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National Insulation Association FOUNDATION For Education, Training and Industry Advancement

Insulation Energy Appraisal Program

Study Guide for Re-Certification Exam

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The Power of Insulation

- Insulation is substantially underutilized by U.S. commercial and industrial facilities despite the enormous cost and energy savings potential.

- A properly selected, specified, installed and maintained thermal insulation system is an excellent investment with high returns.

- When compared to other conservation measures, the payback is very quick — often less than 6 months — and the savings are tremendous.

- Thermal insulation is without doubt the most cost-effective technology available today that allows energy managers to conserve energy, save money and preserve the environment.

What is an Insulation Energy Appraisal?

- A tool that quantifies the amount of energy and actual dollars a facility is losing with the current in-place insulation system and demonstrates how a more efficient system could:
    - Save energy
    - Improve process control and efficiency
    - Reduce fuel bills
    - Contribute to a cleaner environment through reduced emissions

- Evaluates the thermal performance of insulated versus uninsulated processes in a facility.

- Not only puts actual dollar costs to Btu losses, it calculates green house gas emissions.

- Scope usually includes insulated lines, uninsulated lines and equipment only. Items such as small, congested lines of piping, sometimes described as spaghetti lines, are not usually included.

- An Insulation Energy Appraisal is not intended to be a total system analysis.

The Appraisal Process

The Insulation Energy Appraisal is a 5-step process and may take two to four hours or longer, depending on the size of the facility and the scope of the appraisal.

1. **Meet with and interview the facility manager or energy manager**
    - determines the scope of the appraisal, the scope of the facility's energy usage and energy distribution systems, and the cost to operate.
    - Review the facility layout, facility drawings (if available), and determine the major sources of energy serving the facility.

2. **Conduct a walk-through of facility and gather data**
    - Measure and document all applicable pipes, ducts and equipment including both **insulated** and **uninsulated** sections.

3. **Use 3E Plus® software to calculate data**
    - After the on-site visit, use the 3E Plus® computer software program to calculate data.

4. **Prepare Insulation Energy Appraisal Final Report**
   Final Report will document:
    - The fuel cost savings with the current insulation systems and the potential savings with an insulation upgrade.
    - The environmental impact in terms of reduced combustion product gases [CO_2, NO_x and other greenhouse gases (CE)] resulting from increased energy savings and reduced fuel consumption.
    - The amount of energy (Btu) loss or gain from uninsulated surfaces in the facility.
    - The amount of energy (Btu) loss or gain from insulated surfaces in the facility.
    - The amount of Btu or energy loss or gain from a pipe or vessel if the pipe or vessel is insulated to the most thermally efficient, yet cost effective, thickness determined by the 3E Plus® computer program.

5. **Presentation of Final Report**
    - Explain all financial savings information as well as energy and environmental data.
    - Identify recommendations based on analysis findings and discuss the potential return on investment possible with an insulation upgrade.
    - If requested, the appraiser may agree to provide a professional estimate regarding any insulation recommendations.

Gathering Information

- Study and verify line drawings
- Read Process and Instrument drawings (P & ID's)
- Look at "as-built" drawings, if available
- Confirm that blue prints are current
- Review facility insulation specifications
- Note equipment with special insulation requirements. These likely will give the original type(s) and locations of insulation
- Discuss the measurement system used by the plant, IP (for inch pounds,) or SI (for system international, i.e., metric.)

Things You Must Know to Complete an Appraisal

A number of questions MUST be answered in an appraisal in order for you to be able to calculate savings using the 3E Plus® computer program. These "mandatory" questions appear with a CHECK MARK (√) beside them.

The 3E Plus® Questionnaire

It is important to receive answers to questions on the list marked with a√ and those with an * in order to run the 3E Plus® program, and to arrive at an accurate final report. Answers to other questions are also needed, but defaults may be used to complete the spreadsheet.

√	1.	What are the pipe sizes most commonly used? Standard or metric?
√	2.	What is the base metal of the pipe, or equipment? Schedule 40? Stainless Steel? Copper?
√	3.	What is the geometry of the surface? Horizontal or vertical?
√	4.	What type of insulation are you currently using, if any?
√	5.	What is the external jacketing material? Is the covering a shiny or dull finish?
√	6.	What is the average ambient temperature in the area of the piping or equipment?
√	7.	What is the process temperature in the pipe or equipment?
√	8.	What is the average wind velocity at the pipe, for inside and outside applications?
√	9.	Does the energy user require a maximum insulated surface temperature? If yes, what temperature?
√	10.	What is the design relative humidity value for the area of the piping on equipment (for cold systems)?
*	11.	What type of energy do you use: gas oil, etc.?
	12.	Are you controlling a process to a certain temperature: yes or no?
*	13.	List annual number of hours of operation per system. Does the plant have scheduled down time?
*	14.	What are the different thicknesses of the insulation?
	15.	What are the energy sources: boiler or process equipment?
*	16.	How efficient is each energy source? For example, your boiler?

17. What is the cost of the energy?
18. How did you determine the thickness of insulation you currently have on your piping and equipment?
19. Do you have Process and Instrument Drawings (P & ID's) we can review?
20. Do you have insulation specifications we can review?
21. Is your insulation system designed to a maximum heat loss/gain (Btu/SF)?
22. Do your specifications apply to currently installed insulation systems?

Facility Walk-Through

Note: Most industrial facilities require the use of personal protection equipment for safety purposes. Typically this includes a hardhat, safety glasses, hearing protection, and safety shoes.

Following are suggested tools that will help make the next step of the appraisal more accurate and efficient.

- Clipboard and pencil
- A field survey form to record data.
- 3E Plus® Questionnaire.
- A tape measure and measuring wheel.
- Notes from previous meetings or telephone conversations.
- Pipe calipers: may be helpful to measure the diameter of the pipe or diameter of insulation.
- Infrared thermometer.

- Look at one complete energy supply system at a time beginning with the hottest system.

- Concentrate on all supply and return piping within the facility. The appraisal agreement should include the main energy consuming systems. Typically, the main energy consuming system is the steam piping and equipment. When evaluating a steam system include the condensate return if it is being recaptured.

- Evaluate the chilled water loops used for process cooling. Only appraise the piping out to the tracing headers and back to the heat exchanger. Include the heat exchanger vessel and the main supply and return of energy used to cool the water at the exchanger. This same process of identification will be used on all other types of thermal fluid, or liquid/gas cooling or heating system.

- If process control or safety are part of the appraisal scope, follow the same overall system approach used for identifying the main energy consuming systems.

- In refrigeration and cryogenic applications, the actual process piping can be used to cool buildings, tanks, vessels and equipment and should be evaluated as well as energy sources used to cool process lines containing product.

Inventory Systems Separately
Make an inventory of each piping system in linear feet according to process temperature, pipe size, insulation size, thickness, outer jacket, lagging, annual hours of operation, average ambient air temperature and wind speed, if exposed to the elements. (Consider wind speeds indoors when piping is near exhaust fans and intake vents.) Verify the annual hours of operation for each. These hours may match the plant's annual shutdown period, but should be verified.

Measure Pipe Lengths

- Measure pipe lengths (the insulated and the uninsulated portions) with a tape measure, a roller measurer, or estimate the lengths using a regulated walk, pace, stride, or step.

- The lengths of insulated piping and/or uninsulated piping should be approximated to the nearest foot.

- Identifying uninsulated surfaces is critical since heat loss is 20 times higher on bare surface areas.

- Pipe supports may be installed at regular intervals and may be used as a rough guide to pipe measurement.

- Define and measure the horizontal and vertical pipe runs. Uninsulated lines should be measured accurately, as this will give the best comparison, both in linear runs and in temperature.

- The pipe size data should focus on the larger systems and proceed from the energy source out to the heat exchangers.

- Uninsulated lines are impacted the most by: relative humidity, wind speed and ambient temperature. Document all of these conditions.

- Check and verify the pipe maximum surface temperature, the insulation maximum surface temperature and all process temperatures.

Measure Equipment, Ducts and Vessels

Measure the dimensions of large ducts, process conveyers, ovens and vessels, and calculate their surface areas. All sides of the vessels will need to be measured. Determine square area for top, vertical sides and bottom. The various area measurements are added together to give a total square foot area calculation that is entered into the spreadsheet form.

- You do not need to inventory packaged boilers in the appraisal as they are pre-insulated from the factory.

- Collect data from surrounding systems in a specific area. Note all equipment with special insulation applications. Vessels and tanks located in congested areas should be included in your appraisal.

- Map each supply system and return system separately and document the data for later use.

Reminder for Walk-Through

- Review the mandatory 3E Plus® questions to insure that you have gathered data to answer all of the questions for each system and particularly for the "mandatory" questions.
- Verify the annual hours of operation for each system.
- Keep careful notes during the measurement process.

- Use a tape measure in tight areas and on short runs.
- Use a large diameter measuring wheel for long runs.
- Use an infrared thermometer for an accurate measurement of the sensible heat in a given system.
- In all cases the process temperature should be evaluated against the engineering data.
- Map each supply system and return system separately and enter the data on the spreadsheet.

Using 3E Plus® Computer Program

The task of determining how much insulation is necessary to save money, use less energy, reduce plant emissions, and improve process efficiency has been greatly simplified by the 3E Plus® software program. Because insulation calculations for manufacturing processes were so complex, insulation, as a viable solution for increasing the efficiency of industrial processes, was often overlooked.

3E Plus® provides calculations for many fuel types and five different surface applications. Thermal conductivity values are built in to the program for several different ASTM referenced insulation materials, but the user also has the option of supplying conductivity values for any other material.

3E Plus® Calculates:

- Heat gain or heat loss (actual dollar loss)
- Surface temperature requirements
- The thickness of insulation needed for condensation control
- The thickness of insulation needed for personnel protection
- Heat loss efficiencies versus bare pipe
- Payback period or Return on Investment (ROI)
- Emission reductions (CO_2, NO_x and CE)
- Much more

Heat transfer calculations are based on the American Society for Testing and Materials (ASTM) C680 Standard Practice for Determination of Heat Gain or Loss on Bare and Insulated Surfaces of Piping and Equipment.

Entering Data and Using Worksheets

The next step in the appraisal process is taking the data acquired during the on-site interview and facility walk-through and inputting data for each of the lines and equipment surfaces inventoried into 3E Plus® *Each system will be calculated separately.*

Manually transfer the data from the 3E Plus® Questionnaire and/or the Field Survey into the appropriate 3E Plus® program screens and allow the program to make the necessary calculations. There will be a number of different calculations made based on the findings during the walk-through and the various materials used throughout the facility.

Once all of the calculations have been made, this data is then manually entered into a *final spreadsheet* that will calculate the *total savings in dollars and Btu*. This information is then entered into a format that you will use for the Insulation Energy Appraisal Final Report that contains a summary, a display of savings to be effected and appropriate backup data.

Transferring Data to the Spreadsheet

Use MS Excel to create worksheets produced by the 3E Plus® program. Final spreadsheets already have been created and the formulas have been entered. Therefore, when you enter data from the calculations sheets produced by the 3E Plus® program, final calculations are made automatically for you.

Move the cursor to the cell in which you wish to enter data, and then enter the appropriate data. Continue doing this horizontally until you have transferred all of the data from the calculation sheets into the appropriate spreadsheet cells. Continue entering data on successive horizontal lines until you have transferred data from all of the calculation sheets produced by the 3E Plus® program.

The information should be automatically totaled in the appropriate cells and transferred to the summary totals at the bottom of the spreadsheet.

The Final Report

Ask the decision-maker for an appointment to present the information contained in the final report. The charts, tables and spreadsheets that are generated by the 3E Plus® program are part of the final report. Some of the things included in the report are as follows:

Executive Summary

An executive summary is an effective way to highlight the report findings for the decision maker. Summarizing all the facts on one page is important because an energy user's report can be extensive for a large facility. The written report may be more than the energy user wants to read or can fully comprehend. Further, an executive may want to skip to the bottom line.

• Financial Savings
- Improved process control
- Improved process efficiency
- Decreased fuel consumption

Return on Investment (ROI) based on:
- Fuel costs
- Installed costs
- Tax rates
- Economic data
- Financing costs
- Equipment depreciation
- Operating information

• Energy Savings
- Report on the fuel cost savings with the current insulation system and the potential savings with an insulation upgrade.
- Explain the environmental impact in terms of reduced combustion product gases [CO_2, NO_x and CE (carbon equivalent)] resulting from increased energy savings and reduced fuel consumption.
- Report on the amount of energy (Btu) loss or gain from uninsulated surfaces in the facility.
- Report the amount of energy (Btu) loss or gain from insulated surfaces in a facility.

• Environmental Savings (see page 13 of this Guide for more information about energy and the environment)
- Report savings in terms of reduced combustion product gases (CO_2, NO_x, and other greenhouse gases) resulting from increased energy savings and reduced fuel consumption.

• Summary
- Summarize all financial, energy, and environmental savings. provide supporting discussions on Return on Investment (ROI), payback and environmental benefits. Provide a conclusion and suggested action.

Marketing Your Appraisal Service

There are a number of basic marketing methods available for contacting energy users to introduce appraisals. For example:

- Personal Visits
- Personalized Letters
- Telephone Calls
- Networking

Identify Facility Decision-Makers Responsible for Energy Usage
These may be past and present insulation customers or new contacts.

Identify the Decision-Maker
If you are unfamiliar with a facility, the best person to contact may be the plant manager. Other potential contacts may include: the maintenance coordinator, director, manager, or maintenance supervisor; the project engineer, plant engineer, engineering manager or engineering superintendent.

Purchasing Decision Makers
According to a recent study, maintenance and engineering most often have the final say on purchasing insulation. Engineering appears to have a greater impact on the final purchase decision in companies that focus on new capital projects.

Why Energy Users Purchase Insulation
The same study cited a number of reasons why energy users purchase insulation (in order of importance):

- Routine maintenance
- Plant expansion
- Process change or modification
- Reduction of energy consumption
- Laws or regulations

Presenting the Program to Potential Customers

Develop a professional presentation so that you do not waste the energy user's time. Find a common thread that can be used in the initial call or visit. This common thread could be energy consumption, environmental concerns, or the knowledge of insulation performance.

Explain that the final report will:

- Describe opportunities for improvement
- Highlight properly insulated systems
- Document savings in actual costs

Explain the Benefits of an Appraisal

- Increase energy savings
- Protect equipment and personnel
- Increase process efficiency
- Prevent condensation
- Prevent excessive heat in fire hazard areas
- Control noise
- Maintain temperature
- Reduce greenhouse gases

An Insulation Energy Appraisal can demonstrate how to:

- Save hundreds of thousands of Btu
- Improve process control and efficiency
- Decrease fuel consumption, thereby reducing fuel bills and a plant's impact on the environment.

Basic Insulation Science

Ambient Temperature. The average temperature of the medium, usually air, surrounding an object under consideration.

Btus. Heat is measured in British Thermal Units (Btus). One Btu is the amount of heat needed to raise the temperature of one pound of water by one degree Fahrenheit. Btus are especially important when you need to measure and compare the ability of a material to act as an insulator.

CE. Carbon Equivalents. Estimates of greenhouse gas emissions are presented in units of millions of metric tons of carbon equivalents (MMTCE), which weights each gas by its GWP value, or Global Warming Potential.

C-Factor (Value). "C" Factor is the number of Btus that will pass through 1 square foot of material with 1°F temperature difference for a specified thickness. The "C" Factor is the "k" Factor divided by the thickness of the insulation. The formula is the reciprocal of the R-Factor formula. The lower the "C", the better the insulator.

Conduction is direct heat flow through solids. It results from the physical contact of one object with another. Heat is transmitted by molecular motion. Molecules transmit their energy to adjoining molecules of lesser heat content, whose motion is thereby increased.

Convection is the flow of heat (forced or natural) within a fluid. A fluid is a substance that may be either a gas or a liquid. The movement of a heat-carrying fluid occurs either by natural convection or by forced convection as in the case of a forced-air furnace.

Dew Point Temperature is the saturation temperature where water vapor and liquid occur simultaneously.

Emissivity. The ability of a surface to radiate energy as compared to that emitted by an ideal black body at the same temperature. Significant when the surface temperature of the insulation must be regulated as with moisture condensation or personnel protection.

Heat is a form of energy and everything contains heat energy in varying amounts. Heat energy always moves from hot to cold. There are three ways to transfer heat from one object to another: conduction, convection and radiation.

Humidity & Relative Humidity. Humidity is the amount of moisture in the air. Relative humidity is the ratio of the amount of water vapor actually present in the air to the greatest amount possible at the same temperature. Simply put: relative humidity is a measure of the amount of moisture in the air as compared to the maximum amount of water the air can hold. The warmer the air, the more water the air can hold.

Insulation. The material or combination of materials that retard the flow of heat energy by performing one or more of the following functions:

1. Conserve energy by reducing heat loss or gain.
2. Control surface temperatures for personnel protection an comfort.
3. Facilitate temperature control of a process.
4. Prevent vapor flow and water condensation on cold surfaces.
5 Increase operating efficiency of heating/ventilating/cooling, pumping, steam, process and power systems found in commercial and industrial installations.
6. Prevent or reduce damage to equipment from exposure to fire or corrosive atmospheres.
7. Assist mechanical systems in meeting USDA (FDA) criteria in food and cosmetic plants.
   The temperature range within the term "thermal insulation" will apply is from -73.3°C (-100°F) to 815.6°C (1500°F). All applications below -73.3°C (-100°F) are termed "cryogenic" and those above 815.6°F (1500°F) are termed "refractory".

Jacketing. A covering placed over insulation for various functions. Jacketing can be of aluminum, plastic, laminated foil-scrim-kraft treated paper, or fabric types.

k Factor. The actual k factor number for an insulation material is based on the number of Btus per hour that pass through a 1 inch thick by 1 foot square block of insulation with a 1°F temperature difference between the two surfaces.

- Materials with lower k factors are better insulators.
- Insulation materials usually have k factors less than one and are reported at what is called mean temperature.
- When comparing the insulating value of different types of insulation, it's important to look at the k factor and the mean temperature. As mean temperatures rise, so does the k factor. Also expressed in watts/meter kelvin.

Mean Temperature. To determine the mean temperature, measure the surface temperatures on both sides of the insulation, add them together and divide by two. (Operating temperature plus ambient divided by 2.)

Payback. Length of time ti takes for the savings to equal the cost (of insulation).

P & ID's. Process and Instrument Drawings consisting of piping diagrams and control schematics.

R-Factor (Value). A measure of the ability to retard heat flow rather than the ability to transmit heat. "R" is the numerical reciprocal of "U" or "C", thus R = 1/U or 1/C. Thermal resistance "R" is used in combination with numerals to designate thermal resistance values: R-11 equals 11 resistance units. The higher the "R", the higher (better) the insulating value.

Radiation is the transmission of energy through space by means of electromagnetic waves. Radiated heat moves at the speed of light through the air without heating the space between the surfaces.
An example is the warmth you feel on your skin from the sun. The sun is unbelievably hot, but the space between it and us is still unbelievably cold.

ROI. Return on Investment. The time it takes for a facility to save enough money from insulation to pay for the actual cost of the insulation...often as short as 6 months. Usually the rate at which the money used could have earned interest if not spent on insulation with the minimum being the annual cost of money rate.

Energy and the Environment

- Saving energy helps protect the environment. When we save on energy use, we help prevent greenhouse gas emissions and other forms of air pollution.

- Energy efficiency is a smart practice that helps the economy, by saving consumers and businesses millions of dollars in energy costs each year.

- Companies pursuing energy efficiency and pollution prevention projects stand to gain a competitive edge over firms that fail to make these changes.

- "Greenhouse gases" such as carbon dioxide, methane and nitrogen oxide exist naturally in the atmosphere, but are also released in great quantities as a result of human activities including the burning of fossil fuels, land use change and agriculture. Scientists predict that, given current trends of increasing emissions of most greenhouse gases, atmospheric concentrations are expected to increase through the next century.

- Insulation Energy Appraisers can educate themselves, their customers, and their suppliers on the risks associated with climate change and the opportunities available to address those risks. Insulation is one of the easiest, most cost-effective energy efficiency technologies available today to reduce energy bills and reduce emissions into the atmosphere.

- If people consume less energy, there will be less emission of greenhouse gases as the result of burning fossil fuels.

- Every time a system is insulated it improves the energy efficiency of the facility and reduces the level of emissions of greenhouse gases.

- Insulation is one of the easiest, most cost-effective energy efficiency technologies available today.
- And it is available worldwide.

Sample Test Questions

(see bottom of page for correct answers)

1. For the purpose of the appraisal, small piping or "spaghetti-like" piping should:
   a. Always be included.
   b. Not be included if it involves congested areas with short runs.
   c. Never be included.

2. Saving money and reducing emissions are two major reasons for using insulation. Which of the following are not reasons to use insulation?
   a. Reduce noise.
   b. Protect personnel.
   c. Prevent condensation
   d. Prevent vibrations.

3. How do you access the correct process temperature of the pipe, vessel or equipment?
   a. Interview the plant representative or review the Piping and Instrumentation Drawings.
   b. Check the markings on the valves and flanges.
   c. Review the piping for instrument access points and controls.

Answers:

1. b. Not be included if it involves congested areas with short runs.

2. d. Prevent vibrations.

3. a. Interview the plant representative or review the Piping and Instrumentation Drawings.