this example is $18.40/ft/yr and occurs at a thickness of 4 inches (single layer).

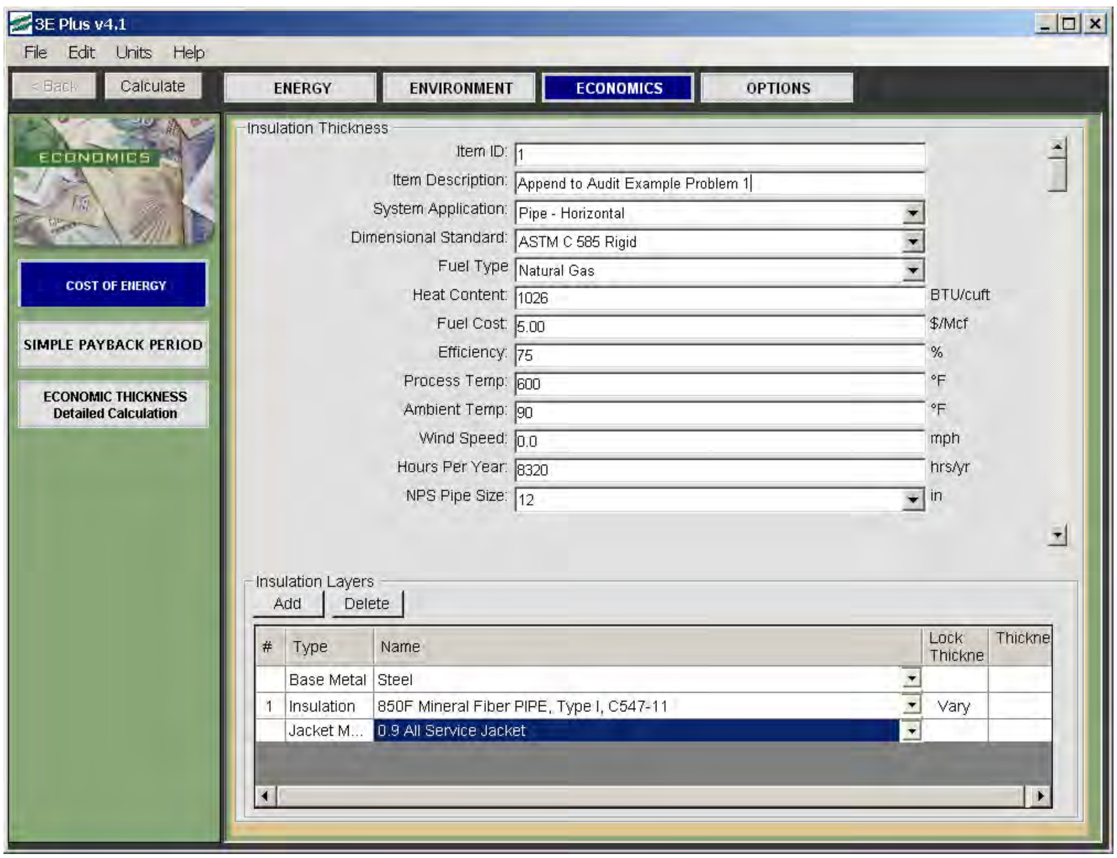
Payback period (relative to the bare case), Heat Loss (Btu/h/ft), and Surface Temperature (°F) are given for each thickness as well. Note that the Payback Period here includes all costs and is not the same as the Simple Payback Period from Example 3.

# Chapter 6
# Handling Audit Data

3E Plus® is often used to perform energy audits of insulation systems. These audits or appraisals are sometimes extensive and may involve the analysis of hundreds or thousands of individual items. To assist users in analysis and reporting of audit results, 3E Plus® includes the capability to output the results of the analysis of individual items to an audit file (either a Microsoft Excel® spreadsheet or a tab-delimited text file). Each item analyzed may be added as a new line item to the audit file. This capability is intended to reduce the time-consuming task of transferring data from the 3E Plus® program to other programs for analysis and to reduce the possibility of errors when manually transferring data.

## Append to Audit Example Problem No. 1- Excel® Installed

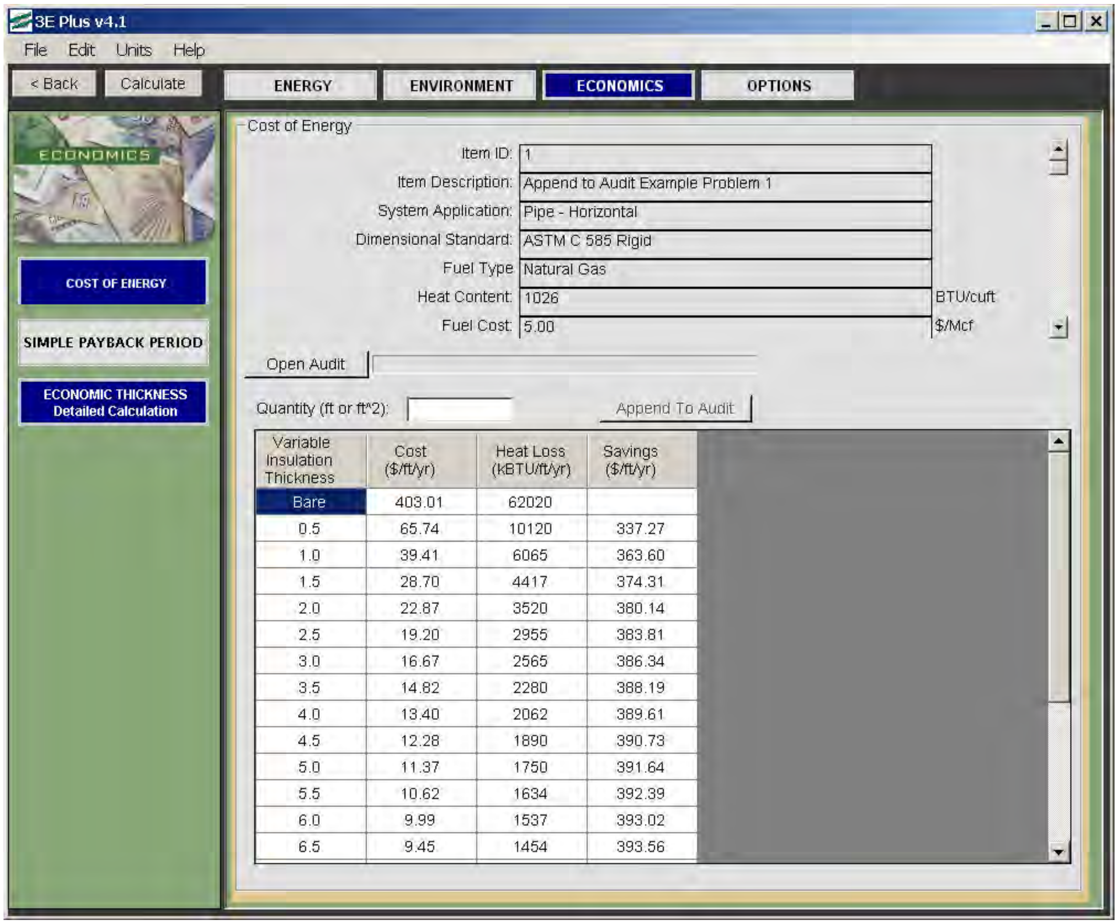
From the Main Menu, click **ECONOMICS**, then **COST OF ENERGY** to generate the input screen shown below:




This example uses same input information as Example Problem 1 from Chapter 5 (12” NPS horizontal pipe operating at 600°F, insulated with 850°F Mineral Fiber Pipe Insulation with ASJ jacketing, ambient temperature of 90°F with 0 mph wind speed, a natural gas-fired boiler at 75% efficiency, and cost of gas at $5/Mcf).

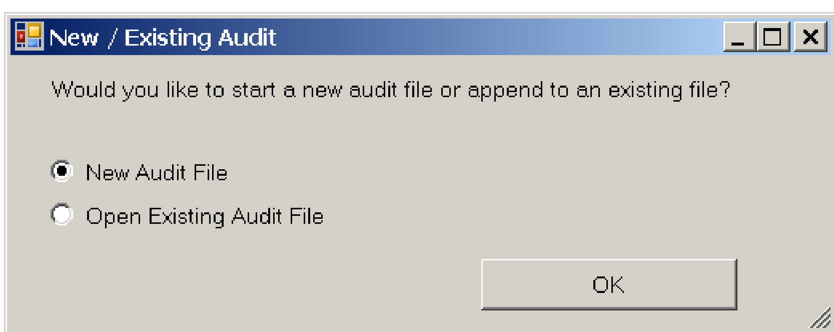
For the purposes of this example, it is assumed that the item is a 25 foot length of pipe with missing insulation that has been identified as a part of the energy audit. It is proposed to install insulation on this pipe to reduce both energy costs and $CO_2$ emissions.

Clicking **Calculate** displays the report screen:



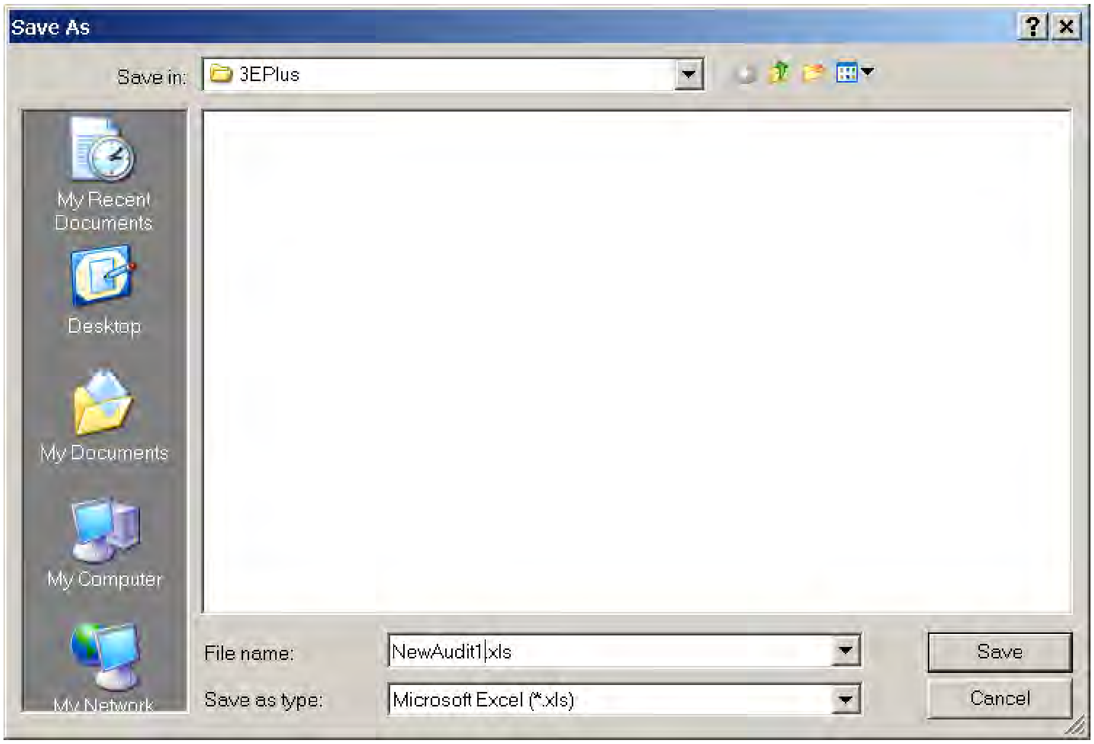

The auditor is proposing to insulate this line with 3” of insulation. As seen in the report screen, it is estimated that 3” will save approximately $386.34/ft/yr in fuel costs relative to the bare case.

To append this data to an audit file, we must first specify the file. Click on the **Open Audit** button to show the New/Existing Audit dialog box:

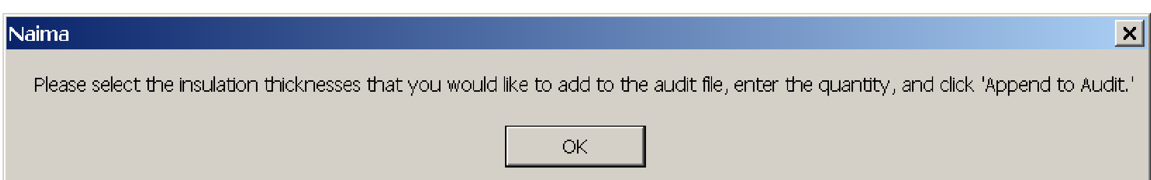



Since this is the first item in the audit, we will assume that the user wishes to define a **New Audit File**

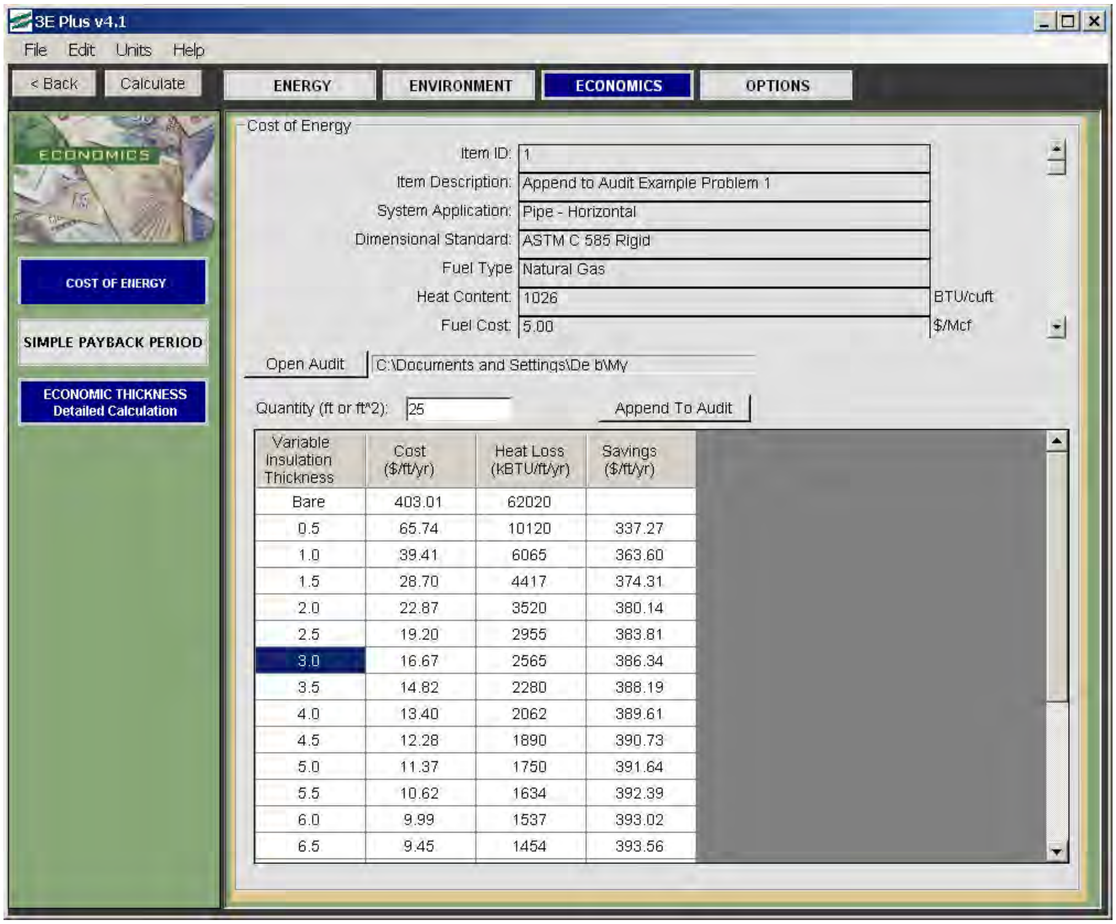
Clicking **OK** displays the Save As dialog box. (Note that selecting **Open Existing Audit File** would bring up the **Open** dialog box to allow users to select the existing file desired).



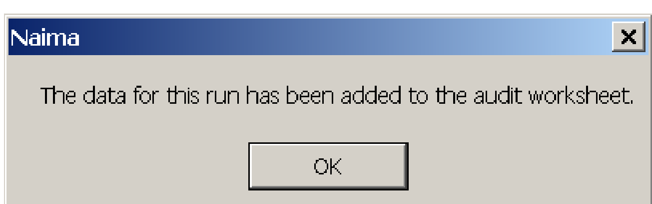

Choose a descriptive file name and location where you want this audit file to reside. Here we have elected to name the file **NewAudit1** and save it in the 3EPlus® folder. Clicking **Save** generates the following message:



This prompts the user to identify the thickness of interest (in this example, 3 inches). Clicking OK allows us to highlight 3.0 in the thickness column, as well as to enter 25 in the field labeled **Quantity (ft or ft$^2$)**.




At this point, click on the **Append To Audit** button to place the selected data into the opened Excel® file.
This action displays the following message to indicate that the identified data has been transferred to the audit file:




The user may repeat the process for as many items as desired, keeping in mind that each time the **Append To Audit** button is clicked; a new row is added to the Excel® spreadsheet.

Switch to the open the Microsoft Excel® window from the task bar (or open it from the folder if you saved it; the default location is \My Documents\3EPlus). Row 1 is a header row populated with column labels. The data for Item Number 1 has been entered in Row 2 immediately below the header row.

Columns A through O of the spreadsheet simply repeat the input information which was used by 3E Plus® for this item. Column P is the Quantity value input in the Append to Audit process (25 ft for this example)

| | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ID | Descriptio | Fuel | Base Meta | Insulation | Jacket | Geometry | Fuel Efficie | Hours Per | BTU | Fuel Cost | Process Te | Ambient T | Wind Spee | Pipe Size | Insulation |
| 2 | 1 | Append to | Natural Ga | Steel | 850F Mine | All Service | Pipe - Hori | 75 | 8320 | 1026 | 5 | 600 | 90 | 0 | 12 | 25 |

Columns Q through Z are the results of the 3E Plus® calculation with the inventoried case listed first (Columns Q through U) followed by the Upgraded case next (columns V through Z). For each case, heat loss, operating cost, $CO_2$ emissions, and $NO_x$ emissions are reported. In this example, the inventoried case is Bare and the upgraded case is 3 inches.

| Q | R | S | T | U | V | W | X | Y | Z | AA |
|---|---|---|---|---|---|---|---|---|---|---|
| Inventorie | Heat Loss | Cost Inven | CO2 Inven | NOx Inven | Upgraded | Heat Loss | Cost Upgra | CO2 Upgra | NOx Upgraded | |
| Bare | 62020 | 403.01 | 9636.255 | 19.32791 | 3 | 2565 | 16.67 | 398.5326 | 0.799357 | |

The user can minimize the audit spreadsheet, analyze another item using 3E Plus®, and append that item to the audit file in a like manner. The new item will be added below the first item as shown below:

| | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ID | Descriptio | Fuel | Base Meta | Insulation | Jacket | Geometry | Fuel Efficie | Hours Per | BTU | Fuel Cost | Process Te | Ambient T | Wind Spee | Pipe Size | Insulation |
| 2 | 1 | Append to | Natural Ga | Steel | 850F Mine | All Service | Pipe - Hori | 75 | 8320 | 1026 | 5 | 600 | 90 | 0 | 12 | 25 |
| 3 | 2 | Append to | Natural Ga | Steel | 850F Mine | All Service | Pipe - Hori | 75 | 8320 | 1026 | 5 | 600 | 90 | 0 | 8 | 12 |
| 4 | | | | | | | | | | | | | | | | |

For item 2, all of the input items were the same except the pipe size was 8"NPS and the length of run was 12 feet.

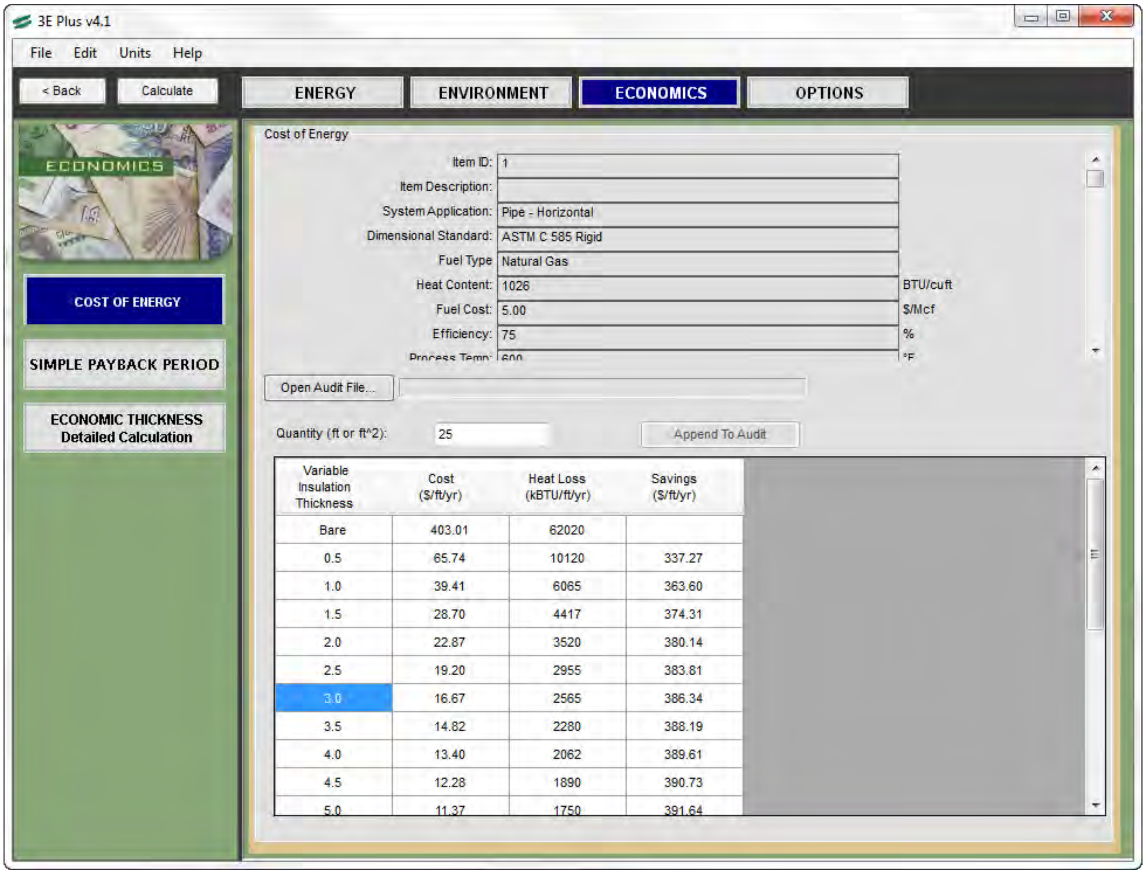
The user can repeat this process to build an audit file containing all of the items identified during the audit or appraisal. The Excel® audit file may be modified to include additional information (e.g. installed cost estimates), analyze results, or generate reports as desired.

For users that have the NIA Insulation Energy Appraisal Program spreadsheets, the data columns are arranged in the exact order as the spreadsheets, which makes it easy to copy and paste the data from the "audit" file into the NIA spreadsheet.

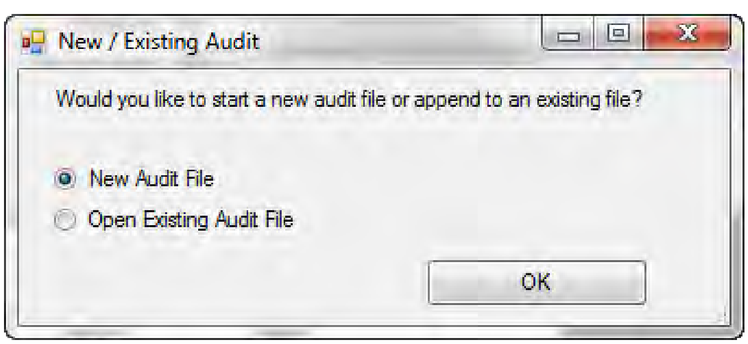
1. **Copy** the data in columns A through Z with as many rows as desired.
2. Switch to the NIA spreadsheet and select columns A through Z and the same number of rows as copied.
3. Right click to display the paste options, and select the "**paste values**" option. This will copy the data from the audit file into the NIA spreadsheet and retain the formatting in the NIA spreadsheet.

# Append to Audit Example Problem No. 2- Excel® Not Installed

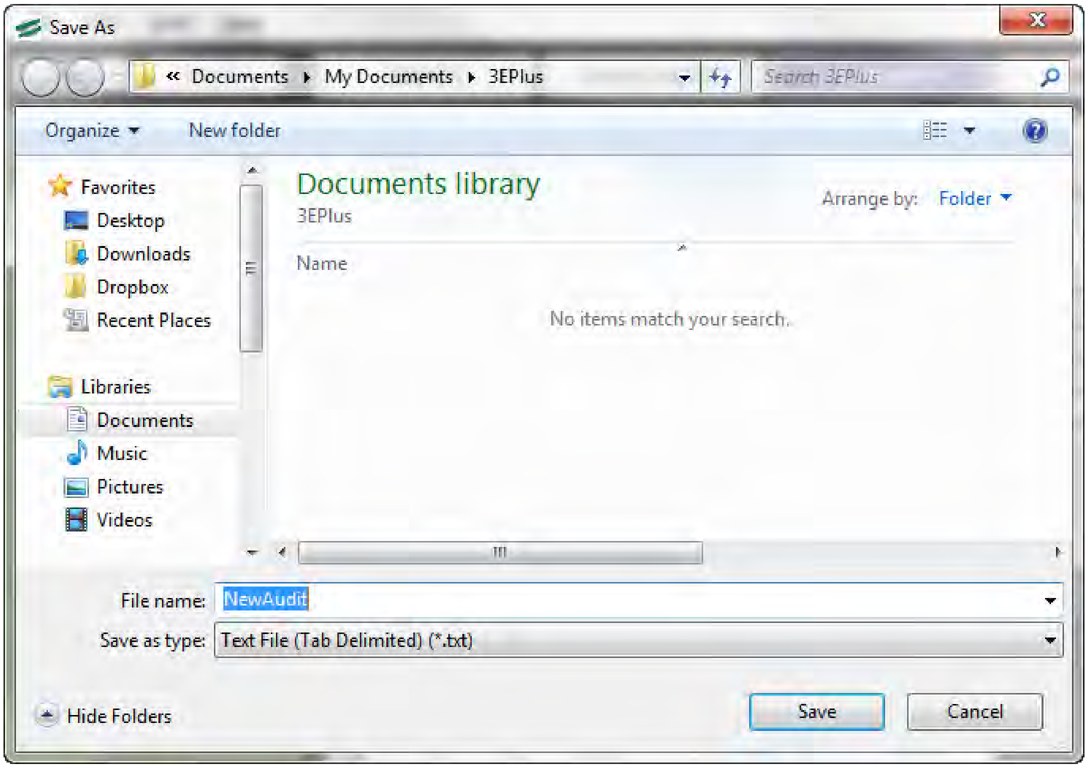
If the user does not have Microsoft Excel® installed, the Append to Audit function will append results to a tab-delimited text file. The process is the same as demonstrated in Example 1 (the report screen is reproduced below with the Quantity input and 3” thickness selected).



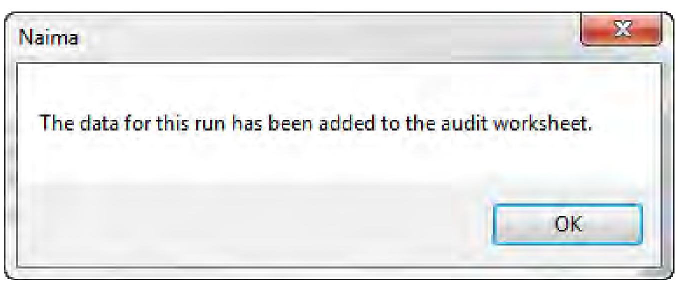

Clicking on the **Open Audit** button brings up the New/Existing Audit dialog box.



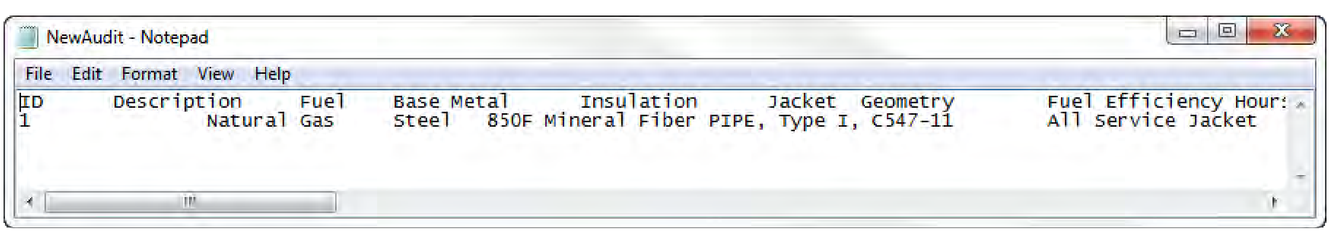
As before, selecting New Audit File and clicking OK generates the Save As dialog box. Since Excel® is not available; the audit file will be a text file with the file extension .txt. The user is asked to name the file (we will accept the default name **NewAudit** in this example) and specify a location.




Clicking **Save**, then Clicking **Append to Audit** produces the notice indicating that the data for that item has been added to the audit file.




Opening the file NewAudit.txt using Notebook (or any text editor) reveals the following:




The user can repeat this process to build an audit file containing all of the items identified during the audit or appraisal. This text file is tab-delimited and may be imported into many spreadsheet or database programs to analyze or report results as desired.