



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



**User Guide** 



- 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



# **3E Plus**<sup>®</sup>

### 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<sup>®</sup> 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<sup>®</sup>, please follow the directions in the *Uninstalling 3E Plus*<sup>®</sup> 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<sup>®</sup> V4.1 and can be downloaded from this Website: <u>www.pipeinsulation.org</u>. 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 <u>www.pipeinsulation.org</u> on the Internet.
- 2. Click on the button **Download Free Software Now** to navigate to the registration page

#### Download Free Software Now! Program software can be downloaded for FREE from this site

- 3. Follow the instructions to register (or re-register) the program
- 4. When registration is complete, you will be directed to the **3E Plus<sup>®</sup> 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

Do you	want to open or save this file?
Ł	Name: 3EPlus_V4,1_Installer_8-22-12.zi_ Type: Compressed (zipped) Folder, 2.13MB From: mail-attachment.googleusercontent.com
~	While files from the Internet can be useful, some files can potentia

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

Organize 🔻 New fo	der	II 👻 🔞
🛠 Favorites	Documents library BEPlus	Arrange by: Folder 🔻
Downloads Dropbox	Name No items match your	search.
📜 Libraries		
Documents  Music  Pictures  Videos		
-	· · ·	
File name: BER	lus-V4.1-Installer7-2-12	T-
Save as type: Cor	npressed (zipped) Folder	

- 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):

Organize 🔻 Extract all	files							
🔆 Favorites	Name	Туре	Compressed size	Password	Size	Ratio	Date modified	
🧮 Desktop	🔀 3EPlus V4.1 Installer	Windows Installer Package	1,998 KB	No	2,297 KB	14%	7/2/2012 9:50 PM	
🚺 Downloads	💷 setup	Application	193 KB	No	418 KB	54%	7/2/2012 9:50 PM	
퉬 Dropbox								
📃 Recent Places								

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:

blisher cou software?	ld not be verified. Are you sure you want to
Name:	Temp3_3EPlus-V4.1-Installer7-2-12.zip\setup.exe
Publisher:	Unknown Publisher
Type:	Application
From:	C:\Users\Ch\AppData\Local\Temp\Temp3_3EPlus
	Run Cancel
 -	

- 11. Click **Run** to initiate the Setup Wizard
- 12. Follow the Instructions in the Setup Wizard to Install 3E Plus<sup>®</sup> V4.1
- 13. When the Installation has completed, you will see the following:

闄 3EPlus V4.1	
Installation Complete	5
3EPlus V4.1 has been successfully installed.	
Click "Close" to exit.	
Please use Windows Update to check for any critical updates to the .NET Fra	amework.
Cancel Báck	Close

- 14. Click Close to complete the installation.
- 15. The **3E Plusv41** program should now appear on your **Programs Menu**
- 16. Start the 3E Plus<sup>®</sup> program by clicking **Start >> Programs >> 3E Plusv41**

17. On initial startup, a registration box will appear

change the functionality. You will be re must wait ten seconds to proceed. To	tware. While failing to registering will not minded each time you use the software and register, please send your email address to your access code, simply enter your email
Access Code:	1

- 18. The access code is **3EPlus4.1** (case sensitive no spaces). Enter the Access Code and left click on "**OK**".
- 19. The 3E Plus<sup>®</sup> program will then start with a disclaimer page.

Disclaimer	
DISCLAIMER OF WARRANTY	
No warranties. The software product is provided as is without warranty of any kind.	
To the maximum extent permitted by applicable law, NAIMA and its members disclaim all warranties, either express or implied, including, but not limited to, implied warranties of merchantability and fitness for a particular purpose and any warranty against infringement, with regard to the software product. This limited warranty gives you specific legal rights. You may have others, which vary from state/jurisdiction to state/jurisdiction. NAIMA's entire liability and your exclusive remedy shall not exceed the price paid for the software product. No liability for damages. To the maximum extent permitted by applicable law, in no event sha NAIMA or its suppliers be liable for any damages whatsoever including, without limitation, damages for loss of business profits, business interruption, loss of business information, or any other pecuniary loss arising out of the use of or inability to use this NAIMA product, even if NAIMA has been advised of the possibility of such damages. Because some states/jurisdictions do not allow the exclusion or limitation of liability for consequential or incidental damages, the above limitation may not apply to you.	n
THE U.S. GOVERNMENT HAS RESTRICTED RIGHTS - If you acquired this product in the Unite States, this license is governed by the laws of the State of Virginia.	d
Use of the 3E Plus program for an assessment of the economic thickness guidelines for all insulations does not ensure or guarantee compliance with any energy code in your geographic location. Consult local authorities before finalizing your installation plans. The us	e 👻
Show At Startup	

- 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<sup>®</sup> program.

### **3E Plus<sup>®</sup> 4.1 Verification**

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

- 1. Start the 3E Plus<sup>®</sup> 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<sup>®</sup> 4.1.



#### Uninstalling 3E Plus®

If you are installing a new version of 3E Plus<sup>®</sup> it is important to uninstall any previous versions that may be on your computer. To uninstall the 3E Plus<sup>®</sup> 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.

		1.2.14	-
Organize 👻 New fold	der		0
🛠 Favorites	Documents library BEPlus	Arrange by: Folder 🔻	
Downloads Dropbox	Name		
词 Libraries			
Documents			
Music  Pictures  Videos			
-	۰ ( m		
File name: User	Data		
Save as type: XML	File (*.xml)		

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).

Control Panel	All Control Panel Items      Programs and Features		• + <sub>7</sub>	Search Programs	and Features	
Control Panel Home View installed updates Turn Windows features on or	Uninstall or change a program To uninstall a program, select it from the list and t	then click Uninstall, Change, or Repair.				
off	Organize 💌				i≣ •	
	Name	Publisher	Installed Or	n Size	Version	
	SEPlus V4.1	NAIMA	12/28/2011	3.86 MB	1.0.0	
	Adobe Flash Player 11 ActiveX	Adobe Systems Incorporated	11/14/2011	6.00 MB	11.1.102.55	
	Adobe Photoshop Elements 3.0	Adobe Systems Inc.	3/21/2010	219 MB	003.000.0000	
	Adobe Reader X (10.1.1)	Adobe Systems Incorporated	12/26/2011	114 MB	10.1.1	
	AnswerWorks Runtime		3/13/2010			
	Apple Application Support	Apple Inc.	11/5/2011	61.1 MB	2.1.5	
	O Apple Mobile Device Support	Apple Inc.	11/29/2011	24.4 MB	4.0.0.97	
	( Apple Software Update	Apple Inc.	6/22/2011	2.25 MB	2.1.3.127	
	ASUSUpdate		3/12/2010			
	AviSynth 2.5		5/23/2010			
	Bing Bar	Microsoft Corporation	3/24/2011	24.4 MB	7.0.609.0	
	🥪 Bonjour	Apple Inc.	11/5/2011	1.46 MB	3.0.0.10	
	a Canon Easy-PhotoPrint EX		1/22/2011			
	👸 Canon MP600		1/22/2011			
	📆 Canon My Printer		1/22/2011			
	Compatibility Pack for the 2007 Office system	Microsoft Corporation	12/15/2011	131 MB	12.0.6425.1000	
	Coupon Printer for Windows	Coupons.com Incorporated	7/28/2010		5.0.0.0	
	Data Lifeguard Diagnostic for Windows 1.24	Western Digital Corporation	9/13/2011	1.54 MB		

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<sup>®</sup> 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**
- 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<sup>®</sup> 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: Disclaimer 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.

Elarch Calcula	te	ENERGY	ENVIRG	ONMENT	ECONOMICS	OPTIONS		
	SS	Sys Dimens	ional Standard:	Pipe - Horizonta ASTM C 585 Ri Heat Loss Per I 850	gid	F F		
Surface Temperatur Condensation Cont Personnel Protectio	rol n	sulation Layers	Wind Speed: NPS Pipe Size:	0.0		mph-		
Condensation Cont	n In	sulation Layers Add Dele	NPS Pipe Size:	0.0			Lock	Thickne
Condensation Cont	n In	Add Dele	NPS Pipe Size:	0.0			Thickness	Thicknet
Condensation Cont	ot n	Add Dele	NPS Pipe Size: te Name Steel	0.0	2547-11	• in	Thickness	Thicknes

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:

	ENERGY ENV	IRONMENT ECONOMICS	OPTIONS			
1 ZON V	Insulation Thickness					
ERGY	item	1 ID: 1				
	Item Descripti					
	System Applicat	ion: Pipe - Horizontal	+			
XXXXXXX	Dimensional Standa	ard: ASTM C 585 Rigid	*			
	Calculation Ty	Personnel Protection	*			
SULATION THICKNESS	Process Te			°F		
Inface Temperatures	Ambient Te			۴F		
ondensation Control ersonnel Protection	Wind Spe			mph		
er sonner roteedon	Max Surface Te			۴F		
	NPS Pipe Si	ize: 12		in		
	Insulation Layers					
	Add Delete				Look	Thickness
					Lock Thickness	Thickness
	Add Delete			-		Thickness
	Add Delete # Type Name Base Metal Steel	al Fiber PIPF Type L C547-11		-	Thickness	Thickness
	Add Delete # Type Name Base Metal Steel	al Fiber PIPE, Type I, CS47-11 um, oxidized, in service		-		Thickness

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:

-			Lock	Thickness
#	Туре	Name	Thickness	mickness
	Base Metal	Steel		
1	in our and the first	Steel Steel	Vary	
	Jacket Material	Stainless Steel Copper PVC		_

isulation Layers	1200F MF BLANKET, Type VII, C5S3-02 Polystyrene BOARD, Type IV, C578-07 Polystyrene BOARD, Type IV, C578-07 PIR, Gr 1, Types I,and II, C591-07 PIR, Gr 2, Type IV, C591-07 MF Metal Mesh BLANKET, Type II, C592-04 Perlite BLOCK+PIPE, C610-07 450P MF BOARD, Type II, C612-04 1000F MF BOARD, Type III, C612-04 1000F MF BOARD, Type IV, C612-04 1800F MF BOARD, Type IV, C612-04 1800F MF BOARD, Type V, C612-04 High Temp Fiber Blanket, Gr 6, C892-05 Glass Fiber Feit, C1086-96(2004) Phenolic Sheet+TUBE, Gr 1, Type II and III, C1126-04 650F Min.Fiber Pipe and Tank, Type II, C1393-00a	E.		
Add De	ele 850F Min.Fiber Pipe and Tank, Type IIIB, C1393-00a 1000F Min.Fiber Pipe and Tank, Type IVB, C1393-00a			
# Type	Melamine PIPE+FLAT, C1410-05a Polyolefin SHT+TUBE, C1427-04 Polvimide.Type I, C1482-04		Lock Thickness	Thickness
Base Metal	Duct Wrap, 0.75 pcf, C1290	-		
		+	Vary	

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:

#	Туре	Name	Lock Thickness	Thickness
	Base Metal	Steel		
1	Insulation	850F Mineral Fiber PIPE, Type I, C547-11	Vary	
	Jacket Material	0.1 Aluminum, oxidized, in service		
•		III		•

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

Bath Calculate	ENERGY ENVIR	ONMENT ECONOMICS	OPTIONS		
INSULATION THICKNESS Surface Temperatures Condensation Control Personnel Protection	Insulation Thickness Item D: Benescription: System Application: Dimensional Standard: Calculation Type: Process Temp: Ambient Temp: Wind Speed Max Surface Temp: NPS Pipe Size:	Pipe - Horizontal ASTM C 585 Rigid Personnel Protection 800 90 0.0 140.0	+ + + + + + + + + + + + + +		
	Add Delete				
				Lock	
	# Type Name			Thickness	Thickness
	# Type Name Base Metal Steel			-	Thickness
	Base Metal Steel	iber PIPE, Type I, CS47-11		] Vary	Thickness

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

< Back Calculate	ENERGY	ENVIRO	NMENT	ECONOMICS	OPTIONS	
1 ROWL V	Personnel Protection	Report	_			_
NERGY		Item ID:	1			Ě
		Item Description:				
		System Application:	and the second second			
THE REAL OF	Dir	nensional Standard:				
307.6 50 200		Calculation Type:		ction	۰F	
INSULATION THICKNESS Surface Temperatures		Process Temp: Ambient Temp:	1.0.0		*F	
Condensation Control		Wind Speed:	Tora.		mph	
Personnel Protection		May Surface Temp	1.000		**	-
	Open Audit File					
	open Addit i ne	_11				
	Quantity (ft or ft^2)	E .		Append To A	udit	
	Variable	2101027				
	Insulation Thickness	Surface Temp (°F)	Heat Loss (BTU/hr/ft)	Efficiency (%)		
	Bare	794.8	14020.00			
	0.5	434.5	1848.00			E
	1.0	324.8	1208.00			
	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		
			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 Isulation hickness	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	Personnel
7.5	136.8	283.80	97.98	Protection Thickness is
8.0	134.1	272.10	98.06	Highlighted in
8.5	131.7	261.60	98.13	Grey
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  $139.9^{\circ}$  F is less than the maximum specified of  $140.0^{\circ}$  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.

: Edit Units Help	1	1	1		
	ENERGY	ENVIRONMENT	ECONOMICS	OPTIONS	
GENERAL OPTIONS	User Information				
Program Defaults	User Name:	User Name			
INSULATION MATERIAL Maintenance	Company	Company Name			
	Address:	Address			
FUEL TYPES	City, State Zip:	City, State Zip			
	Phone Number:	Phone Number			
JACKET MATERIAL					
		Save			
BASE METALS					

### **INSULATION MATERIALS**

Select INSULATION MATERIAL and the following screen will appear:

e Edit Units Help										-		
	I	NER	GY ENVIRONMENT E	соном	ics	OP	TIONS					
GENERAL OPTIONS		tion Ma							Tempe	erature i	Points	
Program Defaults	A	dd	Edit Delete Activate							Row	Temperature	Conducti
INSULATION MATERIAL Maintenance		D	Material Name	Active	Created By	Туре	Max Temp	-	*			
	E F	1	MF Insulating CEMENT, C195-07	True	System	5	1900					
FUEL TYPES		2	Insul + Finish CEMENT, C449-07	True	System	5	1200					
		3	Calcium Silicate BLK+PIPE, Type I, C533-07	True	System	3	1200					
		4	Elastomeric SHT+TUBE, Gr 1, C534-07	True	System	5	220					
JACKET MATERIAL		5	850F Mineral Fiber PIPE, Type I, C547-07	True	System	1	850					
		6	1200F Mineral Fiber PIPE, Types II and III, C547-07	True	System	2	1200					
BASE METALS		7	1000F Mineral Fiber PIPE, Type IV,C547-07	True	System	2	1000					
		8	Cellular Glass, Type I, BLOCK, C552-07	True	System	4	800	-				

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...

General Inform Name:	mation		Conductivity Data Type Paired Data
Nax. Temp	Min. Temp	Active:	Polynomial
Generic		0.00	
Fiber Glass	1	+	3
1	(°F) Conduc	ctivity	
1 2 3 4			
1 2 3 4 5			
1 2 2 3 4 5 6			
1 2 3			
1 2 3 4 5 6 7			

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:

<u>Temp, ° F</u>	<u>Thermal Conductivity</u> , <u>Btu-in/hr-ft<sup>2</sup> - °F</u>
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.

Genera Name:	al Informa	tion				Conductivity Data Type
Generi	ic Insulat	on				Paired Data
Max. T	emp	Min. Ter	mp	Active:		Polynomial
1200		0		True	-	
Generi	ic					
Fiber (	Glass				-	
Please	Temp ( 200 400	least 3 pai	irs of me	0.39 0.56	ure and	
Please	enter at Temp ( 200	least 3 pai		ty 0.39	ure and	
Please	enter at Temp ( 200	least 3 pai		ty 0.39	ure and	
Please	enter at Temp ( 200 400	least 3 pai		ty 0.39 0.56	ure and	
1	enter at Temp ( 200 400	least 3 pai		ty 0.39 0.56	ure and	
Please	enter at Temp ( 200 400	least 3 pai		ty 0.39 0.56	ure and	
Please 1 2 3 4 5 6	enter at Temp ( 200 400	least 3 pai		ty 0.39 0.56	ure and	
Please 1 2 3 4 5 6 7	enter at Temp ( 200 400	least 3 pai		ty 0.39 0.56	ure and	

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.

le Edit Units Help	ENEF	GY	ENVIRONMENT E	CONOM	cs	OP	TIONS					
GENERAL OPTIONS	Insulation M	aterial							Temper	rature	Points	
Program Defaults	Add	Edit	Delete Activate							Row	Temperature	Conduct
INSULATION MATERIAL	0	Material N	ame	Active	Created By	Type	Max	-		1	200	0.39
Maintenance				T	-		Temp			2	400	0.56
	14		e PIPE, Type XIII, C578-07	True	System	5	165			3	600	0.74
FUEL TYPES	15		e BOARD, Type IV, C578-07	True	System	5	165		•*			
	16		Types I, and II, C591-07	True	System	5	300					
JACKET MATERIAL	17	-	Type IV, C591-07	True	System	-	300					
	18		lesh BLANKET, Type II, C592-04	True	System	2	1200					
	19		ICK+PIPE, C610-07	True	System	3	1200					
BASE METALS	20		OARD, Type IB, C612-04	True	System	1	450					
	21		OARD, Type II, C612-04	True	System	1	850					
	22		BOARD, Type III, C612-04	True	System	1	1000					
	23		BOARD, Type IVB, C612-04	True	System	2	1200					
	24		BOARD, Type V, C612-04	True	System	2	1800					
	25	High Temp	Fiber Blanket, Gr 6, C892-05	True	System	1	3000					
	26	Glass Fibe	r Felt, C1086-96(2004)	True	System	1	1200					
	27	Phenolic SI	heet+TUBE, Gr 1, Type II and III, C112	True	System	5	257					
	28	650F Min.F	iber Pipe and Tank, Type II, C1393-00a	True	System	1	650	-				
	29	850F Min.F	iber Pipe and Tank, Type IIIB, C1393	True	System	1	850	-				
	30	1000F Min.	Fiber Pipe and Tank, Type IVB, C139	True	System	2	1000					
	31	Melamine P	PIPE+FLAT, C1410-05a	True	System	5	350					
	32	Polyolefin S	SHT+TUBE, C1427-04	True	System	5	200					
	33	Polyimide,T	ype I, C1482-04	True	System	5	400					
	34	Duct Wrap	, 0.75 pcf, C1290	True	System	1	250					
	35	Duct Wrap	, 1.0 pcf, C1290	True	System	1	250					
	36	Duct Wrap	, 1.5 pcf, C1290	True	System	1	250					
	▶ 37	Generic Ins	sulation	True	User	1	1200		A.			

#### **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**:

		ENER	GY EN	VIRONMENT	E	CONOMI	cs	OP	TIONS				
GENERAL OPTIONS		Types				_	_	-		Pollu	utants	-	
Program Defaults		Add	Edit D	elete Act	ivate						ID	Name	Lbs / 10^6 Btu
INSULATION MATERIAL Maintenance		D	Fuel Name	Active	Created By	Cost	Cost Units	BTU	BTU Units		1	C02	116.53
	•	1	Natural Gas	True	System	5.00	S/Mcf	1026	Btu/cuft		1	CO2 MT	0.05285
FUEL TYPES		2	Oil	True	System	2.50	S/gal	138700	Btu/gal		2	NOx	0.23373
		3	LPG	True	System	2.20	S/gal	86310	Btu/gal	▶*			
JACKET MATERIAL		4	Coal	True	System	50.00	\$/ton	12500	Btu/lb				
		5	Electricity	True	System	0.10	S/kwh	3412	Btu/kwh				
BASE METALS	*		-		-	1.000		-					

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<sub>X</sub> so different values can be inserted by the User to replace the default values.

	Information			
Name:			Active:	
Natural Gas			True	
Cost:	Units (ie: \$/gallon):			
9.50	S/Mcf			
BTU:	Units (ie: BTU/ft <sup>s</sup> ):			
1026	Btu/cuft			
Unit Cost Fa	ctor (ie: Unit Cost Facto	or * Cost / Heat	Content)	
0.001				
Pollutants				
Pollutants The first thro may add dat	ee pollutants (CO2, NO: ta for up to five additior	al pollutants.		
Pollutants The first thro may add dat Name	ta for up to five addition Lbs / 10^6 Btu	al pollutants.	required but yo Lbs / 10^	
Pollutants The first thro may add dat	ta for up to five addition	al pollutants.		
Pollutants The first thro may add dat Name	ta for up to five addition Lbs / 10^6 Btu	al pollutants.		
Pollutants The first thro may add dat Name CO2	Lbs / 10^6 Btu 116.53	al pollutants.		

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):

le Edit Units Help					_	_
	I	NER	Y ENVIRONMENT ECONOMICS	PTIONS		
GENERAL OPTIONS Program Defaults	Jacket	1.1.1	ls Edit Delete Activate			
INSULATION MATERIAL Maintenance		D	Material Name	Active	Created By	Emittance
2000/2001 000/11/202	F.	1	Aluminum, new, bright	True	System	0.04
FUEL TYPES		2	Aluminum, oxidized, in service	True	System	0.1
		3 Stainless Steel, new, cleaned			System	0.13
and an an and a set		4	Stainless Steel, dull, in service	True	System	0.3
JACKET MATERIAL		5	Iron or Steel	True	System	0.8
		6	Copper	True	System	0.6
BASE METALS		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:

	1	ENER	GY ENVIRONMENT ECONOMICS OPTIONS			
GENERAL OPTIONS Program Defaults	Base	Metals dd	Edit Delete Activate			
INSULATION MATERIAL Maintenance		D	Material Name	Active	Created By	Emittance
	E F	1	Steel	True	System	0.8
FUEL TYPES		2	Stainless Steel	True	System	0.3
		3	Copper	True	System	0.6
		4	PVC	True	System	0.9
JACKET MATERIAL	*					

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.

ENERGY	ENVIRONMENT	ECONOMICS	OPTIONS
--------	-------------	-----------	---------

#### 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:

Edit Units Help					
Calculate	ENERGY	RONMENT	ECONOMICS	OPTIONS	
7 RAN -	Insulation Thickness				
REY	item II	: Example Problem	i No. 1		
A STAN	Item Description				
		1: Pipe - Horizontal			•
XXXXXXX		S: ASTM C585			¥
		Personnel Protec			-
LATION THICKNESS		Personnel Protec			۴F
face Temperatures	Ambient Tem	Condensation Co Heat Flow Limitat			۴F
idensation Control sonnel Protection	NPS Pipe Size	: Interface Temper	atures		in
	Wind Speed	Heat Loss Per Ye	ear		mph
	Max Surface Tem	: Insulation Thickne			°F

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.

ack Calculate	ENERGY	ENVIRONMENT	ECONOMICS	OPTIONS			
NSULATION THICKNESS Surface Temperatures Condensation Control Personnel Protection	Sys	tem D: Example Proble tem Description: tem Application: Pipe - Horizon System Units: ASTM C585 Process Temp: 600 Ambient Temp: 90 NPS Pipe Size: 12 Wind Speed: 0.0 c Surface Temp: 120	ial			set set	= iph
	# Type	Name				Lock Thickness	Thickne
		199540	0547.07			\/an/	
					-	vary	
	Base Metal           1         Insulation           Jacket Material	Steel 850F Mineral Fiber PIPE, Type I, 0.1 Aluminum, oxidized, in serv			•	Vary	

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.

ENERGY	ENVIRO	NMENT	ECONOMICS	OPTIONS	
Personnel Protectio	a Penart				
Personner Protectic		Example Problem N	6.4		
ALL	Item Description:	Example Problem is	10. 1		
	System Application:	Pine - Horizontal			
	System Units:				
SW.		Personnel Protectio	n		
ss	Process Temp:	600	-		۰F
es	Ambient Temp:	90			۴F
ol In	NPS Pipe Size:	12			in
	Wind Sneed	0.0			mph
Open Audit File.					
			[ Anno 19	- 4. 19	
Quantity (ft or f	t^2):		Append	IG AUGE	
Variable Insulation Thickness	Surface Temp (°F)	Heat Loss (BTU/hr/ft)	Efficiency (%)		ŕ
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		
	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  $\div$  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<sup>®</sup> 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, 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:

iac)	Calculate	EN	IERGY	ENVIRO	NMENT	ECONOMICS	OPT	IONS		
	17AUL	Insulatio	n Thickness					_	-	
ERG				Item ID:	-	546.2	_			
				Item Description: System Application:						
X		Dimensional Standard:			Pipe - Horizonti	al 				
NR				Calculation Type:	Personnel Prote	yiu action	+			
				Process Temp:		SCHOIL		۰F		
	ON THICKNESS remperatures			Ambient Temp:				۴F		
Condens	sation Control lel Protection			Wind Speed:	5			mph		
Personn	lei Protection			Max Surface Temp:	120			۴F		
				NPS Pipe Size:		_	•]	in		
		A		NPS Pipe Size:			•		Lock	Thickness
				NPS Pipe Size:			•		Lock Thickness	Thickness
		#	dd [	NPS Pipe Size:			•	in T		Thickness
		#	dd [	NPS Pipe Size: Delete Name Steel	12	II and III, C547-11	•	in T		Thickness
		# 1	dd I I Type Base Metal	NPS Pipe Size: Delete Name Steel	12 iber PIPE, Types		•	in	Thickness	
		# 1 2	dd [ [ Type Base Metal Insulation Insulation	NPS Pipe Size: Delete Name Steel 1200F Mineral F	iber PIPE, Types ber PIPE, Type I,	C547-11	•	in T	Thickness Fix	

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

le Edit Units Help					
< Back Calculate	ENERGY	ENVIRO	NMENT	ECONOMICS	OPTIONS
A Starling	Personnel Protection	Report			
NERGY		Item ID:	2		
		Item Description:	Example Problem I	No. 2	
		System Application:			
	Din	nensional Standard:			
			Personnel Protecti	on	۰F
INSULATION THICKNESS Surface Temperatures		Process Temp: Ambient Temp:	1200		*F
Condensation Control		Wind Speed:	074.00		mph
Personnel Protection		Max Surface Temn			°F.
	Open Audit File				
	Quantity (ft or ft <sup>^</sup> 2)	£		Append To Audit	
	Variable Insulation Thickness	Surface Temp (°F)	Heat Loss (BTU/hr/ft)	Efficiency (%)	Ē
	Bare	1181.9	39480.00		
	Layer 1 (4.1)	169.9	886.70	97.75	
	0.5	158.5	807.20	97.96	
	1.0	150.9	755.10	98.09	
	1.5	144.6	712.30	98.20	
	2.0	139.3	676.20	98.29	
	2.5	134.8	645.20	98.37	
	3.0	130.8	618.10	98.43	
	3.5	127.4	594.20	98.50	
	4.0	124.3	572.90	98.55	
	4.5	121.6	553.90	98.60	
	5.0	119.1	536.60	98.64	

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:

ile Edit Units Help			1		1		_
= Bach Calculate	ENERGY	ENVIRO	NMENT	ECONOMICS		OPTIONS	0
INSULATION THICKNESS Surface Temperatures Condensation Control Personnel Protection	Di	ttem ID: Item Description: System Application: mensional Standard: Calculation Type: Process Temp: Ambient Temp: Wind Speed: Max Surface Temp: NPS Pipe Size:	Example Problem Pipe - Horizontal ASTM C 585 Rigic Personnel Protect 1200 75.0 5 120	ion •F	ph		, <u>m</u>
		Delete			Lock	Thickness,	-
	Туре	Name			Thickness		
	Insulation	Glass Fiber Felt, C1	086-09		<ul> <li>Fix</li> </ul>	1	
	Insulation	Calcium Silicate BL	<pre>K+PIPE, Type I, C53</pre>		▼ Fix	2	Ξ
	Insulation	1200F Mineral Fiber	PIPE, Types II and	III, C547-11	<ul> <li>Vary</li> </ul>	1.1	
	Jacket Material	0.9 All Service Jack	tet.		•		
	The supervised sectors of						-

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**:

e Edit Ur	nits Help		-		_	-	
Back	Calculate	ENERGY	ENVIRO	NMENT	ECONOMIC	s	OPTIONS
1	ZOW V	Personnel Protection			_	_	
NERGY			System Application.	the state of the state	- 19		6
K		Uin	nensional Standard: Calculation Type:	Personnel Protect			
X			Process Temp:			۰F	
			Ambient Temp:	Men y		۰F	L
AINZEN	and and a second		Wind Speed:	5		mph	
INSULATION 1 Surface Term			Max Surface Temp:	120		۴F	
Condensatio	on Control		NPS Pipe Size:	12		in	
Personnel P	Protection		Jacket Material:	All Service Jacket			[
		Open Audit File					
		Quantity (ft or ft^2)			App	end To Àudi	a
		Variable Insulation Thickness	Surface Temp (*F)	Heat Loss (BTU/hr/ft)	Efficiency (%)	(	
		Bare	1181.9	39480.00			
		Layer 1 (1.1)	247.2	2204.00	94.42		
		Layer 2 (2.1)	146.0	982.70	97.51		
		0.5	132.7	824.10	97.91	100	
		1.0	125.2	739.10	98.13		
		1.5	119.6	676.60	98.29		
		2.0	115.2	627.90	98.41	10 C	
		2.5	111.5	588.40	98.51		
		3.0	108.5	555.60	98.59	1	

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:

Bask Calculate	ENERGY	ENVIRONMENT	ECONOMICS	OPTIONS			
ZENI	Insulation Thickness					_	_
NERGY		Item ID: 4					
K K K K		tem Description: Example Prob					
		stem Application: Pipe - Horizo	ntal		-		
-XXXXX		sional Standard: ASTM C 585			-		
	(	Calculation Type: Condensation	n Control		-		
SULATION THICKNESS		Process Temp: 40			۴F		
Surface Temperatures		Ambient Temp: 90			۰F		
Condensation Control Personnel Protection		Wind Speed: 0			mph		
		NPS Pipe Size: 4			▼ in		
	Cor	idensation Data: 💮 Wet Bult	b Temp 86.0	Ŧ			
		Relative	Humidity 85	%			
		Dew Poi	int 84.9	王			
	handeline to some						
	Add Dele						
	Add Dea						
	# Туре	Name				Lock Thickness	Thickness
	Base Metal	Steel			-		
	A COMPANY OF A COM	850F Mineral Fiber PIPE, Type	I, C547-11			Vary	
	Jacket Material	0.9 PVC Jacketing			-		-

Back Calcu	late ENERGY	ENVIRO	NMENT	ECONOMICS	OPTIONS		
12	Condensation Cont	rol Report					
ERGY		Item ID:	4				
	CAN I	Item Description:	Example Problem N	lo. 4			
		System Application:	and the second sec				
		imensional Standard:					
in a sur a		Calculation Type: Process Temp:	Condensation Con	trol		•F	
SULATION THICKN urface Temperatu		Ambient Temp:				*F	
Condensation Con	itrol	Wind Speed:	100 M			mph	
Personnel Protect	uon	NPS Pine Size	12			in	
	Open Audit File. Quantity (ft or ft*			Append To A	udit		
	Quantity (fl or ft <sup>A</sup> Variable Insulation		Heat Gain (BTU/hr/ft)	Append To A Efficiency (%)	udit	_	
	Quantity (ft or ft^ Variable	2): Surface Temp	Heat Gain	Efficiency	udž		
	Quantity (ft or ft <sup>A</sup> Variable insulation Thickness	2): Surface Temp (*F)	Heat Gain (BTU/hr/ft)	Efficiency	udž		
	Quantity (fl or ff <sup>4</sup> Variable Insulation Thickness Bare	2): Surface Temp. (°F) 40.0	Heat Gain (BTU/hr/ft) 98.45	Efficiency (%)	udi		
	Quantity (fi or ft <sup>4</sup> Variable Insulation Thickness <u>Bare</u> 0.5	2): Surface Temp (*F) 40.0 79.6	Heat Gain (BTU/hr/ft) 98.45 23.23	Efficiency (%) 76.41	udž		
	Quantity (fi or ft <sup>A</sup> Variable Insulation Thickness Bare 0.5 1.0	2): Surface Temp (*F) 40.0 79.6 84.4	Heat Gain (BTU/hr/ft) 98.45 23.23 14.12	Efficiency (%) 76.41 .85.85	udit		
	Quantity (fi or ft <sup>A</sup> Variable Insulation Thickness Bare 0.5 1.0 1.5	2): Surface Temp (*F) 40.0 79.6 84.4 86.2	Heat Gain (BTU/hr/ft) 98.45 23.23 14.12 10.73	Efficiency (%) 76.41 .85.65 .89.10	udit		1
	Quantity (fi or ft <sup>4</sup> Variable Insulation Thickness Bare 0.5 1.0 1.5 1.0 1.5 2.0	2): Surface Temp (*F) 40.0 79.6 84.4 86.2 87.1	Heat Gain (BTU/hr/ft) 98.45 23.23 14.12 10.73 8.87	Efficiency (%) 76.41 85.85 89.10 90.99	udit		

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  $86.2^{\circ}$ F which is above the dew point of  $84.9^{\circ}$ 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  $84.1^{\circ}$ F, but that  $84.1^{\circ} < 86.0^{\circ}$  (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  $0.75^{\circ}$ 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<sup>®</sup> 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:

ach Calculate	ENERGY	ENVIRO	NMENT	ECONOMICS	OPTION	IS		
	Insulation Thickness	item ID:						
KINGKA	- 1	tem Description:	-	m No. 5				
		tem Application:			-			
	Dimen	sional Standard:	ASTM C 585 Ri	nid	÷			
	(	Calculation Type:	Heat Flow Limit	ation				
		Process Temp:				۶F		
ISULATION THICKNESS urface Temperatures		Ambient Temp:	80			۴F		
Condensation Control		Wind Speed:	10			mph		
Personnel Protection			101					
Personnel Protection		Heat Flow Limit:	101			BTU/hr/f	t^2	
Personnel Protection	Insulation Layers	Heat Flow Limit:	101				¥2	
Personnel Protection		Heat Flow Limit:	101				¥2	
Personnel Protection	Insulation Layers	Heat Flow Limit:	101			BTU/hr/f	₩2 Lock Thickness	Thickness
Personnel Protection	Insulation Layers	Heat Flow Limit:	101			BTU/hr/f	Lock	
Personnel Protection	Insulation Layers Add Deie # Type Fase Metal	Heat Flow Limit:	8	78-116		BTU/hr/f	Lock	
Personnel Protection	Insulation Layers Add Deid # Type Fase Metal 1 Insulation	Heat Flow Limit: ste Name Steel	8 ARD, Type IV, CS			BTU/hr/f	Lock Thickness	
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.

	Units Help		-					
Back	Calculate	ENERGY	ENVIRON	IMENT	ECONOMICS	OPTION	IS	
	ZONI	Heat Flow Limitation F	Report					
IERD		-	Wind Speed:	10			mph	
			Heat Flow Limit:	8			BTU/hr/ft^2	
N			Jacket Material:		ized, in service			
			Jacket Emittance:	28 C				
	a all and		Insulation Layer 1:	Polystyrene BC	ARD, Type IV, C578-11b		Varied	
	TION THICKNESS Temperatures							
Conde	nsation Control							
Person	nnel Protection							
		Open Audit File						
		Quantity (ft or ft <sup>^</sup> 2)	6		Append To A	Audit		
						Audit		
		Quantity (ft or ft^2) Variable Insulation	Surface Temp	Heat Gain		Audit	_	_
		Variable		Heat Gain (BTU/hr/ft^:		Audit	-	-
		Variable Insulation	Surface Temp		2)	Audit		
		Variable Insulation Thickness	Surface Temp (°F)	(BTU/hr/ft^:	2)	Audit		
		Variable Insulation Thickness Bare	Surface Temp (°F) -9.9	(BTU/hr/ft^: 234.80	2)	Audit		
		Variable Insulation Thickness Bare 0.5	Surface Temp (*F) -9.9 65.0	(BTU/hr/ft^: 234.80 26.99	2)	Audit	1	1
		Variable Insulation Thickness Bare 0.5 1.0	Surface Temp. (*F) -9.9 65.0 71.7	(BTU/hr/ft <sup>A</sup> ) 234.80 26.99 14.81	2)	Audit		
		Variable Insulation Thickness 0.5 1.0 1.5	Surface Temp (*F) -9.9 65.0 71.7 74.2	(BTU/hr/ft <sup>A</sup> ) 234.80 26.99 14.81 10.22	2)	Audit		
		Variable Insulation Thickness 0.5 1.0 1.5 2.0	Surface Temp (*F) -9.9 65.0 71.7 74.2 75.6	(BTU/hr/ff*) 234.80 26.99 14.81 10.22 7.80	2)	Audit		1

#### 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:

iach Calculate	ENERGY	ENVIRG	ONMENT	ECONOMICS	ΟΡΤΙΟ	NS	
AND	Insulation Thickness Sys Dimen	Item ID: Item Description: stem Application: usional Standard: Calculation Type: Process Temp: Ambient Temp: Wind Speed: x Surface Temp:	5 Example Proble Pipe - Horizont ASTM C 585 R Insulation Thick -10 80 10	m No. 5 al	• • • •	]	

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

eport Progress	
Creating Table	

After completing the calculations a table which looks like this:



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:

Edit Units Help		-		-		_
Back Calculate	ENERGY	ENVIRONMENT	ECONOMICS	OPTIONS		
INSULATION THICKNESS Surface Temperatures Condensation Control Personnel Protection	Sys Diment C	tem ID: 7 tem Description: Example Proble tem Application: Pipe - Horizont sional Standard: ASTM C 585 R Process Temp: 350 Ambient Temp: 20 Wind Speed: 1.5 cSurface Temp: 50	al igid	• • • • • • • • • • • • • • •		
	Insulation Layers	NPS Pipe Size: (150		mn 🗸	1	
		<u>1</u>		mm	Lock	Thickness
	Add Dele	te			Lock Thick	
	Add Dele # Type Base Metal 1 Insulation	ite Name Steel 1200F Minerál Fiber PIPE. Types	Contract of the		Lock	iness
	Add Dele # Type Base Metal 1 Insulation	te Name Steel	Contract of the		Lock Thick	iness

The results of the calculation show that 65 mm of Mineral Fiber PIPE, Types II and III are required to keep the surface

< Back	Calculate	ENERGY	ENVIRO	NMENT	ECONOMICS	OPTIC	INS	
_			1		Loonomice			
	ABIL	Personnel Protection R					4.55	
ENERG			Wind Speed:	1.1			m/s	
R		м	ax Surface Temp: NPS Pipe Size:	100			°C mm	
V				Aluminum, oxidize	1 in sancica		TOTAL	
31 B			Jacket Emittance:		1, IT SCITICE		-	
INSULAT	ION THICKNESS			and the	r PIPE, Types II and III, C5	47-11	Varied	
Surface	Temperatures							
	sation Control nel Protection							Ľ
		Open Audit File						
		Quantity (ft or ft <sup>2</sup> ):			Append To A	udit		
		Variable Insulation	Surface Temp	Heat Loss	Efficiency			-
		Thickness	(°C)	(W/m)	(%)			
		Bare	348.4	5328.00				
		15.0	132.4	784.90	85.27			-
		05.0	82.8	462.20	91.33			
		25.0	02.0					
		40.0	63.0	335.90	93.69			
				335.90 262.80	93.69 95.07			
		40.0	63.0					
		40.0	63.0 51.6	262.80	95.07			

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:

Column     ENVIRONMENT     ECONOMICS       Insulation Thickness     Item D:     1       Item Description:     Example Problem No. 1     System Application:       System Application:     Pipe - Horizontal       Dimensional Standard:     ASTM C 585 Rigid       Fuel Type     Natural Gas       Heat Content:     1026       Efficiency:     75       Process Temp:     600       Ambient Temp:     5       Hours Per Year:     8320       NPS Pipe Size:     8	
ENVIRONMENT       tem D: 1         Item Description:       Example Problem No. 1         System Application:       Pipe - Horizontal         Dimensional Standard:       ASTM C 585 Rigid         Fuel Type       Natural Gas         Heat Content:       1026         Process Temp:       600         Ambient Temp:       75.0         Wind Speed:       5         Hours Per Year:       8320         NPS Pipe Size:       8	OPTIONS
# Type Name	▼ ▼ ▼ ▼ ♥ ♥ ♥ ♥ ♥ ♥ ♥ ♥ ♥ ♥ ♥ ♥ ♥ ♥ ♥ ♥
	Lock Thickness Thickness
Base Metal Steel	
1 Insulation 850F Mineral Fiber PIPE, Type I, C547-11	Vary
Jacket Material 0.9 All Service Jacket	

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

< Back Calculate	ENERGY	ENVIRO	ONMENT	ECONOMICS	OPTIONS	
Sec. 26	Pollutant Reduction					
ENVIRONMENT		Item ID	1			
1141	A.C.	Item Description	Example Problem N	lo. 1		
	S	system Application	Pipe - Horizontal			
NAL REAL	Dim		ASTM C 585 Rigid			
			Natural Gas			
CO2, NOX & CE REDUCTIO Emission Reduction Tab	DN	Heat Content			BTU/cuft %	
Emission Reduction Tab		Efficiency Process Temp			70 *F	
		Amhient Temn			*F	+
	Open Audit File	1				
		7.				
	Quantity (ft or ft <sup>2</sup> ):			Append To Ar	udit	
	Variable Insulation Thickness	CO2 (lb/ft/yr)	CO2 MT (MT/ft/yr)	NOx (lb/ft/yr)		*
	Bare	7884.00	3.58	15.81		E
	0.5	1404.00	0.64	2.82		11
	1.0	725.90	0.33	1.46		
	1.5	523.00	0.24	1.05		
	2.0	416.00	0.19	0.83		
	2.5	337.00	0.15	0.68		
	3.0	295.60	0.13	0.59		
	3.5	265.10	0.12	0.53		
	3.5					

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<sub>2</sub> 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**  $\rightarrow$  **FUEL TYPES** section of the 3E Plus<sup>®</sup> 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.

E Plus v4.1 e Edit Units Help		_	_	-			
Flach Calculate	ENERGY	ENVIR	ONMENT	ECONOMICS	OP	rions	
ECONOMIC THICKNESS Detailed Calculation	Dim Insulation Layers	ystem Application: ensional Standard:	Cost of Energy Eb Pipe - Horizontal ASTM C 585 Rigk Natural Gas 1026 5.00 75 600 90 0 8320		▼ ■ BTU/cuft S/Mcf % *F *F mph hrs/yr ▼ in		
	# Туре	Name				Lock Thickness	Thickness
	Base Metal	Steel 850F Mineral Fi	ber PIPE, Type I, CS	47-11	-	Vary	
		al 0.9 All Service					
				m			F

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 (f/f/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 (f/f/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:



Edit Units Help	_		_	_			
Back Calculate	ENERGY	ENVIRO	NMENT	ECONOMICS	OPTIONS		
C CREAT	Cost of Energy		_	_			
CONOMICS		Item ID:	1				
4 30			Cost of Energy Exa	ample No. 1			
MA STA			Pipe - Horizontal				
	Dime		ASTM C 585 Rigid Electricity			-	
		Heat Content:				Btu/kwh	
COST OF ENERGY		Fuel Cost:				\$/kwh	
		Efficiency:	300			%	
PLE PAYBACK PERIOD		Process Temp	45			•F	
	Open Audit File						
ECONOMIC THICKNESS Detailed Calculation	Quantity (ft or ft^2):			Append To A	udit		
	Variable Insulation Thickness	Cost (\$/ft/yr)	Heat Gain (kBTU/ft/yr)	Savings (\$/ft/yr)			
	Bare	13.32	1364	1.1			
	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			
		12.120					
	5.0	0.52	54	12.80			

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

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<sup>®</sup> 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).

Calculate	ENERGY ENVIR	ONMENT ECONOMICS	OPTIONS			
	ENERGY		or mono			
	Insulation Thickness	5		į		
ONOMICS	Fuel Type	Natural Gas	•			
A	Heat Content			BTU/cuft		
1.9	Fuel Cost			\$/Mcf		
	Efficiency Process Temp			% °F		
and a file of the	Ambient Temp			۰F		
COST OF ENERGY	Wind Speed			mph		
	Hours Per Year			hrs/yr		
Constant of the local division of the	NPS Pipe Size			in		
LE PAYBACK PERIOD	Installation Complexity					
	Material Price, \$/ft for 2 x 2 pipe	5.00				
ONOMIC THICKNESS	insulation, including jacket					
etailed Calculation	Material Price, \$/sqft for 2 inch thick board or block, including jacket	\$ 2.00				
	Labor Rate, \$/hr including overhead					
	Labor Productivity Factor					
		Edit FEA Cost Data				
		-				
	Insulation Layers				Lock	Thicknes
	# Type Name			1.0000000	Thickness	
	Base Metal Steel			*	200	
	1 Insulation 850F Mineral F	iber PIPE, Type I, C547-11		-	Vary	
	Jacket Material 0.9 All Service	Jacket		•	-	

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 1 inch 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.

	Pipe Size: 1	2"			
ingle Layer		Double Layer		Triple Layer	
Thick	Cost	Thick	Cost	Thick	Cost
1	0.00	3	53.32	6	107.54
1.5	30.07	4	66.98	7	125.10
2	35.60	5	80.35	8	143.11
2.5	40.58	6	93.71	9	160.37
3	45.50	0	0.00	10	178.24
4	55.47	0	0.00	0	0.00

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:

Calculate	ENERGY	ENVIRO	NMENT	ECONOMICS	OPTION	IS	
SHA 2	Thickness & Surface Te	mp Report					
AICS		Item ID:	3				
30			Payback Period Ex	ample No. 3			
		stem Application:	19 Mar 19				
	Dimen		ASTM C 585 Rigid				
		Heat Content:	Natural Gas		_	BTU/cuft	
GY		Fuel Cost:				\$/Mcf	
		Efficiency:	75			%	
PERIOD		Process Temp	600			۶F	
	Open Audit File						
CKNESS	Quantity (ft or ft <sup>^</sup> 2):			Append To	Audit		
iculation	Insulation	Insulation	Fuel Cost	Fuel Savings	Payback	Heat Loss	-
			i uuroodt		ruybuok		
	Thickness (in)	Cost (\$/ft)	(\$/ft/yr)	(\$/ft/yr)	Period (yrs)	(kBTU/ft/yr)	
	Thickness (in) Bare	Cost (\$/ft)	(\$/ft/yr) 403.01	(\$/ft/yr)	Period (yrs)	(kBTU/ft/yr) 62024	
		Cost (\$/ft) 30.07		(\$/ft/yr) 374.31	Period (yrs)		
	Bare		403.01			62024	
	Bare 1.5	30.07	403.01 28.70	374.31	0.1	62024 4417	1
	Bare 1.5 2.0	30.07 35.60	403.01 28.70 22.87	374.31 380.14	0.1	62024 4417 3520	
	Bare           1.5           2.0           2.5	30.07 35.60 40.58	403.01 28.70 22.87 19.20	374.31 380.14 383.82	0.1 0.1 0.1 0.1	62024 4417 3520 2955	
	Bare           1.5           2.0           2.5           3.0	30.07 35.60 40.58 45.50	403.01 28.70 22.87 19.20 16.67	374.31 380.14 383.82 386.35	0.1 0.1 0.1 0.1	62024 4417 3520 2955 2565	
	Bare           1.5           2.0           2.5           3.0           4.0	30.07 35.60 40.58 45.50	403.01 28.70 22.87 19.20 16.67	374.31 380.14 383.82 386.35	0.1 0.1 0.1 0.1	62024 4417 3520 2955 2565	
	Bare           1.5           2.0           2.5           3.0           4.0           Double Layer	30.07 35.60 40.58 45.50 55.47	403.01 28.70 22.87 19.20 16.67 13.40	374.31 380.14 383.82 386.35 389.61	0.1 0.1 0.1 0.1 0.1	62024 4417 3520 2955 2565 2062	
	Bare           1.5           2.0           2.5           3.0           4.0           Double Layer           3.0	30.07 35.60 40.58 45.50 55.47 53.32	403.01 28.70 22.87 19.20 16.67 13.40 	374.31 380.14 383.82 386.35 389.61 	0.1 0.1 0.1 0.1 0.1 0.1	62024 4417 3520 2955 2565 2062 262 2565	
	Bare           1.5           2.0           2.5           3.0           4.0           Double Layer           3.0           4.0	30.07 35.60 40.58 45.50 55.47 53.32 66.98	403.01 28.70 22.87 19.20 16.67 13.40 16.67 13.40	374.31 380.14 383.82 386.35 389.61 386.35 389.61	0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.2	62024 4417 3520 2955 2565 2062 2565 2565 2565 2062	

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:

Calculate	ENERGY	ENVIRG	ONMENT	ECONOMICS	OPT	IONS		
A MAR	Insulation Thickness				_			-
NOMICS	Instalk	ation Complexity:	Average		+	1		
		Discount Rate:				%		
	Effective I	ncome Tax Rate:	0			%		
	Physical Plant Dep	reciation Period:	20			yrs		
	Expected Service	Life of Insulation	20			yrs.		
	Incremental Cost o	f Plant Capacity:	0.00			\$/MMBtu/	'hr/ft	
FENERGY	Percent of New In Annual Insulati	sulation Cost for on Maintenance:	1					
BACK PERIOD	Percent of Annual Fue Pla	Bill for Physical ant Maintenance:	0					
	Reference Thickn	ess for Payback Calculations:	o					
IIC THICKNESS d Calculation		/ft for 2 x 2 pipe including jacket:	5.00					
Station of the local division of the	Material Price, \$/sqt board or block,	t for 2 inch thick including jacket:	2.00					
	Labor Rate, \$/hr incl		60.00					
	Labor Pro	ductivity Factor:	100					
			-	Select Surfaces		T		
			-	Edit FEA Cost Data		1		
	Insulation Layers	ete						
	# Туре	Name					Lock Thickness	Thicknes
	Base Metal	Steel				-	- T	
	1 Insulation	850F Mineral Fi	ber PIPE, Type I,	C547-11		-	Vary	
	Jacket Material	0.9 All Service	Jacket			-		

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.

Select Surface	es		
0.5*	() 4"	() 14."	Vertical Flat
0 0.75*	© 4.5 °	① 16 "	🔘 Top of Tank or Duct
O 1*	O 5"	① 18 *	🔘 Bottom of Tank or Duct
O 1.25 "	0 6*	O 20 "	
O 1.5"	© 7"	② 24 "	
0 2*	0 8"	() 30 "	
O 2.5*	O 9"	③ 36 *	
O 3*	O 10"	O 48 "	Close
O 3.5"	12"		

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.

	Pipe Size: 1	2"			
ingle Layer		Double Layer		Triple Layer	
Thick	Cost	Thick	Cost	Thick	Cost
1	0.00	3	53.32	6	107.54
1.5	30.07	4	66.98	7	125.10
2	35.60	5	80.35	8	143.11
2.5	40.58	6	93.71	9	160.37
3	45.50	0	0.00	10	178.24
4	55.47	0	0.00	0	0.00

nsulation 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 Laye	r		
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	r		
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 sing	gle layer 4.00 incl	nes.	<u> </u>

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

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<sup>®</sup> 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<sup>®</sup> includes the capability to output the results of the analysis of individual items to an audit file (either a Microsoft Excel<sup>®</sup> 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<sup>®</sup> 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<sup>®</sup> Installed

< Back Calculate	ENERGY	ENVIRONMENT	ECONOMICS	OPTIONS		
Mar Carlos	Insulation Thickn	ess			_	-
ECONOMICS		Item ID:	C		1	-
			Append to Audit Example Pr	oblem 1	Ĩ	_
		System Application:		*		
34018	D	mensional Standard:		•	1	
		Fuel Type	Natural Gas	*		
COST OF ENERGY		Heat Content:	1.9.90		BTU/cuft	
		Fuel Cost:	5.00		\$/Mcf	
SIMPLE PAYBACK PERIOD		Efficiency:	L		%	
ECONOMIC THICKNESS		Process Temp:	1		۰F	
Detailed Calculation		Ambient Temp:	1		°F	
		Wind Speed:			mph	
		Hours Per Year.	and the second s		hrs/yr	
		NPS Pipe Size:	12	*	] in	
	Add De	rs lete				
	Add De	lete				
	# Type	Name			Lock Thickne	Thickne
	Base Meta	Steel				
	1 Insulation	850F Mineral Fiber	PIPE, Type I, C547-11		Vary	
	Jacket M	0.9 All Service Jack	et			
	the second se					

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:

ENERGY	ENVIRONMEN	(T )	CONQMICS	OPTIONS		
Cost of Energy	1			_		
	item il	D: 1				ł
	Item Descriptio	n: Append	to Audit Example F	Problem 1		
	System Applicatio	n: Pipe - Ho	orizontal			
	Dimensional Standar	d: ASTM C	585 Rigid			
7	Fuel Typ	e Natural C	∋as			
	Heat Conter		Are a second and a second and		BTU/cuft	
	Fuel Cos				\$/Mcf	
	1				17.000	-
Open Audit						
Quantity (ft or	ft*2):		Append To A	udit		
Variable Insulation Thickness		Heat Loss (BTU/ft/yr)	Savings (\$/ft/yr)			
Bare	403.01	62020				
0.5	65.74	10120	337.27			
1.0	39.41	6065	363.60			
1.5	28.70	4417	374.31			
2.0	22.87	3520	380.14			
2.5	19.20	2955	383.81			
3.0	16.67	2565	386.34			
3.5	14.82	2280	388.19			
4.0	13.40	2062	389.61			
4.5	12.28	1890	390.73			
5.0	11.37	1750	391.64			
5.5	10.62	1634	392.39			
6.0	9.99	1537	393.02			
6.5	9.45	1454	393.56			

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).

Save As					<u>? ×</u>
Save in:	3EPlus		- 0	🏦 😂 🛄 🔻	
My Recent Documents Desktop My Documents					
My Computer	File name:	NewAudit1 xls		-	Save
My Network	Save as type:	Microsoft Excel (*xls)	-	<b>*</b>	Cancel

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<sup>®</sup> folder. Clicking **Save** generates the following message:

Naima	×
Please select the insulation thicknesses that you would	like to add to the audit file, enter the quantity, and click 'Append to Audit.'
	OK

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  $ft^2$ ).

Edit Units Help							
ack Calculate	ENERGY	ENVIRONMENT		CONOMICS	OPTIONS		
- Are	Cost of Energy						
CONOMICS		Item ID:	1				14
V		Item Description:	Append t	to Audit Example P	problem 1		-
15		System Application:	Pipe - Ho	prizontal			
	D	imensional Standard:	ASTM C	585 Rigid			
		Fuel Type	Natural G	Jas			
COST OF ENERGY		Heat Content:	1026	61		BTU/cuft	
		Fuel Cost	5.00			\$/Mcf	
LE PAYBACK PERIOD			La con			12000	-
	Open Audit	C:\Documents and S	Settings\De	е р/мү			
CONOMIC THICKNESS Detailed Calculation	Quantity (ft or ft	*2): 25		Append To A	udit		
	Variable Insulation Thickness		at Loss TU/ft/yr)	Savings (\$/ft/yr)			
	Bare	403.01 6	2020				
	0.5	65.74 1	0120	337.27			
	1.0	39.41	6065	363.60			
	1.5	28.70	4417	374.31			
	2.0	22.87	3520	380.14			
	2.5	19.20	2955	383.81			
	3.0	16.67	2565	386.34			
	3.5	14.82	2280	388.19			
	4.0		2062	389.61			
	4.5	12.28	1890	390.73			
	5.0	11.37	1750	391.64			
	5.5	10.62	1634	392.39			
	6.0	9.99	1537	393.02			
		9.45	1454	393.56			

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

Naima		×
The data for this run l	has been added to the audit w	vorksheet.
	ок	

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<sup>®</sup> spreadsheet.

Switch to the open the Microsoft Excel<sup>®</sup> 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<sup>®</sup> for this item. Column P is the Quantity value input in the Append to Audit process (25 ft for this example)

	A	В	С	D	E	F	G	Н		J	K	L	М	N	0	Р
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<sup>®</sup> 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	Т	U	V	W	Х	Y	Z	AA
Inventorie	Heat Loss	Cost Inven	CO2 Inven	NOx Inven	Upgraded	Heat Loss	Cost Upgra	CO2 Upgra	NOx Upgra	ded
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<sup>®</sup>, 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	В	С	D	E	F	G	Н	I.	J	K	L	М	N	0	Р
1	ID	Descriptio	Fuel	Base Meta	Insulation	Jacket	Geometry	Fuel Efficie	Hours Per	BTU	Fuel Cost	Process T	Ambient T	Wind Spee	Pipe Size	Insulation
2		1 Append to	Natural G	a Steel	850F Mine	All Service	Pipe - Hori	75	8320	1026	5	600	90	0	12	25
3		2 Append to	Natural G	a Steel	850F Mine	All Service	Pipe - Hori	75	8320	1026	5	600	90	0	8	12

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<sup>®</sup> 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<sup>®</sup> Not Installed

If the user does not have Microsoft Excel<sup>®</sup> 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).

e Edit Units Help				T		-	_
< Back Calculate	ENERGY EI	NVIRONM	AENT	ECONOMICS	OPTIONS		
A Star	Cost of Energy	_	_			_	
ECONOMICS		Item ID: 1				1	
	Item Desc	cription:					
1.41			pe - Horizontal				
1000 \ 3/// B			STM C 585 Rigid				
		el Type Na Content: 10	extra parts			BTU/cuft	
COST OF ENERGY		el Cost: 5.0				S/Mcf	
		iciency: 75				%	
SIMPLE PAYBACK PERIOD	Proces	s Temn' 60	10				
	Open Audit File						
ECONOMIC THICKNESS							
Detailed Calculation	Quantity (ft or ft^2): 25			Append To Au	jit .		
	Variable Cos Insulation (\$/ft/y Thickness		Heat Loss (kBTU/ft/yr)	Savings (\$/ft/yr)			
	Bare 403	.01	62020				
	0.5 65.	74	10120	337.27			
	1.0 39.	41	6065	363.60			
	1.5 28.	70	4417	374.31			
	2.0 22.	87	3520	380.14			
	2.5 19.	20	2955	383.81			
	3.0 16.	67	2565	386.34			
	3.5 14.	82	2280	388.19			
	4.0 13.	40	2062	389.61			
	4.5 12.	28	1890	390.73			
	5.0 11.	37	1750	391.64			

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<sup>®</sup> 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.

Organize 🔻 New	folder				• 0
🚖 Favorites 📃 🗮 Desktop	Â	Documents library BEPlus	Arran	ige by: Fol	der 🔻
Downloads	E	Name	*		
Jropbox		No items mate			
🕞 Libraries					
Documents					
J Music					
Pictures					
Videos					
	* 1				
File name:	NewAi	dit			
Course to man 17	out Eil	e (Tab Delimited) (*.txt)			

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:

🖉 NewAudit - Notepad								
File Edit Format View Help								
ID Description Fuel 1 Natural Gas	Base Metal Insulation Jacket Geometry Steel 850F Mineral Fiber PIPE, Type I, C547-11	Fuel Efficiency Hour: A All Service Jacket						
× [								

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.