CHAPTER III

RESEARCH OBJECTIVES AND METHODOLOGY

After reviewing the four-way hot box as presented in the previous chapter, the major concern was the air conditioner must be turned on throughout the test. And since each test took 4 hours there was some considerable operational cost. This leads to a question that the air conditioner was truly necessary or not.

3.1 Research Objectives

Karno (2008) indicated that the air conditioner was required because he anticipated there might be different heat lose through the 4-inch thick EPS walls when the environment or ambient temperature varied all the time. Therefore, the objectives of this research were about investigating these conditions when running the four-way hot box.

1. **To investigate the effect of ambient temperature change due to testing time.**

Since a series of testing for *k*-value or *R*-value normally takes 4 hours, therefore, it might take a whole morning period, an afternoon period or an early night period of 2-4 hours to run. During a day, normally varies depending on these periods of a day.

2. To investigate the effect of different ambient temperature levels.

As previously indicated in the previous chapter, the differences and the changes of environment temperature significantly affect the test. Therefore, the temperature outside the box must be controlled, but at which degree?

3.2 Research Process and Tools

To organize the research experiment indicated in the research objectives, the processes involving in this research are shown in Figure 3.1, which contains the following testing procedures as:

A. To investigate the effect of the ambient temperature, three period of time in a day were considered because researchers run on a series of tests in four hour without disturbing breakfast, lunch, and dinner times. Thus, this research experiment was conducted by following the temperature series of 19 ºC to 24 ºC, 25 ºC to 30 ºC, and 30 ºC to 24 ºC to represent the testing period of morning, afternoon, and night, respectively.

B. To investigate the effect of starting ambient temperature, eight different types of starting ambient temperatures were chosen to conduct the experiment for this test by following the range of temperature that located in Chiang Mai, Thailand, around 18 ºC to 32 ºC, (TMD, 2010), which this place was already done in previous research experiment by Karno (2008). The study temperatures were

set at 18 ºC, 20 ºC, 22 ºC, 24 ºC, 26 ºC, 28 ºC, 30 ºC and 32 ºC to run the series of experiments.

The Following of Figure 3.1 shows the diagram of research procedure:

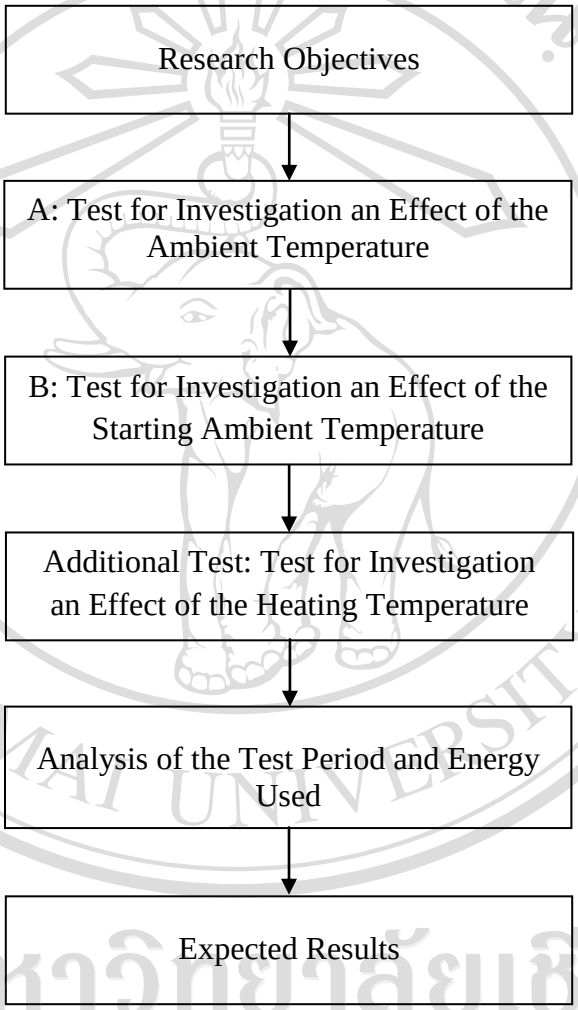

Figure 3.1 Research Procedure

3.3. Review of the Comparative Hot Box Test Method

Guarded Hot Plate (GHP) Method

Flynn et al (2005) described that the guarded hot plate apparatus is generally recognized as the primary method for measurement of thermal transmission properties of homogeneous insulation materials in the form of flat slabs. The steady-state test method has been standardized by ASTM International as ASTM Standard Test Method C 177 and by the International Organization for Standardization (ISO) as ISO 8302 with the two test methods being similar, but not identical. Instruments GHP 8302 are designed for use in test laboratories, manufacturing processes and quality control procedures for a wide range of materials with low and intermediate thermal conductivity including minerals, ceramics, glasses, plastics, mineral and glass fibers, cellular polyurethane and polystyrene etc. GHP 8302 have modular structure, which provides an easy way for calibration of embedded instruments to ensure their metrological traceability to higher standards.

Although the specimens are often rather large (0.3 x 0.3m and 0.61 x 0.61m), this usually presents no difficulty (Lasercomp, 2003). A flat, electrically heated metering section surrounded on all lateral sides by a guard heater section controlled through differential thermocouples supplies the planar heat source introduced over the hot face of the specimens. The most common measurement configuration is the conventional, symmetrically arranged guarded hot plate where the heater assembly is sandwiched between two specimens. In the single

sided configuration, the heat flow is passing through one specimen and the back of the main heater acts as a guard plane creating an adiabatic environment.

Guarded Hot Box (GHB) Method

There are two types of hot box test as the guarded hot box (an absolute method) and the calibrated hot box (a secondary method similar in form but which requires calibration using panels or materials of known thermal conductance). They are used at ambient temperatures to measure the thermal performance of building envelope components such as walls, roofs and windows. The hot box measurement standards were designed and operated of both types of hot box. And there are several international and European standards specifying hot box measurement procedures for specific structures (Shah and Curcija, 2000).

The Standard Test Method for Steady-State Thermal Performance of Building Assemblies by Means of a Guarded Hot Box (GHB) has been standardized by ASTM C-236 (ASTM C-236 Document Information, 1989). In the studies of (Kosney et al, 1999) and (Kosney and Childs, 2000), this GHB is used to measure the thermal performance of the walls components. The measurements for the wall samples have dimensions of (2.4 x 2.4 m). This apparatus consists of two chambers; one is the hot chamber and the other is the cold chamber, there are also metering boxes in the hot chamber. At the ORNL BTC, structural insulated panel (SIP) walls were tested in the guarded hot box under steady-state conditions. During the test, steady air temperatures and air

velocities were set on both surfaces of the tested wall. In the study of Kosney et al (1999), the SIP walls were not covered by any finish materials. Exterior wooden siding and interior gypsum board finish were considered only for computer modeling and the test results were presented.

Comparative Hot Box Test Method

Related to the review of thermal insulation testing method described above, Karno (2008) chose a design of the hot box test by using EPS foams for construction and he used it to evaluate thermal resistance of remains of packaging EPS foam materials in concept of comparative experiments with the reference insulations of pre known *R*-value.

According to the research procedure of Karno (2008), the experiment was processed along with three different parts. First, the research was conducted by breaking packaging EPS foam in to small pieces, which was made by three means as scratching by a papaya shredder, scratching by nail pad and hand picking, and was determined as the testing samples. Second, the test was conducted as a primary testing of hot box to construct a referent data of pre-known insulation materials for estimation of thermal resistance (*R*-value). Finally, the experiment was tested on the effect of EPS particle sizes and predicted approximate thermal resistances of specimens.

3.4. Experimental Arrangement

3.4.1. Testing Samples

To process the experiment in this research, six types of the reference samples, made from EPS forms, were designed to test for observing air temperatures inside the metering cells in case of approximated thermal resistance performance of reference insulations properties with pre-known of *R*-value. In addition, four samples were installed between heating cell and metering cells and tested as a series of experiments, simultaneously. The size of all samples were designed in 1m x 1m, (1 m^2) in surface with any different thickness of 2.5cm (1 inch), 5cm (2 inches), 7.5cm (3 inches), 10cm (4 inches), 12.5cm (5 inches), and 15cm (6 inches) and *R*-value of 0.70 ºC•m^2/W (4 °F.ft^2.h/Btu), 1.41 ºC•m^2/W (8 °F.ft^2.h/Btu), 2.11 ºC•m^2/W (12 °F.ft^2.h/Btu), 2.82 ºC•m^2/W (16 °F.ft^2.h/Btu), 3.52 ºC•m^2/W (20 °F.ft^2.h/Btu), and 4.23 ºC•m^2/W (24 °F.ft^2.h/Btu).

3.4.2. Measurement Tools

There were two kinds of measurement tools used to collect any temperatures data in metering cells, heating cell and room environment in the experimental procedure. All of those tools were called as thermometers sensors, and thermo gun, shown in Figure 3.2.

Figure 3.2 Two types of thermometers sensor, and a thermo gun

There were two types of thermometers sensors which were used in this research experiment. One type of them was made in Germany and another made in the United States. Both types of these tools had different appearance, quality and ability to work. They could be used to measure the temperature in deeper location including the value of wind velocity and humidity at the same time. The output signal was provided from the heat flux sensor and thermocouple. After that it digitized, treated the signal and then manually saved the results showing on its screen. One type of them (produced in the United States) was used to collect temperature in all four metering cells and another type was used to measure temperature inside the heating cell and the room space.

Normally, the thermo gun was used to estimate the temperature on the surface of an object to predict heat gain or loss between two sides of the object by its sensor. The gun was measured in distance between 0.8m to 1.2m from the object and the result came out after the sensor's light attaching to the surface of that object directly.

3.4.3. Room Arrangement and Temperature Control

The testing procedure was conducted in a room size of 3.5 m in length x 3.5m in wide and 3m in height and it was possible to prepare a hot and a cool air temperature condition inside the room space. The air temperatures in the room were controlled by a heater and air conditioner, which are shown in Figure 3.3. The heating machine could increase heating in the room up to 50 ˚C and automatically close by itself. On the other hand, the air conditioner could control cool air temperature in the room between 16 ˚C to 27 ˚C, too.

Figure 3.3 A heater and an air-conditioner