



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



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



- New user interface
- Improved report formats
- Calculates in both metric and inch-pound units
- Ability to add custom fuels
- Calculates multiple insulation layers

Calculates The Savings For A Range of Insulation Thicknesses

Energy Savings • Economic Savings • Environmental Savings

www.PipeInsulation.org



3E Plus[®]

Version 4.1 Users Guide

August 2012

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Chapter 1 Introduction

GETTING STARTED

Program Installation

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

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

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

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

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

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

This program is named 3E Plus[®] V4.1 and can be downloaded from this Website: <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[®] 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 notential

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

Organize 🔻 New fo	lder	II 👻 🔞
🛠 Favorites	Documents library BEPlus	Arrange by: Folder 🔻
Lownloads 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 al	l 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
鷆 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:

The pu un 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
E.	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[®] V4.1
- 13. When the Installation has completed, you will see the following:

岁 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 Fr	amework.
Cancel Bácit	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[®] program by clicking **Start >> Programs >> 3E Plusv41**

17. On initial startup, a registration box will appear

hease take the functionality. You will be re must wait ten seconds to proceed. To ccottrel@naima.org. When you receive	eminded each time you use the software and register, please send your email address to a 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[®] 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 d low the exclusion or limitation of liability for consequential or incidental damages, the other induction of liability for consequential or incidental damages, the	E
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[®] program.

3E Plus[®] 4.1 Verification

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

- 1. Start the 3E Plus[®] computer program by clicking **Start >> Programs >> 3E Plusv41**.
- 2. The disclaimer window will appear clear the check in the "show at start-up box" unless you want to review this every time the program starts.
- 3. Left click on "OK"
- 4. If the "Access Code" window appears, enter the access code (**3EPlusv4.1**) that was sent in your registration confirmation e-mail. Without the access code you will be required to wait 10 seconds every time the program is started. Otherwise left click "Register Later"
- 5. Once the program is running, click Help >> About
- 6. You should see the following information box. The important part is Version 4.1



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



Uninstalling 3E Plus®

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

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

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

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

		iter	
Organize 🔻 New fol	der		
🛠 Favorites	Documents library BEPlus	Arrange by: Folder 🔻	
Downloads Dropbox	Name 📄 NaimaConfig		
词 Libraries			
Documents			
Music Pictures Videos			
-	* [
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		 ★ ★	earch Programs	and Features	
Control Panel Home	Uninstall or change a program					
View installed updates	To uninstall a program select it from the list and t	then click Uninstall Change or Renair				
Turn Windows features on or	To annistan a program, select it nom ale ist and	anen enek onnistan, enenge, or nepan.				
off	Organize 👻				100 v	(
	Name	Publisher	Installed On	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	and the second s	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	
	ar Canon Easy-PhotoPrint EX		1/22/2011			
	👸 Canon MP600		1/22/2011			
	Canon My Printer		1/22/2011			
	23 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[®] 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[®] 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.

= Bach (Calculate	ENERGY	ENVIR	ONMENT	ECONOMICS	OPTIONS		
	ICKNIESS Eratures	ាnsulation Thickness ទ្រ Dime	Item ID: Item Description: Istem Application: nsional Standard: Calculation Type: Process Temp: Ambient Temp:	Pipe - Horizont ASTM C 585 R Heat Loss Per 850 75.0	al gid Hour	*F		
Sufface lemp Condensation Personnel Pro	Control	Insulation Layers	Wind Speed: NPS Pipe Size:	0.0 8		mph T		
Surface Temp Condensation Personnel Pro	Control Stection	Insulation Layers	Wind Speed: NPS Pipe Size: lete	0.0		mph	Lock	Thickne
Surface Lemp Condensation Personnel Pro	Control stection	Insulation Layers Add De # Type Base Metal	Wind Speed: NPS Pipe Size: lete Name Steel	8		mph v in	Lock	Thicknee
Surface Lemp Condensation Personnel Pro	Control stection	Insulation Layers Add De # Type Base Metal 1 Insulation	Wind Speed: NPS Pipe Size: NPS Pipe Size: Name Steel 850F Mineral Fi	ber PIPE, Type I,	c547-11	mph v in	Lock Thickness	Thicknee

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 ENVI	RONMENT ECONOMICS	OPTIONS			
1 ZON V	Insulation Thickness					
ERGY	Item	ID: 1				
K ASTAN	Item Descriptio	on:				
	System Application	on: Pipe - Horizontal	÷	-		
XXXXXXX	Dimensional Standar	rd: ASTM C 585 Rigid	-			
	Calculation Typ	e: Personnel Protection	-			
	Process Ten	np: 800		°F		
Inface Temperatures	Ambient Ten	1p: 90		°F		
ondensation Control	Wind Spee	ed: 0.0		mph		
er sonner Protection	Max Surface Ten	np: 140.0		۴F		
	NPS Pipe Siz	28: 12		. in		
	Insulation Layers					
	Insulation Layers				Look	Thickness
	Insulation Layers Add Delete # Type Name				Lock	Thickness
	Insulation Layers Add Delete # Type Name Base Metal Steel			T	Lock Thickness	Thickness
	Insulation Layers Add Delete Type Name Base Metal Steel 1 Insulation 850F Minera	Fiber PIPE Type I CS47-11		1	Lock Thickness Vary	Thickness
	Insulation Layers Add Delete Type Name Base Metal Steel 1 Insulation 850F Minera Jacket Material 0,1 Aluminum	I Fiber PIPE, Type I, CS47-11 n, oxidized, in service			Lock Thickness Vary	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	
	Base Metal	Steel		
1	Insulation	Steel	Vary	
	Jacket Material	Stamless Steel Copper PVC		
		PVC		

sulation Layers	1000F MF BLANKET, Type V, C553-02 1200F MF BLANKET, Type VI, C553-02 Polystyrene PDE, Type XIII, C578-07 Polystyrene BOARD, Type IV, C578-07 PIR, Gr 1, Types I, and II, C591-07 MF Metal Mesh BLANKET, Type II, C592-04 Perite BLOCK-PIPE, C610-07 450F MF BOARD, Type IB, C612-04 850F 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	III	'n	pn
Add Del	e 850F Min.Fiber Pipe and Tank, Type IIIB, C1393-00a 1000F Min.Fiber Pipe and Tank, Type IVB, C1393-00a			
# Туре	Melamine PIPE+FLAT, C1410-05a Polyolefin SHT+TUBE, C1427-04 Debrimier SHT+TUBE, C1427-04		Lock Thickness	Thickness
Base Metal	Duct Wrap, 0.75 pcf, C1290	-		
1 Insulation	850F Mineral Fiber PIPE, Type I, C547-07	÷	Vary	1

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:

and the second second	ENERGY	ENVIRONMENT	ECONOMICS	OPTIONS		
INSULATION THICKNESS Surface Temperatures Condensation Control Personnel Protection	Insulation Thickness Item Dr System A Dimensional Calcula Proc Amb Wi Max Surf NPS	Item ID: 1 escription: pplication: Standard: ASTM C 585 Ri Personnel Prote ess Temp: 90 dd Speed: 0.0 ace Temp: 140.0 Pipe Size: 12	al gid Lection	<pre></pre>		
	Insulation Layers					
	Insulation Layers Add Delete # Type Nam	e			Lock Thickness	Thickness
	Insulation Layers Add Delete # Type Nam Base Metal Steel	e			Lock Thickness	Thickness
	Add Delete # Type Nam Base Metal Steel 1 Insulation 850F	e Mineral Fiber PIPE, Type I, (c547-11	×	Lock Thickness Vary	Thickness

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

Back Calculate	ENERGY	ENVIRO	NMENT	ECONOMICS	OPTIONS	
1200	Personnel Protection	Report				
ERGY		item ID:	1			
A A A A A A A A A A A A A A A A A A A		Item Description:				
		System Application:	Pipe - Horizontal			
KXXX	Dir	mensional Standard:	ASTM C 585 Rigid			
		Calculation Type:	Personnel Protecti	on		
NSULATION THICKNESS		Process Temp:	800		*F	
Condensation Control		Wind Sneed:	90		mnh	
Personnel Protection		Max Surface Temp	140.0		•F	
	Onen Audit File					
		_1.				
	Quantity (ft or ft^2):		Append To Ar	udit	
	Variable Insulation Thickness	Surface Temp (°F)	Heat Loss (BTU/hr/ft)	Efficiency (%)		-
	Bare	794.8	14020.00			
	0.5	434.5	1848.00	86.82		
	1.0	324.8	1208.00	91.38		
	1.5	268.4	907.10	93.53		
	2.0	234.2	733.80	94.77		
	2.5	211.1	621.40	95.57		
	3.0	194.5	542.60	96.13		
	3.5	181.9	484.30	96.55		
		170.0	400.40	06.97		

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

Variable Insulation Thickness	Surface Temp (*F)	Heat Loss (BTU/hr/ft)	Efficiency (%)	5	
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	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° F is less than the maximum specified of 140.0° F. The program also gives you the heat loss as 297.10 Btu/hr/ft (of pipe length) with an efficiency of 97.88%.

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

Chapter 2 Options

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

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

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

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

	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	1			-	_	_	_	_	-	-		_
	E	NER	GY ENVIRONMENT E	соном	ics	OP	TIONS					
GENERAL OPTIONS Program Defaults	Insulat	ion Ma dd	terial Edit Delete Activate						Tempe	erature P	oints	Conduct
INSULATION MATERIAL Maintenance		D	Material Name	Active	Created By	Туре	Max Temp	^	*	Row	remperature	Conduct
	•	1	MF Insulating CEMENT, C195-07	True	System	5	1900					
FUEL TYPES		2	Insul + Finish CEMENT, C449-07	True	System	5	1200					
A REAL PROPERTY AND A REAL		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 Inforr Name:	nation		Conductivity Data Type Paired Data
lax. Temp	Min. Temp	Active:	Polynomial
Generic			1
Fiber Glass	1	-]
1		Livity	
1 2 3 4		avray	
1 2 3 4 5 6		атту	
1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2		Arry	
1 2 3 4 5 6 7 8		Arry	
1 2 3 4 5 6 7 8 9		Arry	

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-ft² - °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:	l Informa	tion			Conductivity Data	Туре
Generic	c Insulati	on			Paired Data	ial
Max. Te	emp	Min. Temp	Active:		Polynomial	
1200		0	True	-		
Generic	0					
Fiber G	lass			-		
2	400		0.39			
2	400		0.39			
2 3 4	400 600		0.39 0.56 0.74			
2 3 4 5	400		0.39 0.56 0.74			
2 3 4 5 6	200 400 600		0.39 0.56 0.74			
2 3 4 5 6 7	200 400 600		0.39 0.56 0.74			
2 3 4 5 6 7 8	200 400 600		0.39 0.56 0.74			
2 3 4 5 6 7 8 9	200 400 600		0.39 0.56 0.74			
2 3 4 5 6 7 8 9 1	200 400 600		0.39 0.56 0.74			
2 3 4 5 6 7 8 9 1	200 400 600		0.39 0.56 0.74			

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.

		1		1			-				
	ENERGY	ENVIRONMENT E	CONOM	CS	ÖP	TIONS					
GENERAL OPTIONS	Insulation Materi	ial	_	-	_	_		Tempe	rature	Points	_
Program Defaults	Add	Edit Delete Activate							Rov	/ Tempera	ature Condu
INSULATION MATERIAL	D	Material Name	Active	Created By	Туре	Max Temp	^		1	200	0.39
	14 P	olystyrene PIPE, Type XIII, C578-07	True	System	5	165			3	600	0.74
FILEL TYPES	15 P	olystyrene BOARD, Type IV, C578-07	True	System	5	165		•*			
roce mes	16 P	NR, Gr 1, Types I,and II, C591-07	True	System	5	300					
	17 P	IR, Gr 2, Type IV, C591-07	True	System	5	300					
JACKET MATERIAL	18 M	IF Metal Mesh BLANKET, Type II, C592-04	True	System	2	1200					
	19 P	Perlite BLOCK+PIPE, C610-07	True	System	3	1200					
BASE METALS	20 4	50F MF BOARD, Type IB, C612-04	True	System	1	450					
	21 8	SOF MF BOARD, Type II, C612-04	True	System	1	850					
	22 1	000F MF BOARD, Type III, C612-04	True	System	1	1000					
	23 1	200F MF BOARD, Type IVB, C612-04	True	System	2	1200					
	24 1	800F MF BOARD, Type V, C612-04	True	System	2	1800					
	25 H	ligh Temp Fiber Blanket, Gr 6, C892-05	True	System	1	3000					
	26 G	Glass Fiber Felt, C1086-96(2004)	True	System	1	1200					
	27 P	henolic Sheet+TUBE, Gr 1, Type II and III, C112	True	System	5	257					
	28 6	50F Min.Fiber Pipe and Tank, Type II, C1393-00a	True	System	1	650					
	29 8	50F Min.Fiber Pipe and Tank, Type IIIB, C1393	True	System	1	850	=				
	30 1	000F Min.Fiber Pipe and Tank, Type IVB, C139	True	System	2	1000					
	31 M	felamine PIPE+FLAT, C1410-05a	True	System	5	350					
	32 P	olyolefin SHT+TUBE, C1427-04	True	System	5	200					
	33 P	Polyimide,Type I, C1482-04	True	System	5	400					
	34 D	Duct Wrap, 0.75 pcf, C1290	True	System	1	250					
	35 D	Duct Wrap, 1.0 pcf, C1290	True	System	1	250					
	36 D	Duct Wrap, 1.5 pcf, C1290	True	System	1	250					
	▶ 37 G	Seneric Insulation	True	User	1	1200		. 4.			

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**:

	4	ENER	GY EN	VIRONMENT	EC	CONOMI	cs	OP	TIONS				
GENERAL OPTIONS	FuelT	ypes				_		_	_	Pol	utants		
Program Defaults	A	dd	Edit D	elete Act	tivate				_		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
	E F	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	0.2337
		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			-	1.000	1	1					
DHOL METHES													

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

	Information		
Name:			Active:
Natural Gas			True
Cost:	Units (ie: \$/gallon):		
9.50	\$/Mcf		
BTU:	Units (ie: BTU/ft ^s):		
1026	Btu/cuft		
Unit Cost Fa	ctor (ie: Unit Cost Facto	r * Cost / Heat	Content)
0.001			
Pollutants			
Pollutants The first thro may add dat	ee pollutants (CO2, NO) ta for up to five addition	c, and CE) are al pollutants.	required but you
Pollutants The first thro may add dat Name	ee pollutants (CO2, NO) ta for up to five addition Lbs / 10^6 Btu	k, and CE) are al pollutants. Name	required but you Lbs / 10^6 Btu
Pollutants The first thro may add dat Name CO2	ee pollutants (CO2, NO2 ta for up to five addition Lbs / 10^6 Btu 116.53	k, and CE) are al pollutants. Name	Lbs / 10^6 Btu
Pollutants The first thro may add dat Name CO2 CO2 MT	ee pollutants (CO2, NO; ta for up to five addition Lbs / 10^6 Btu 116.53 0.052857	k, and CE) are al pollutants. Name	Lbs / 10^6 Btu
Pollutants The first thro may add dat Name CO2 CO2 MT NOx	ee polutants (CO2, NO2 ta for up to five addition Lbs / 10^6 Btu 116.53 0.052857 0.23373	k, and CE) are al pollutants. Name	Lbs / 10^6 Btu

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

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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):

Edit Units Help	-	_			_	_
	E	NER	GY ENVIRONMENT ECONOMICS	OPTIONS		
GENERAL OPTIONS Program Defaults	Jacket	Mater dd	als Edit Delete Activate			
INSULATION MATERIAL Maintenance		D	Material Name	Active	Created By	Emittance
	•	1	Aluminum, new, bright	True	System	0.0
FUEL TYPES		2	Aluminum, oxidized, in service	True	System	0.
		3	Stainless Steel, new, cleaned	True	System	0.1
		4	Stainless Steel, dull, in service	True	System	0.
JACKET MATERIAL		5	Iron or Steel	True	System	0.
		6	Copper	True	System	0.
BASE METALS		7	Painted Metal	True	System	0.
		8	Galvanized steel, new, bright	True	System	0.
		9	Galvanized steel, dipped or dull	True	System	0.2
		10	All Service Jacket	True	System	0.
		11	Aluminum Paint	True	System	0.
		12	Canvas	True	System	0.
		13	Roofing felt and black mastics	True	System	0.9
		14	Colored mastics	True	System	0.9
		15	PVC Jacketing	True	System	0.5

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:

	E	NER	GY ENVIRONMENT ECONOMICS OPTIONS			
GENERAL OPTIONS Program Defaults	Base	Metals dd	Edit Delete Activate			
INSULATION MATERIAL Maintenance		D	Material Name	Active	Created By	Emittance
	•	1	Steel	True	System	0.8
FUEL TYPES		2	Stainless Steel	True	System	0.3
Totte Thires		3	Copper	True	System	0.6
An alternative states and		4	PVC	True	System	0.9
IACKET MATERIAL	*			1.1		

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:

le Edit Units Help					
< Back Calculate	ENERGY	VIRONMENT	ECONOMICS	OPTIONS	
	Insulation Thickness				
NERGY		tem ID: Example Probl	em No. 1		
	Item Desc	ription:			
	SystemAppi	Pipe - Horizon	tal		•
	System	ASTM C585			· ·
ANY R MAR TRUE	Calculation	Type: Personnel Pro	tection		•
INSULATION THICKNESS	Process	Temp: Personnel Pro	tection		۴F
Surface Temperatures	Ambient	Temp: Condensation	Control		۴F
Condensation Control	NPS Pipe	e Size: Interface Tem	peratures		in
Personnel Protection	Wind 5	Speed: Heat Loss Per	Year		mph
	Max Surface	Heat Loss Per	Hour		°E
	Max Surface	insulation inic	Kness Table		

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.

Insulation Thickness Item D: Example Problem No. 1 Item Description: System Application: System Application: System Units ASTM C585 Calculation Type Personnel Protection Process Temp: 600 F F Supersonnel Protection F Supersonnel Protection F Supersonnel Protection F Supersonnel Protection S S Supersonnel Protection S S Supersonnel Protection S S Supersonnel Protection S S S S S S S S S S S S S S S S S S S	salediate	ENERGY	ENVIRONMENT ECONOMICS OPTIONS					
# Type Name Lock Thickness	NULATION THICKNESS Burface Temperatures Condensation Control Personnel Protection	Insulation Thickness te Syste Ca Max t Insulation Layers Add Delete	Item D: Example Proble m Description: Im Application: System Units: ASTM CS85 Personnel Prof Process Temp: 600 Amblent Temp: 90 VPS Pipe Size: 12 Wind Speed: 0.0 Surface Temp: 120	em No. 1 al			• • • • • • • • • • • •	ph :
		# Type	Name			_	Lock Thickness	Thicknes
Lase Metal Steel Insulation 850F Mineral Fiber PIPE Type I C547-07		1 Insulation	Steel	C547_07			Vary	
Jacket Material 0.1 Aluminum oxidized, in service		Jacket Material).1 Aluminum, oxidized, in serv	ice			vury	-

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.

Edit Units Help						
Back Calculate	ENERGY	ENVIRO	NMENT	ECONOMICS	OPTIONS	
ZAN	Personnel Protection	Report				
NERBY		item ID:	Example Problem No	1.1		
		Item Description:		-		
		System Application:	Pipe - Horizontal			
		System Units:	ASTM C585			
		Calculation Type:	Personnel Protection	n -		
NSULATION THICKNESS		Process Temp:	600			۴F
Surface Temperatures		Ambient Temp:	90			۴F
Personnel Protection		NPS Pipe Size:	12			in
		Wind Sneed	100			mnh
	Open Audit File					
				Lauras	5 Aug	
	Quantity (ft or ft'	2):		Append	IO AUDR	
	Variable	Surface Temp	Heatloss	Efficiency		*
	Insulation Thickness	(°F)	(BTU/hr/ft)	(%)		
	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		E
	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		

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[®] 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:

	ENERGY	ENVIRONMENT	ECONOMICS	OPT	IONS		
	Insulation Thickness	Barn Die					
ERGY		Item Description: 5		_			
	Sv	stem Application: Example Pr	obiem No. 2				
	Dimer	nsional Standard: ASTM C 58	5 Diaid				
	1	Calculation Type: Personnel I	culation Type: Personnel Protection				
		Process Temp: 1200			۴F		
Surface Temperatures Condensation Control Personnel Protection		Ambient Temp: 75.0			۴F		
		Wind Speed: 5			mph		
rer sonner rotection	Ma	ax Surface Temp: 120		-	۴		
		NPS Pipe Size: 12		-	in		
	Insulation Layers Add De	lete				Lock	Thicknes
	Insulation Layers Add De # Type	lete Name			-	Lock Thickness	Thicknes
	Insulation Layers Add De # Type Base Metal	lete Name Steel				Lock Thickness	Thicknes
	Insulation Layers Add De # Type Base Metal 1 Insulation	Name Steel 1200F Mineral Fiber PIPE, Ty	rpes II and III, C547-11			Lock Thickness Fix	Thicknes.
	Insulation Layers Add De # Type Base Metal 1 Insulation 2 Insulation	Name Steel 1200F Mineral Fiber PIPE, Ty 850F Mineral Fiber PIPE, Typ	rpes II and III, C547-11 ie I, C547-11		••••	Lock Thickness Fix Vary	Thickness 4

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

			D.	ii.	
< Back Calculate	ENERGY	ENVIRO	NMENT	ECONOMICS	OPTIONS
120WI	Personnel Protection	Report			_
NERBY		Item ID:	2		
- ASPAN		Item Description:	Example Problem I	No. 2	
		System Application:	Pipe - Horizontal		
THE AND	Dir	mensional Standard:	ASTM C 585 Rigid		
AND A SHI ALD		Calculation Type:	Personnel Protect	on	
INSULATION THICKNESS		Ambient Temp:	1200		
Condensation Control		Wind Speed:	5		mph
Personnel Protection		May Surface Temn	100		*F
	Open Audit File				
	Quantity (ft or ft ²)):		Append To Audit	
	Variable Insulation Thickness	Surface Temp (°F)	Heat Loss (BTU/hr/ft)	Efficiency (%)	
	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	
	50	119.1	536.60	03.64	

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:

1 I.I.			i i			1		_
Elensity Calculate	ENERGY	ENVIRG	NMENT	ECONOMIC	S	-	OPTIONS	0
INSULATION THICKNESS Surface Temperatures Condensation Control Personnel Protection	Insulation Thickness S Dim	Item ID: Item Description: System Application: ensional Standard: Calculation Type: Process Temp: Ambient Temp: Wind Speed: Max Surface Temp: NPS Pipe Size:	3 Example Problem Pipe - Horizontal ASTM C 585 Rigid Personnel Protect 1200 75.0 5 120 120 12	No. 3	°F °F mph °F in			. 100
	Insulation Layers	1						
	Add	Jelete						-
	Туре	Name				Lock Thickness	Thickness,	*
	Insulation	Glass Fiber Felt, C1	086-09		-	Fix	1	
	Insulation	Calcium Silicate BL	(+PIPE, Type I, C53	3-11	-	Fix	2	=
			100 C	III C547-11	-	Vary	1	
	Insulation	1200F Mineral Fiber	PIPE, Types II and					
	Insulation Jacket Material	1200F Mineral Fiber 0.9 All Service Jack	PIPE, Types II and et		-			

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 Unit	ts Help	_	-		_		
Back	Calculate	ENERGY	ENVIRO	NMENT	ECONOMIC	s	OPTIONS
1	ZOWI	Personnel Protection	Report		_	_	
NERGY			System Application.	Pipe - nonzoniai	- 14		ĺ.
K		Din	Coloulation Turou	ASTM C 585 Rigid			
No.			Process Temp:	Personnel Protect	1011.	•F	
			Ambient Temp:	75.0		۰F	L
JUN K PR	ALXIN'		Wind Speed:	5		mph	
INSULATION TH	HICKNESS		Max Surface Temp:	120		۴F	
Surface Temp Condensation	eratures 1 Control		NPS Pipe Size:	12		in	
Personnel Pr	otection		Jacket Material:	All Service Jacket			f
		Onas Aud? Ella	11				
		open Audit i lie	Jr.				
		Quantity (ft or ft^2)			App	end To Aud	t
		Variable Insulation Thickness	Surface Temp (°F)	Heat Loss (BTU/hr/ft)	Efficienc (%)	y	
		Bare	1181.9	39480.00			
		Layer 1 (1.1)	247.2	2204.00	94.42	2	
		Layer 2 (2.1)	146.0	982.70	97.51		
		0.5	132.7	824.10	97.91		
		1.0	125.2	739.10	98.13		
		1.5	119.6	676.60	98.29		
		2.0	115.2	627.90	98.41	11 C	
		2.5	111.5	588.40	98.51	1.0	
		3.0	108.5	555.60	98.59		

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:

Bash Calculate	ENERGY	ENVIRONMENT	ECONOMICS	OPTIONS			
ZENI	Insulation Thickness	-				_	_
NERGY		Item ID: 4					
K S S M		tem Description: Example Pro	blem No. 4				
	Sys	tem Application: Pipe - Horizo	ontal		-		
- NORMAR	Dimen	sional Standard: ASTM C 585	i Rigid		*		
	(Calculation Type: Condensatio	in Control		-		
SULATION THICKNESS		Process Temp: 40			۴F		
Surface Temperatures		Ambient Temp: 90			۴F		
Condensation Control Personnel Protection		Wind Speed: 0			mph		
		NPS Pipe Size: 4			▼ in		
	Cor	densation Data: 💿 Wet Bul	b Temp 86.0	モ			
		Relative	Humidity 85	%			
		Dew Po	int 84.9) IF			
	handleft of a stress						
	Insulation Layers						
	Add Dea	ale				_	
	# Type	Name				Lock Thickness	Thickness,
	Base Metal	Steel			-		
	1 Insulation	850F Mineral Fiber PIPE, Type	I, C547-11		•	Vary	
	Jacket Material	0.9 PVC Jacketing			-		-
	The second s						

lack Calcula	te ENERGY	ENVIRO	NMENT	ECONOMICS	OPTIONS		
120	Condensation Contro	ol Réport					
ERBY		Item ID:	4				
		Item Description:	Example Problem N	lo. 4			
		System Application:	Pipe - Horizontal				
	Di	mensional Standard:	ASTM C 585 Rigid				
		Calculation Type:	Condensation Cont	trol			
ISULATION THICKN	SS	Ambient Temp:	40			*F	
Condensation Cont	rol	Wind Speed:	0			mph	
Personnel Protecti	on	NDS Dine Size				in	
	Open Audit File Quantity (ft or ft*2):		Append To A	udit		
	Open Audit File Quantity (ft or ft ² 2 Variable Insulation Thickness): Surface Temp (*F)	Heat Gain (BTU/hr/ft)	Append To A Efficiency (%)	udit	_	
	Open Audit File Quantity (fl or fl*2 Variable Insulation Thickness Bare	Surface Temp (*F) 40.0	Heat Gain (BTU/hr/ft) 98.45	Append To A Efficiency (%)	udî		
	Open Audit File Quantity (ft or ft*2 Variable Insulation Thickness Bare 0.5): Surface Temp (*F) 40.0 79.6	Heat Gain (BTU/hr/ft) 98.45 23.23	Append To A Efficiency (%) 76.41	udž		
	Open Audit File Quantity (ft or ft*2 Variable Insulation Thickness Bare 0.5 1.0): Surface Temp (*F) 40.0 79.6 84.4	Heat Gain (BTU/hr/ft) 98.45 23.23 14.12	Append To A Efficiency (%) 76.41 85.65	udi		
	Open Audit File Quantity (ft or ft*2 Variable Insulation Thickness Bare 0.5 1.0 1.5): Surface Temp (*F) 40.0 79.6 84.4 86.2	Heat Gain (BTU/hr/ft) 98.45 23.23 14.12 10.73	Append To A Efficiency (%) 76.41 85.65 89.10	udž		
	Open Audit File Quantity (ft or ft*2 Variable Insulation Thickness Bare 0.5 1.0 1.5 2.0): 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	Append To A Efficiency (%) 76.41 85.65 89.10 90.99	udit		
	Open Audit File Quantity (ft or ft*2 Variable Insulation Thickness Bare 0.5 1.0 1.5 2.0 2.5): Surface Temp (°F) 40.0 79.6 84.4 86.2 87.1 87.7	Heat Gain (BTU/hr/ft) 98.45 23.23 14.12 10.73 8.87 7.67	Append To A Efficiency (%) 76.41 85.85 89.10 90.99 92.21	udit		
	Open Audit File Quantity (ft or ft*2 Variable insulation Thickness Bare 0.5 1.0 1.5 2.0 2.5 3.0): Surface Temp (°F) 40.0 79.6 84.4 86.2 87.1 87.7 88.2	Heat Gain (BTU/hr/ft) 98.45 23.23 14.12 10.73 8.87 7.67 6.75	Append To A Efficiency (%) 76.41 85.65 89.10 90.99 92.21 93.14	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° F which is above the dew point of 84.9° F. Since 86.0 > 84.9, condensation should not occur on the surface with 1.5 inches of pipe insulation with 0.9 PVC Jacket. Notice with only 1 inch of insulation, the calculated Surface Temperature is predicted to be 84.1° F, but that $84.1^{\circ} < 86.0^{\circ}$ (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° F greater than the dew point temperature.

Heat Flow

Heat Flow Limitation – Example Problem No. 5

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

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

Design Colombia		-	FORMOMOR	options		
Calculate	ENERGY	ENVIRONMENT	ECONOMICS	OPTIONS	-	
INSULATION THICKNESS	Insulation Thickness Sys Dimen	Item ID: 5 Item Description: Example Proble stem Application: Flat Surface - Isional Standard: ASTM C 585 R Calculation Type: Heat Flow Limi Process Temp: .10 Ambient Temp: 80	em No. 5 Vertical ligid Itation	* * *		
Personnel Protection		Wind Speed: 10 Heat Flow Limit: 8		mph BTU/hr	/ft^2	
Personnel Protection	Insulation Layers	Wind Speed: 10 Heat Flow Limit: 8		mph BTU/hr	/ft^2	
Personnel Protection	Insulation Layers Add Deli # Type	Wind Speed: 10 Heat Flow Limit: 8 ete		mph BTU/hr	/ff^2 Lock Thickness	Thickness,
Personnel Protection	Insulation Layers Add Deli # Type Base Metal	Wind Speed: 10 Heat Flow Limit: 8 ete		mph BTU/hr	/ft ⁺ 2 Lock Thickness	Thickness,
Personnel Protection	Insulation Layers Add Deli # Type Base Metal 1 Insulation	Wind Speed: 10 Heat Flow Limit: 8 ete Name Steel Polystyrene BOARD, Type IV, C	578-116	mph BTU/hr	Lock Thickness Vary	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.

	onits Help		-				-	
Back	Calculate	ENERGY	ENVIRO	MENT	ECONOMICS	OPTI	ONS	
	170W	Heat Flow Limitation I	Report			-		
IERD			Wind Speed:	10			mph	
			Heat Flow Limit:	8			BTU/hr/ft^2	
N			Jacket Material:	Aluminum, oxid	lized, in service			
			Jacket Emittance:	0.1			1	
	a all allo		Insulation Layer 1:	Polystyrene BC	OARD, Type IV, C578-11b		Varied	
NSULA	TION THICKNESS							
Conde	nsation Control							
Person	nnel Protection							
		Open Audit File						
		Quantity (ft or ft [^] 2)			Append To	Audit		
		Quantity (ft or ft [*] 2)			Append To	Audit		_
		Quantity (ft or ft*2)	Surface Temp	Heat Gain	Append To	Audit	_	-
		Quantity (ft or ft^2) Variable Insulation Thickness	Surface Temp (*F)	Heat Gain (BTU/hr/ft^:	Append To 2)	Audit	-	-
		Quantity (ft or ft^2) Variable Insulation Thickness Bare	Surface Temp (*F) -9.9	Heat Gain (BTU/hr/ft/* 234.80	Append To	Audit		1
		Quantity (ft or ft*2) Variable Insulation Thickness Bare 0.5	Surface Temp (*F) -9.9 65.0	Heat Gain (BTU/hr/ft^: 234.80 26.99	2)	Audit		1
		Quantity (ft or ft*2) Variable Insulation Thickness Bare 0.5 1.0	Surface Temp (*F) -9.9 65.0 71.7	Heat Gain (BTU/hr/ft ⁴² 234.80 26.99 14.81	2)	Audit		1
		Quantity (ft or ft*2) Variable Insulation Thickness Bare 0.5 1.0 1.5	Surface Temp (*F) -9.9 65.0 71.7 74.2	Heat Gain (BTU/hr/ff*) 234.80 26.99 14.81 10.22	2)	Audit		1
		Quantity (ft or ft*2) Variable Insulation Thickness Bare 0.5 1.0 1.5 2.0	Surface Temp (°F) -9.9 65.0 71.7 74.2 75.6	Heat Gain (BTU/hr/ff*) 234.80 26.99 14.81 10.22 7.80	2)	Audit		1
		Quantity (ft or ft*2) Variable Insulation Thickness Bare 0.5 1.0 1.5 2.0 2.5	Surface Temp (*F) -9.9 65.0 71.7 74.2 75.6 76.4	Heat Gain (BTU/hr/ff*) 234.80 26.99 14.81 10.22 7.80 6.31	2)	Audit		1
		Quantity (ft or ft*2) Variable Insulation Thickness Bare 0.5 1.0 1.5 2.0 2.5 3.0	Surface Temp (*F) -9.9 65.0 71.7 74.2 75.6 76.4 77.0	Heat Gain (BTU/hr/ff*) 234.80 26.99 14.81 10.22 7.80 6.31 5.29	2)	Audit		

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:

iash Calculate	ENERGY	ENVIRG	ONMENT	ECONOMICS	OPTIO	NS	
NSULATION THICKNESS Surface Temperatures Condensation Control Personnel Protection	Insulation Thickness Sys Dimen	Item D: Item Description: stem Application: ssional 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 10 120	im No. 5 al igid criess Table	•	°F °F °F	

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

port Progress		
Creating Table		
		i

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:

and the second s		-		_		_
Back Calculate	ENERGY	ENVIRONMENT	ECONOMICS	OPTIONS		
NSULATION THICKNESS Surface Temperatures Condensation Control Personnel Protection	Insulation Thickness it Syst Dimens C Max	tem ID: 7 em Description: Example Proble tem Application: Pipe - Horizont isional Standard: ASTM C 585 R alculation Type: Personnel Prot Process Temp: 350 Ambient Temp: 20 Wind Speed: 1.5 Surface Temp: 50 NPS Pipe Size: 1150	em No. 7 al igid ection	*C		
	Insulation Layers	te				
	Insulation Layers Add Dele # Type	te Name			Lock Thickness	Thickness
	Insulation Layers Add Dele # Type Base Metal	te Name Steel			Lock Thickness	Thickness
	Add Dele # Type Base Metal 1 Insulation	te Name Steel 1200F Mineral Fiber PIPE, Types	¥and W, C547-11		Lock Thickness	Thickness
	Add Dele	te Name Steel 1200F Mineral Fiber PIPE, Types 0.1 Aluminum, oxidized, in servi	¥ and W, C547-11 ce		Lock Thickness Vary	Thickness s

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

		-	-			-	_
Calculate	ENERGY	ENVIRO	MENT	ECONOMICS	OPTIONS	5	
	Personnel Protection	Report				_	
		Wind Speed:	1.5		r	n/s	
	1	Max Surface Temp:	50			с	
		NPS Pipe Size:	150		r	nm	
		Jacket Material:	Aluminum, oxidize	d, in service			
		Jacket Emittance:	0,1 1200E Mineral Eibr	PIDE Types II and III CE47	7.11	/aried	
HICKNESS peratures		madiation Layer 1.	1200F milleral Fibe	a FIFE, types it and it, Co4/	-11	/dried	
n Control							
	Open Audit File						
	Open Audit File			(
	Open Audit File. Quantity (ft or ft [*] 2)			Append To Aud	tit		
	Open Audit File Quantity (ft or ft*2) Variable	Surface Temp	Heat Loss	Append To Aud	iit	_	
	Open Audit File Quantity (ft or ft^2) Variable Insulation Thickness	Surface Temp (°C)	Heat Loss (W/m)	Append To Aud Efficiency (%)	18		
	Open Audit File. Quantity (ft or ft^2) Variable Insulation Thickness Bare	Surface Temp. (*C) 348.4	Heat Loss (W/m) 5328.00	Append To Aud Efficiency (%)	tił		
	Open Audit File. Quantity (ft or ft*2) Variable Insulation Thickness Bare 15.0	Surface Temp (*C) 348.4 132.4	Heat Loss (W/m) 5328.00 784.90	Append To Aud Efficiency (%) 85.27	tit		
	Open Audit File. Quantity (fl or ft*2) Variable Insulation Thickness Bare 15.0 25.0	Surface Temp (*C) 348.4 132.4 82.8	Heat Loss (W/m) 5328.00 784.90 462.20	Append To Aud Efficiency (%) 85.27 91.33	tit	1	
	Open Audit File. Quantity (ft or ft*2) Variable Insulation Thickness Bare 15.0 25.0 40.0	Surface Temp (*C) 248.4 132.4 82.8 63.0	Heat Loss (W/m) 5328.00 784.90 462.20 335.90	Append To Aud Efficiency (%) 85.27 91.33 93.69	tê	i	i
	Open Audit File. Quantity (fl or ft*2) Variable Insulation Thickness Bare 15.0 25.0 40.0 50.0	Surface Temp (*C) 348.4 132.4 82.8 63.0 51.6	Heat Loss (VV/m) 5328.00 784.90 462.20 335.90 262.80	Append To Aud Efficiency (%) 85.27 91.33 93.69 95.07	tê	1	İ
	Open Audit File Quantity (ft or ft*2) Variable Insulation Thickness Bare 15.0 25.0 40.0 50.0 65.0	Surface Temp (*C) 348.4 132.4 82.8 63.0 51.6 45.5	Heat Loss (VV/m) 5328.00 784.90 462.20 335.90 262.80 223.70	Append To Aud Efficiency (%) 85.27 91.33 93.69 95.07 95.80	1ê	1	
	Open Audit File Quantity (ft or ft*2) Variable Insulation Thickness Bare 15.0 25.0 40.0 50.0 65.0 80.0	Surface Temp (*C) 348.4 132.4 82.8 63.0 51.6 45.5 41.4	Heat Loss (VV/m) 5328.00 784.90 462.20 335.90 262.80 223.70 196.80	Append To Aud Efficiency (%) 85.27 91.33 93.69 95.07 95.80 96.31	tê		

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:

e Edit Units Help	_	_		_	_	_
Back Calculate	ENERGY	ENVIRONMENT	ECONOMICS	OPTION	s	
CO2, NOX & CE REDUCTION mission Reduction Table	Insulation Thickness Sy Dime Insulation Layers Add De	Item ID: 1 Item Description: Example Proble stem Application: ASTM C 585 R Fuel Type Heat Content: 1026 Efficiency: 75 Process Temp: 600 Ambient Temp: 75.0 Wind Speed: 5 Hours Per Year: 8320 NPS Pipe Size: 8	im No. 1 al Igid	▼ ▼ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■	Vcuft V	
	# Type	Name			Lock	Thickness
	Rana Matal	Staal			Thicknes	\$5
	1 Insulation	850F Mineral Fiber PIPF. Type I.	C547-11		▼ Varv	
	Jacket Materia	0.9 All Service Jacket			•	
	2		m			L K

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

1	1	1		1		
< Back Calculate	ENERGY	ENVIRO	NMENT	ECONOMICS	OPTIONS	S
	Pollutant Reduction		_			
ENVIRONMENT		Item ID:	1			
2 1 1 1 1 1		Item Description:	Example Problem N	No. 1		-
	Sj	stem Application:	Pipe - Horizontal			
	Dime	nsional Standard:	ASTM C 585 Rigid			
ACTACIÓN DE LA COMPANY		Fuel Type	Natural Gas			in the
CO2, NOX & CE REDUCTION		Heat Content:	1026		BIU	/cuπ
Emission Reduction Table		Process Temp:	600		*F	
		Amhient Temp:	75.0		•F	+
		1				
	Open Audit File					
	Open Audit File	J				
	Quantity (ft or ft^2):	ļ	-	Append To A	udit	
	Open Audit File Quantity (ft or ft*2): Variable Insulation Thickness	CO2 (lb/ft/yr)	CO2 MT (MT/ft/yr)	Append To A NOx (lb/ft/yr)	udit	-
	Open Audit File Quantity (ft or ft*2): Variable Insulation Thickness Bare	CO2 (lb/ft/yr) 7884.00	CO2 MT (MT/fb/yr) 3.58	Append To A NOx (lb/ff/yr) 15.81	udit	E
	Open Audit File Quantity (ft or ft*2): Variable Insulation Thickness Bare 0.5	CO2 (lb/ft/yr) 7884.00 1404.00	CO2 MT (MT/fbyr) 3.58 0.64	Append To A (lb/ft/yr) 15.81 2.82	udit	÷.
	Open Audit File Quantity (ft or ft*2): Variable Insulation Thickness Bare 0.5 1.0	CO2 (lb/ft/yr) 7884.00 1404.00 725.90	CO2 MT (MT/fbyr) 3.58 0.64 0.33	Append To A NOx (lb/ft/yr) 15.81 2.82 1.46	udit	F
	Open Audit File Quantity (ff or ft*2): Variable insulation Thickness Bare 0.5 1.0 1.5	CO2 (lb/ft/yr) 7884.00 1404.00 725.90 523.00	CO2 MT (MT/ft/yr) 3.58 0.64 0.33 0.24	Append To A NOx (lb/ft/yr) 15.81 2.82 1.46 1.05	udit	E
	Open Audit File Quantity (ft or ft*2): Variable Insulation Thickness Bare 0.5 1.0 1.5 2.0	CO2 (lb/ft/yr) 7884.00 1404.00 725.90 523.00 416.00	CO2 MT (MT/fb/yr) 3.58 0.64 0.33 0.24 0.19	Append To A NOx (lb/ft/yr) 15.81 2.82 1.46 1.05 0.83	udit	E
	Open Audit File Quantity (ft or ft*2): Variable Insulation Thickness Bare 0.5 1.0 1.5 2.0 2.5	CO2 (lb/ft/yr) 7884.00 1404.00 725.90 523.00 416.00 337.00	CO2 MT (MT/ft/yr) 3.58 0.64 0.33 0.24 0.19 0.15	Append To A NOx (lb/ft/yr) 15.81 2.82 1.46 1.05 0.83 0.68	udit	-
	Open Audit File Quantity (ft or ft*2): Variable Insulation Thickness Bare 0.5 1.0 1.5 2.0 2.5 3.0	CO2 (lb/ft/yr) 7884.00 1404.00 725.90 523.00 416.00 337.00 295.60	CO2 MT (MT/ft/yr) 3.58 0.64 0.33 0.24 0.19 0.15 0.13	Append To A NOx (lb/ft/yr) 15.81 2.82 1.46 1.05 0.83 0.68 0.59	udit	E
	Open Audit File Quantity (ft or ft*2): Variable Insulation Thickness Bare 0.5 1.0 1.5 2.0 2.5 3.0 3.5	CO2 (lb/ft/yr) 7884.00 1404.00 725.90 523.00 416.00 337.00 295.60 265.10	CO2 MT (MT/fUyr) 3.58 0.64 0.33 0.24 0.19 0.15 0.13 0.12	Append To A NOx (lb/ft/yr) 15.81 2.82 1.46 1.05 0.83 0.68 0.59 0.53	udit	

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 CO₂ 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[®] 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.

Calculate ENERGY ENVIRONMENT ECONOMICS OPTIONS Image: Control of the content	E Plus v4.1 Ie Edit Units Help				-			
Insulation Thickness Insulation Boor Manage Insulat	East Calculate	ENERGY	ENVIRG	NMENT	ECONOMICS	OP.	rions	
Insulation Layers Add Delete # Type Name Lock Thickness Base Metal Steel 1 Insulation 850F Mineral Fiber PIPE, Type I, C547-11 Vary Jacket Material 0.9 All Service Jacket	Calculate	ENERGY Insulation Thickness S) Dime	Item ID: Item Description: vstem Application: nsional Standard: Fuel Type Heat Content: Fuel Cost: Efficiency: Process Temp: Ambient Temp; Wind Speed: Hours Per Year:	1 Cost of Energy Pipe - Horizonta ASTM C 585 Ri Natural Gas 1026 5.00 75 600 90 0 8320	ECONOMICS	OP OP S/Mcf % 'F 'F 'F mph hrs/yr	IIONS	
		Insulation Layers Add De # Type Base Metal I Insulation Jacket Materia	NPS Pipe Size: Name Steel 850F Mineral Fil 0.9 All Service .	12 per PIPE, Type I, 4	2547-11	v in v	Lock Thickness Vary	Thickness

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:



3E Plus v4.1	lala						
< Back Calcula	te ENERGY	ENVIRO	NMENT	ECONOMICS	OPTIONS	1	
E DINDMIDS	Cost of Energy D	Item ID: Item Description: System Application: imensional Standard: Fuel Type Heat Content: Fuel Cost:	1 Cost of Energy Exa Pipe - Horizontal ASTM C 585 Rigid Electricity 3412 0.10	mple No. 1		Btu/kwh \$/kwh	
MPLE PAYBACK PE	Cuantity (ft or ft*2	Process Temn	42	Append To Au	dž		
Detailed Calculate	Variable Insulation Thickness	Cost (\$/ft/yr)	Heat Gain (kBTU/ft/yr)	Savings (\$/ft/yr)		-	
	Bare	13.32	1364				
	0.5	3.60	369	9.72			
	1.0	2.04	209	11.28			
	1.5	1.44	147	11.88			
	2.0	1.12	115	12.20			
	2.5	0.93	95	12.39			
	3.0	0.80	81	12.52			
	3.5	0.70	72	12.62			
	4.0	0.63	64	12.69			
	4.5	0.57	58	12.75			
	5.0	0.52	54	12.80			
	5.5	0.48	50	12.84			

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[®] 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	ENVID		ECONOMICS	OPTIONS			
	ENERGY	Enviro		Economico				
	Insulation Thickness		ş					
DNOMICS		Fuel Type	Natural Gas			1		
A		Heat Content:	1026			BTU/cuft		
1.1		Fuel Cost:	5.00			\$/Mcf		
		Efficiency:	75			%		
and the second second		Process Temp:	600					
COST OF ENERGY		Ambient Temp:	90			·F		
COST OF EILENOT		wind Speed.	0.0			hrefur		
The second second second second		NPS Pine Size:	8320			lin		
E PAYBACK PERIOD	Installat	tion Complexity:	12					
	Material Price, S/	ft for 2 x 2 pipe	Average		•			
CONOMIC THICKNESS insulation, including jack		ncluding jacket:	5.00					
etailed Calculation	Material Price, \$/sqft	for 2 inch thick	2.00					
	Labor Rate. S/hr inclu	iding overhead:	60.00					
	Labor Proc	Juctivity Factor:	100			-		
			100	Edit FEA Cost Data				
			1			1		
	Add Dele	te					Lock	Thicknes
	# туре	Name				1	Thickness	0
	Base Metal	Steel				-		
	1 Insulation	850F Mineral Fi	iber PIPE, Type I, C	547-11		-	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"			
Single 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:

Edit Units Help						_	
Back Calculate	ENERGY	ENVIRO	NMENT	ECONOMICS	ορτιοι	IS	
THE AVE	Thickness & Surface T	emp Report		_			_
CONOMICS		item ID:	3				
A SEA		Item Description:	Payback Period E	xample No. 3			
1.6	S	ystem Application:	Pipe				
	Dime	ensional Standard:	ASTM C 585 Rigi	1			
		Heat Content:	Natural Gas		_	BTU/cuff	
COST OF ENERGY		Fuel Cost:	5.00			S/Mcf	
		Efficiency:	75			%	
PLE PAYBACK PERIOD		Process Temp	600			*F	
	Open Audit File						
CONOMIC THICKNESS							
Detailed Calculation	Quantity (ft or ft [*] 2):			Append To	Audit		
	Insulation Thickness (in)	Insulation Cost (\$/ft)	Fuel Cost (\$/ft/yr)	Fuel Savings (\$/ft/yr)	Payback Period (yrs)	Heat Loss (kBTU/ft/yr)	<u>^</u>
	Bare		403.01	112410		62024	
	1.5	30.07	28.70	374.31	0.1	4417	
	2.0	35.60	22.87	380.14	0.1	3520	
	2.5	40.58	19.20	383.82	0.1	2955	E
	3.0	45.50	16.67	386.35	0.1	2565	
	4.0	55.47	13.40	389.61	0.1	2062	
	Double Layer	-		-			
	3.0	53.32	16.67	386.35	0.1	2565	
	4.0	66.98	13.40	389.61	0.2	2062	
	50	80.35	11.37	391.64	0.2	1750	
	5.0			202.02	0.2	1537	
	6.0	93.71	9.99	393.05	19		
	6.0 Triple Layer	93.71	9.99	393.03			

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	NMENT	ECONOMICS	OPT	IONS		
C SHAN	Insulation Thickness		_	_	_			-
INOMICS	Install	ation Complexity:	Average		+	1		
		Discount Rate:	5			%		
	Effective I	ncome Tax Rate:	0			%		
	Physical Plant Dep	preciation Period:	20			yrs		
	Expected Service	Life of Insulation	20			yrs.		
	Incremental Cost o	f Plant Capacity:	0.00			\$/MMBtu/	/hr/ft	
T OF ENERGY	Percent of New In Annual Insulati	sulation Cost for ion Maintenance:	1					
YBACK PERIOD	Percent of Annual Fue Pla	Bill for Physical ant Maintenance:	0					
	Reference Thickn	ess for Payback Calculations:	이					
MIC THICKNESS ed Calculation	Material Price, S insulation,	Wft for 2 x 2 pipe including jacket:	5.00					
	Material Price, \$/sq board or block,	ft for 2 inch thick including jacket:	2.00					
	Labor Rate, \$/hr inc	luding overhead:	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		
O 0.5*	(7) 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"	② 20 "	
O 1.5"	⑦ 7*	② 24 "	
0 2"	0 8"	() 30 "	
O 2.5*	() 9"	③ 36 *	
O 3*	O 10"	O 48 "	Close
0 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.

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

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

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

< Back Calculate	ENERGY	ENVIRONMENT	ECONOMICS	OPTIONS		
No ser As	Insulation Thickn	ess				
ECONOMICS		Item ID:	1		1	-
		Item Description:	Append to Audit Example Pr	oblem 1	1	
1.81		System Application:	Pipe - Horizontal	*]	
S 20 8/10 13/	D	mensional Standard:	ASTM C 585 Rigid		J	
The second s		Fuel Type	Natural Gas	*]	
COST OF ENERGY		Heat Content:	1026		BTU/cuft	
		Fuel Cost	5.00		\$/Mcf	
SIMPLE PAYBACK PERIOD		Efficiency.	75		%	
ECONOMIC THICKNESS		Process Temp:	600		°F	
Detailed Calculation		Ambient Temp:	90		۴F	
		Wind Speed:	0.0		mph	
		Hours Per Year.	8320		hrs/yr	
		NPS Pipe Size:	12	*] in	
						-
	Insulation Layer	s				
	Add De	lete				
	# Type	Name			Lock	Thickne
	Base Meta	Steel			THICKIC	_
	1 Insulation	850F Mineral Fiber	PIPE, Type I, C547-11		Vary	
	Jacket M	0.9 All Service Jack	et	•		
	And the second second					

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:

ate ENERGY	ENVIRONME	ENT	CONOMICS	OPTIONS	
Cost of Energy	1				
27	Item	ID: 1			
	Item Descripti	ion: Append t	o Audit Example F	Problem 1	
	System Applicati	ion: Pipe - Ho	nizontal		
	Dimensional Standa	ard: ASTM C	585 Riaid		
	Fuel T	vpe Natural G	as		
	Heat Contr	ent 1026			BTU/cuft
	Fuel C	ost: 5.00			\$/Mcf
RIOD	1				1
Open Audit					
ESS Ouantity (ft o	r #423)	-	Annend To A	udit I	
			- ippend tor	SOLUTE	
Insulation	Cost	Heat Loss	Savings		
Thickness	(\$/TD/ýr)	(KBTU/ID/yr)	(\$/Tt/yr)		
Bare	403.01	62020			
0.5	65.74	10120	337.27		
1.0	39.41	6065	363.60		
	28.70	4417	374.31		
1.5					
1.5	22.87	3520	380.14		
1.5 2.0 2.5	22.87 19.20	3520 2955	380.14 383.81		
1.5 2.0 2.5 3.0	22.87 19.20 16.67	3520 2955 2565	380.14 383.81 386.34		
1.5 2.0 2.5 3.0 3.5	22.87 19.20 16.67 14.82	3520 2955 2565 2280	380.14 383.81 386.34 388.19		
1.5 2.0 2.5 3.0 3.5 4.0	22.87 19.20 16.67 14.82 13.40	3520 2955 2565 2280 2062	380.14 383.81 386.34 388.19 389.61		
1.5 2.0 2.5 3.0 3.5 4.0 4.5	22.87 19.20 16.67 14.82 13.40 12.28	3520 2955 2565 2280 2062 1890	380.14 383.81 386.34 388.19 389.61 390.73		
1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0	22.87 19.20 16.67 14.82 13.40 12.28 11.37	3520 2955 2565 2280 2062 1890 1750	380.14 383.81 386.34 388.19 389.61 390.73 391.64		
1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5	22.87 19.20 16.67 14.82 13.40 12.28 11.37 10.62	3520 2955 2565 2280 2062 1890 1750 1634	380.14 383.81 386.34 388.19 389.61 390.73 391.64 392.39		
1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0	22.87 19.20 16.67 14.82 13.40 12.28 11.37 10.62 9.99	3520 2955 2565 2280 2062 1890 1750 1634 1537	380.14 383.81 386.34 388.19 389.61 390.73 391.64 392.39 393.02		

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		-) 🕸 😂 🖽 🔻	
My Recent Documents Desktop My Documents					
My Computer	File name:	NewAudit1 xls		×	Save
My Network	Save as type:	Microsoft Excel (*.xls)		*	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[®] folder. Clicking **Save** generates the following message:

Na	ima 🗙
	Please select the insulation thicknesses that you would like to add to the audit file, enter the quantity, and click 'Append to Audit.'
	ОК

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	E	CONOMICS	OPTIONS		
SAS AS	-Cost of Energy						
CONOMICS		Item ID:	1				19
A - W		Item Description:	Append t	o Audit Example P	problem 1		-
15		System Application:	Pipe - Ho	rizontal			
9110 31	D	imensional Standard:	ASTM C	585 Rigid			
		Fuel Type	Natural G	as			
COST OF ENERGY		Heat Content:	1026			BTU/cuft	
		Fuel Cost	5.00			\$/Mcf	
LE PAYBACK PERIOD			14.000			14.004	-
	Open Audit	C:\Documents and S	Settings\De	e p/MA			
CONOMIC THICKNESS Detailed Calculation	Quantity (ft or ft	*2): 25		Append To A	udit		
	Variable Insulation Thickness	Cost He (\$/ft/yr) (kB	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 1	3065	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			
		0.45	1454	202.56			

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

Naima		×
The data for this run l	has been added to	the audit worksheet.
	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[®] spreadsheet.

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

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

		А	В	С	D	E	F	G	Н		J	K	L	М	N	0	Р
1	1 I	D	Description	Fuel	Base Meta	Insulation	Jacket	Geometry	Fuel Efficie	Hours Per	BTU	Fuel Cost	Process Te	Ambient T	Wind Spee	Pipe Size	Insulation
1	2	1	Append to	Natural Ga	Steel	850F Mine	All Service	Pipe - Hori	75	8320	1026	5	600	90	0	12	25

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

Q	R	S	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[®], 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:

1		Α	В	С	D	E	F	G	Н	1	J	K	L	M	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 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[®] audit file may be modified to include additional information (e.g. installed cost estimates), analyze results, or generate reports as desired.

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

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

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

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

		i.	i i			
< Back Calculate	ENERGY ENV	RONMENT	ECONOMICS	OPTIONS		
A MENT	Cost of Energy			_		-
ECONOMICS	Iten	ID: 1			1	
	Item Descript	ion:				
1.41	System Applicat	ion: Pipe - Horizonti	al			
19 North 19	Dimensional Stand	ard: ASTM C 585 Ri	gid			
and	Fuel I	ype Natural Gas			DTIllaut	
COST OF ENERGY	Fuel C	ent. 1026			S/Mcf	
	Efficier	ICV: 75			%	
	Process Te	mn: 600				
SIMPLE FATBACK FERIOD	Open Audit File					
ECONOMIC THICKNESS						
Detailed Calculation	Quantity (ft or ft^2): 25		Append To Au	ıdit		
	Variable Cost Insulation (\$/ft/yr) 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[®] 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 fol	der	i = 👻 🔞
🛠 Favorites	Documents library BEPlus	Arrange by: Folder 🔻
Downloads	Name	×
Dropbox	No items o	match your search
incent Places	- Noncentra	nater your starten.
🕞 Libraries		
Documents		
J Music		
Pictures		
Videos		
the second Mar	1.0.5.104	

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:

New/	Audit - Notepad		
File Ed	dit Format View Help		
μр 1	Description Fuel Natural Gas	Base Metal Insulation Jacket Geometry Steel 850F Mineral Fiber PIPE, Type I, C547-11	Fuel Efficiency Hour: A All Service Jacket
	117		, - ,

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.