DETERMINATION OF THE THERMAL CONDUCTIVITY OF TRIPOLI SOIL WITH A CHANGE IN LIME AMOUNT, WATER CONTENT AND DENSITY

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Ali Mohamed K. HANDAR

ABSTRACT

M. Sc. Thesis

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Population growth is one of the causes of increasing the demand on the prime requirement of life like water, food, and energy. These prime requirements have an intensive effect on the environment, especially energy production. Thus, increasing the demand for energy and global warming leads the researchers to explore new renewable and sustainable energy resources to cover the energy demand and be more friendly with the environment. Geothermal and Thermal Geology energy is one of the methods to produce energy that took the researchers' attention due to its good results. This study aimed to examine the thermal conductivity of Tripoli soil in Libya to evaluate its capability to take advantage of the Geothermal energy. Three series have been used to conduct this process and these series are W series to examine the water content of soil sample, L series to add the ratio of lime to the samples and D series to change the density ratio of samples. In this context, the mentioned series with multiple batch were made to examine the thermal conductivity of the soil using laboratory steady-state method. Then, the definition of tests series was given to examine the thermal conductivity of Tripoli soil with a different water content in each sample (W series), examine the thermal conductivity of Tripoli soil samples with the addition of lime and keeping the water content at 10% for each sample (L series), and examining the thermal conductivity of Tripoli soil samples with different densities and keeping at 10% water content for all samples (D series). The best results associate with thermal conductivity of the soil is listed as W series, D series and L series. The maximum thermal conductivity has been obtained with 3.41 W/m.℃ in the WTS20 batch in the W series.

Key Words : Geothermal Energy, Thermal Conductivity, Tripoli Soil, Lime, Water Content, Density, Laboratory Steady-State Method, Environmental Pollution.

Science Code : 91105

ÖZET

Yüksek Lisans Tezi

TRİPOLİ TOPRAĞININ SU İÇERİĞİ VE YOĞUNLUĞU DEĞİŞKEN KİREÇ EKLENEREK ISI İLETKENLİĞİNİN BELİRLENMESİ

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Nüfus artışı, su, gıda ve enerji gibi yaşamın temel gereksinimlerine olan talebin artmasına neden olmaktadır. Bu temel gereksinimler, özellikle enerji üretimi olmak üzere çevre üzerinde yoğun bir etkiye oluşturmaktadır. Enerji talebinin artması ve küresel ısınma, araştırmacıları hem enerji talebini karşılamak hem de çevre dostu olabilecek yenilenebilir ve sürdürülebilir yeni enerji kaynakları keşfetmeye yönlendirmektedir. Jeotermal ve Termal yer enerjisi, iyi sonuçları nedeniyle araştırmacıların dikkatini çeken enerji üretme yöntemlerinden biridir. Bu çalışma ile jeotermal enerjiden yararlanma kabiliyetini değerlendirmek için Libya'daki Trablus zeminlerinin termal iletkenliğinin farklı koşullarda incelenmesi amaçlanmıştır. Çalışma kapsamında zeminlerin ısıl iletkenliği laboratuvar kararlı durum yöntemi kullanılarak farklı özelliklere sahip üç seri numune ile test edilmiştir. Bu seriler, her numunede farklı su içeriğine sahip zemin numunesi (W serisi), %10 su içeriğine sahip kireç ilaveli zemin numunesi (L Serisi) ve %10 su içeriğine ve farklı yoğunluklara sahip zemin numunesi (D Serisi) dir. Çalışma kapsamında elde edilen sonuçlar zeminin ısıl iletkenliği ile ilgili en iyi sonuçların sıralamasının W serisi, D serisi ve L serisi şeklinde olduğunu göstermiştir. Ayrıca maksimum termal iletkenliğin 3,41 W/m.℃ ile W serisinde WTS20 partisinde olduğu gözlenmiştir.

Anahtar Kelimeler : Jeotermal Enerji, Termal İletkenlik, Trablus Toprağı, Kireç, Su İçeriği, Yoğunluk, Laboratuvar Kararlı-Durum Metodu, Çevre Kirliliği.

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SYMBOLS AND ABBREVIATIONS

SYMBOLS

% : Percent Sign.

A : Area.

V : Volume.

N : Newton.

m : Meter.

cm : Centimeter.

mm : Millimeter.

s : seconds.

Kg : Kilogram.

g : Gram.

^{o}C : Degrees Celsius.

K : Kelvin.

ρ : Density.

ρb : Wet density.

ρd : Dry density.

k : Effective thermal conductivity.

□ : Thermal diffusivity.

Q : Power.

T : Temperature.

L : Lime.

Δ : The change in.

W : Watts.

J : Joll.

ABBREVIATIONS

GHG : Green House Gases.

CO_2 : Carbon Dioxide

TRT : Thermal Response Test.

ASTM : American Society for Testing and Materials.

ISO : International Organization for Standardization.

BS : British Standards.

DIN : Deutsches Institut für Normung.

GHP : Guarded Hot Plate.

$Ca(OH)^2$: Calcium Hydroxide.

PART 1

INTRODUCTION

1.1. GENERAL

Day by day, the total population is increasing, and it is projected to reach 9.0 billion by 2050 [1]. This growth in the total population is one of the causes of increasing the demand on the primary requirement of life like water, food, and energy. Massive environmental damage can be caused by the conventional methods to produce energy for different uses in life. Due to this, the energy supply systems can be considered one of the biggest challenges facing humankind. This challenge is increasing day by day with the increase of the world population. Fossil fuels used to face the energy demand can be directly related to the Green House Gases (GHG) increases in the atmosphere. When the removal processes of these gases are lesser than emissions, the concentrations of the GHGs in the atmosphere is increased. One of the gases produced during the production of energy and can increase global warming is Carbon Dioxide (CO_2). The annual emission of CO_2 is increasing significantly during the last few decades, leading to speed up global warming. Scientists reported that the warming of this planet is already started. They estimated that the Earth's temperature would rise about 2.5 °C by the year 2100 [2]. Thus, the awareness about the increase of global warming and increasing the demand for energy leads the researchers to explore new renewable and sustainable energy resources to cover the energy demand and be more friendly with the environment. Geothermal and Thermal Geology energy is one of the methods to produce energy that took the researchers' attention due to its good results in general. Geothermal power is considered a natural energy in which the heat of the ground is its source. This energy can be gained via boiling wells or boreholes to a greater depth so that heating or electric power can take use of the stems or hot water at very high temperatures.

However, this sort of energy source cannot be far-reaching. However, it is not possible to get this type of energy source far and wide. Due to this, the use of this energy is limited. On the other hand, Thermogeology energy and technology are readily available the world over. Thermogeology can be derived from the heat stored in the ground surface gained from the ground, groundwater, rivers, and streams tapped from the solar system and from the conductive flow of heat from the deep hotter zones to the cooler zones in the surface. Ground energy and heat systems may provide cooling and heating for different structures and a heat sink source in Summer and in Winter. But the efficiency of the ground in order to supply this energy should be taken into account, because this energy is supplied. All temperature characteristics determine the layers of soil. Moreover, in some civil and electrical engineers' projects for safe and proper execution, the soils' thermal properties determination is quite essential. Projects like pipelines for oil and gas, disposal in deep underground dumping places or repositories of high-voltage high-level radioactive waste, lay and bury power cables and soil modifications techniques required to determine the thermal characteristics of the soil before these projects are executed. The factors describing heat flow through the soil and the soil heat absorption capacity are in each case evaluated thermal diffusivity, heat capacity and thermal conductivity. The soil thermal conductivity is believed to play a substantial influence in regulating the heat transport through the soil under all thermal soil characteristics. Thermal conductivity is recognized as the most variable value and hardest to correctly measure in all the thermal soil properties [3].

The thermal conductance is the amount of heat transmitted in a single unit across the quantity of unit area. This transfer takes place under the influence of the temperature gradient unit. *W/m* is the thermal conductivity *SI* unit. [4]. Due to heat transfer fields and thermal conductivity relation, soil's thermal characteristics are widely different from other transfer fields. In air and water the molecular thermal conductivity is less than in solids and soils. The functure of thermal conductivity of soils is believed to include parameters such as the form of particles, mineralogy, dry density, particle volume, temperature, volumetric soil content and water content. The thermal conductivity is therefore related to the physical characteristics which will lead to change in the soil status if thermal conductivity changes. The measurement of soil thermal conductivity techniques has great difficulties because of the complex character of the soil. For example, the soil's water is impacted by temperature change, and its thermal conductivity depends on the soil's humidity level. However, as the temperature changes, the water content might also fluctuate [5].

Several academics have recently been trying to measure in different terms the heat conductivity of various soil types. In-house or utilizing laboratory procedures are employed two types of methodology to test thermal conductivity. Thermal Response Test (TRT) is the most frequent in situ test for regulating subterranean thermal conditions. This test was developed in 1995 in Sweden and America, and now this test is used in many countries all over the world [6]. However, TRT is a costly test that takes time, which only offers the average value of the soil heat conductivity together with its heat exchanger. It also has numerous drawbacks. Contrary to laboratory technology, two general methods are split. The first is the state of continuity. This technique measures the thermal conductivity of soil access thermal flux up to a certain level and the temperature of the soil specimen is constant at each point. The second lab process consists of state-specific procedures. The thermal conductivity is measured by the transient state using this approach [7].

Between the two laboratory procedures, stable methods are easier and faster than stable methods. But the procedures of instable states are not exact as the methods of steady state. Many researchers have explored these approaches and successfully controlled the thermal characteristics of many soil types. Low J.E et al. [8] for example carried out a comparison research on heat conductivity in soils comparing two methods. One is a steady-state thermal cell, and the second is a needle sample, which is a temporary technique. In an experimental investigation with the change in thermal conductivity for silty soil samples treated with limestone, Yejiao WANG et al. [9]. The impacts of organic matter, salt density concentration and soil conductivity wetness were investigated by Nidal Abu-Hamdeh et al. [10]. The thermal conductivity of sand and fine sand soils was assessed by Indra Hamdhan et al. [11]. The study has shown a difference in soil conductivity with organic matter, salt content, water content and soil texture. Soil conductivity is different.

Following a comprehensive study on soil thermal properties in Tripoli/Libya, thermal characteristics of the soil in Tripoli/Libya were not investigated yet. Tripoli has a moderate wet climate in Winter and a dry climate in Summer. Due to the measurement of thermal conductivity of the soil, it is therefore difficult to develop different sorts of projects in Tripoli. The goal of this study is to establish Tripoli soil's thermal conductivity. This research also intends to examine the effects of water content, density and addition of lime to the land on the thermal conductivity of Tripoli soil.

1.2. THE AIM OF THE STUDY

This thesis is concerned with an experimental investigation for determining Tripoli soil's thermal conductivity using laboratory techniques. This study aims to achieve the following goals:

- To test Tripoli soil's thermal conductivity.
- To examine the effect of altering the water content on the thermal conductivity of Tripoli soil.
- To examine the impact of Tripoli soil with a varied density on heat conductivity.
- To investigate the impact of adding lime to the soil on the thermal conductivity of Tripoli soil.

1.3. THESIS ARRANGEMENT

The remainder of the thesis contains several of the following chapters:

Part 1 provides a general introduction about the topic of this study in addition to provide the goal of this study.
Part 2 provides a background of the widely thermal conductivity testing methods used and previous investigations regarding this topic.
Part 3 provides the experimental part of this study by describing the soil program of the city of Tripoli in Libya to discover the thermal conductivity of the soil.
Part 4 presents and debate the findings of the study.
Part 5 provides an overview about the conclusion reached by this study.

PART 2

LITERATURE REVIEW

2.1. THERMAL ENERGY, HEAT AND TEMPERATURE

2.1.1. Thermal Energy

One of the most crucial and universal concepts of sciences in general and physics in specific is energy. The basic unit of this essential concept is the joule. 1J = 1 N-m. = 1 kg. $m^2.s^{-2}$. Thermal energy is a terminology that is used to represent the sum of the sensible and latent internal energy ingredients [2,4]. Sensible energy is described as the internal energy linked with atoms and molecules' kinetic energy within the system, where latent energy is related to the molecules' binding forces.

2.1.2. Heat

Heat is one of the forms of energy. Heat can be transferred between systems and objects with different temperatures degrees. When a cold body contacts a warm body, for instance, heat from the warmer to the cooler is transferred from. This transfer will continue until both of the body becomes at the same temperature. The loses of a quantity of thermal energy is ΔE, and the acquires quantity will be the same amount of thermal energy. It is possible to represent this transmission mechanism — heat joules are transported from the body at higher temperatures to the body at lower temperatures. Heat can, therefore, be described as the kind of energy which is transmitted between two different temperature systems [4].

2.1.3. Temperature

Temperature can be described in many ways. Basically, it expresses hot and cold using the term temperature. The scientific definition of this term is that it measures the average of translational kinetic energy associate with disorderly microscopic motion with molecules and atoms. This is scientifically defined by the average translational kinetic energy associated with the disordered microscopic movement of atoms and molecules. Thus, this system will have higher internal energy if the molecules possess higher kinetic energies. In other words, the temperature is a measure of how quickly the atoms and molecules of a matter are moving [4]. The irregular movement of the atoms and molecules is the major form of thermal energy. However, these molecules can also be subjected to other types of motion and movements, namely rotations and internal vibrations. These two forms of thermal energy do not contribute to changes in the temperature. This can explain why two matters with similar internal energy do not necessarily hold the same temperature.

2.2. FORMS OF HEAT TRANSFER

Because of a difference in temperatures heat can be transferred by passing from one object or material to another. However, heat transformation in soils is quite complicated. And this process can be in any of three forms [12]:

1. Conduction.
2. Convection.
3. Radiation.

2.2.1. Conduction

The heat transfer is achieved by interacting two objects with different temperatures which result in the interaction of the surrounding elements transferring the internal thermal energy from the body at higher tempers to the body (electrons, molecules, atoms, ions, etc.). This process, fast-moving molecules bang the slow molecules, due to this the fastmoving molecules will slow down by the slow molecules. The surface will cool down if it was hot and it was cold, it will heat up. This process will continue until the two matters become with the same temperature.

The Fourier's heat conduction law summed them with the famous law. This rule states that the heat flow ratio (dQ/dt) to solid or permeable matter can be exactly proportional to the section *(A)* area and to the heat flow gradient (dT/dL). In other words, the temperature gradient of the heat transfer rate per unit region is relative. [12]. As shown in Figure 2.1, the heat transfer rate can be expressed by Equation 1.1:

$$\frac{q}{A} \propto \frac{dt}{dx} \tag{2.1}$$

Using a proportionality constant leads us to Equation 2.2:

$$q = -kA\frac{dT}{dx} \tag{2.2}$$

Where q indicates the ratio of heat transmission, A is the cross-section of the section that is perpendicular toward the direction of the heat flow, and dT/dx signifies the temperature gradient. The k (constant proportionality) is termed the material thermal conductance and is measurable using the *W/m.K* unit. The minus sign in the equation assures that heat flows down to the lower temperature gradient.

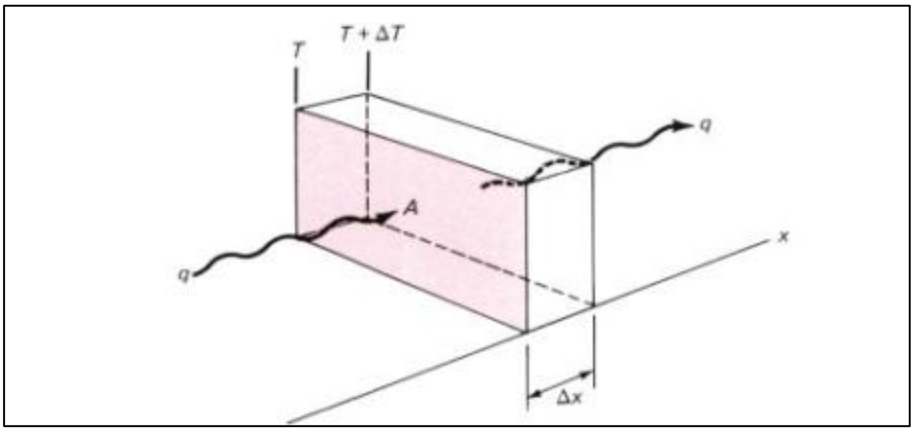


Figure 2.1. Unidirectional conduction heat transfer [13].

The heat does transfer in soils mainly by conduction [14]. Nevertheless, additional mechanisms could participate within heat transfer process measure. The soil conduction is the transmission process of thermal energy from particle to particle, or through pore fluids, i.e., Conduction happens in any of the soil mass ingredients (solids, liquid, and gas). The rate of heat transmission in soils depends heavily on thermal properties, including the temperature gradient and the soil constituents' mass fraction.

2.2.2. Convection

The transmission of the inner energy within or outside of the item through the nearby movement of the fluid can be accomplished, sending the internal energy towards the forehead of their mass. Bulk energy transfer comes from the fluid movement, though by conduction, heat is originally transferred among the object and the fluid. Convection can occur through creating convection cells or being forced by impelling the fluid crosswise the matter or by the matter through the fluid. Convection can also occur within the processes that involve a change of phase of the fluid. This happens due to the fluid motion and movement produced during the process such as the growth of a vapour bubble during heating and boiling or liquid dropping during condensation [2]. The basic rate equation as convective heat transfer is described by Isaac Newton in 1701, and his description is Newton's Cooling Law. expressed as the Equation 2.3:

$$q = hA(T - T_\infty) \quad (2.3)$$

Where q in the equation is the ratio of convective heat transfer in W, A is the area normal into the path of heat flow in m^2, T represents the temperature of surface in K unit, $T\infty$is the surrounding temperature in K, and h means the convective heat-transfer coefficient in ($W/m^2.K$).

The convection process can happen in saturated and partially saturated soils. The pore size and granular of soils are important in this process. Furthermore, convection becomes necessary in soils with granular characteristics due to their high permeability, and it is sufficient to enable groundwater to flow at a sufficient rate. In this scenario, the permeability and convection become too essential as the primary heat transmission characteristic. Through the buoyancy forces that occur from density variations generated by temperature variations practically in course dry soil. free or natural convection can be induced. In contrast, forced convection takes place if, due to variations in pressure, air or water must flow within the rock or soil pores. The flow of groundwater is an instance of the forced convection in soil or rocks. Convection might cause the thermal conductivity of the soil mass to develop considerably (up to 20 percent) [14].

2.2.3. Radiation

Radiation is described as the heat energy transfer by electromagnetic spectrum and wave motion that occurs due to the body's temperature. The waves can move and travel through space and get absorbed by other atoms. The quantity of energy absorbed by a matter depends on the object's absorptivity and the radiation's intensity striking the matter. Thermodynamic factors have been taken into account in explaining that the optimum radiator produces a ratio between the fourth absolute body power and its surface area directly [15]:

$$q_{emitted} = \sigma . A . T^4 \tag{2.4}$$

Where q in the equation is the heat transfer rate in watts' unit, σ is the Stefan-Boltzmann constant 5.699×10^{-8} in $W/m^2\ K^4$, A represents the surface area in m^2 and T represents the temperature. In soils, at normal atmospheric temperature, radiation typically performs an insignificant contribution upon heat transfer. The whole impact of radiation on the heat transmission process as it is analysed is less than 1 percent [16]. when the particle size is over 20mm, its influence could reach 10% of total heat transfer [14]. Thus, the heat transferred by radiation could be only notable for dry and coarse crushed stone material.

2.3. THERMAL PROPERTIES OF SOILS

According to several prior research, the heat transmission is determined by the thermal characteristics of the soil. Properties include thermal cleanliness *k*, specific heat *Cp* capabilities and thermal diffusiveness *α*. Equation 2.5 could relate those three parameters:

$$\alpha = \frac{k}{\rho Cp} \tag{2.5}$$

The third property may thus be determined by the knowledge of two of the thermal characteristics in conjunction with material density. The main factors for heat energy transmission through a particular material are the thermal conductivity and particular warmth. However, the volumetric heat capability or specific heat capacity is established to a fair extent depending on the fractions in the soil constitutions. The thermal conductivity is nevertheless difficult to accurately evaluate.

2.3.1. Thermal Conductivity of Soils

W/m.K is measured in thermal conductivity. A unit area may be defined in a unit time and under the unit temperature gradient [17] as the quantity of heat transferred. Thermal conductivity is connected to heat conduction in most heat transfer disciplines. Soils contained a complex in two or three phases, with holes capable of containing air, water or both organic and mineral crystals. Solids considered to be having a higher molecular thermal conductivity than air and water, and each component's thermal properties can vary considerably. The volumetric amount of soil components, particle shape, particle size, dry density, the water content and mineralogy are estimated in soil thermal conductivity using several factors. soil conductivity is computed [18]. As a result, the soil's thermal conductivity is closely related to its physical properties, meaning that any change in the soil condition will change its thermal conductivity. Both calculation methods for soil thermal conductivity have their own challenges and uncertainties due to the complexity of the soil's composition. For instance, water is a major component of soil impacted by climate change, and the thermal conductivity of the soil is significantly influenced by the moisture content that changes with the increasing temperature.

2.3.2. Heat Capacity of Soils

The heat capacity of the soil determines the amount of thermal energy needed to elevate the soil temperature by one degree [19]. This feature is provided as volumetric volume thermal heat capacity (Cv) and the amount of heat needed to raise the volume of the unit by one degree. In contrast, it is expressed as specific heat (Cp) when it is related to mass. The SI units of the explicit heat volume are $J.kg^{-1}.K^{-1}$. The soil's heat potential is influenced by the amount of moisture and the composition of the soil. Soil solids have a lower heat potential than water. Wet soil consequently has far more heat than dry soils, therefore it takes longer to warm wet soil than dry soil. This is since the amount of energy required to increase water temperature (Cv = 4180 $J.\ K^{-1}.\ m^{-1}$) by $1^{o}C$ is more than that required for soil solids warming by $1^{o}C$. The large soil capacity enables the exchange of substantial energy without changing the temperature of the ground significantly. The special heat in soil has increased when the water content of the specified majority density is raised, was observed by Abu-Hamdeh [18]. He also showed that the soil's volumetric heat capacity computed by theoretical relations agreed closely with that measured by the calorimetric method. Where Ms, Mw, and Ma were the soil mass fractions, while Cs, Cw, and Ca were the solids' fundamental heat capacity (water, and air, respectively), with a total mass of M, the specific heat of this soil mass (Cp) could be calculated by Equation 2.6:

$$Cp = \frac{1}{M}(Cs.Ms + Cw.Mw + Ca.Ma) \tag{2.6}$$

Experimentally, the actual heat could be determined by combining water and soil of varying temperatures and letting them cool to the same temperature. The mix temperature Tmix is measured using the soil temperature Ts of 0°C and a water temperature Tw 20°C. The water-soil mixture's energy balance can be written as Equation 2.7:

$$(Cs.Ts.Ms) + (Cw.Tw.Mw) = (Cs.Ms + Cw.Mw)\ Tmix \tag{2.7}$$

Where,

Ms and Mw: the masses of water and soil in (kg).
Cs and Cw: the specific heats of water and soil in (J/kgK).

2.3.3. Thermal Diffusivity of Soils

Thermal diffusivity (α) can be defined as the material capacity to transfer the difference of temperature. Expressly, the calculation of the heat transfer propagation rate. Thermal diffusivity is evaluated in units of (m^2s^{-1}), and the product of special density and heat as given in Equation 2.8 divides thermal conductivity.:

$$\alpha = \frac{k}{\rho Cp} \tag{2.8}$$

In contrast to their power to hold heat they perform heat fast, soil with high thermal diffusiveness changes its temperature quickly when exposed to temperature gradients.

2.4. FACTORS INFLUENCING THERMAL PROPERTIES OF SOILS

The thermal characteristics and thermal conductivity of soil include volumetric heat energy, thermal diffusivity and heat conservation in the soil. These features are governed by certain variables which may be divided into two classes: soil-intrinsic variables including grain-size distribution, mineralogy and structure, which can also be adjusted externally such as the temperature, water content and bulk density of the soil [20]. Thermal conductivity is the most valuable property. This has a huge influence on how much heat gets moved into the soil [5]. Mineral fragments, organic matter, and pores that may or may not contain water or air make up soil. The physical characteristics of the soil's constituents determine how effectively heat is transferred through it.

2.4.1. Moisture Content

The connection between soil water content and thermal conductivity has been highly interested [21,22]. These investigations have shown that the heat conductivity of the soil increases the water content. Two phases or three phases of soils can be classified. Given that air is significantly less than other materials' thermal conductivity, heat is only shown through contact sites between soil particles in dry surroundings. The water contents expand and the pores fill, which creates water bridges between soil grain, are further water pools in the various touch sites. [23]. The water bridges increase the heat transfer from one grain to another. As the thermal conductivity of air is slightly less than the thermal conductivity of water (0.6 W/m.K for water vs. 0.025 W/m.K for air), enhanced water content in the soil enhances its thermal conductivity in bulk. The thermal conductivity increases steadily as the moisture content grows at first, but after a certain extent, the rate of increase decreases significantly [24]. The analytical relationships given by Kersten (1949) [25] were based on numerous tests, as thermal conductivity is linear to the water logarithm content, based on several studies. By understanding the water content and dry density of soils, he was able to derive two scientific equations for predicting their thermal conductivity.

For unfrozen silt and clay soils consisting of 50 percent or more silt and clay, the first equation (Equation 2.9) is unfrozen sandy, 50% or more sludge and clay soils (Equation 2.10).

$$k = 0.1442.(0.91ogw - 0.2)10^{0.6243pd}\ For\quad w \geq 7\% \tag{2.9}$$

$$k = 0.1442.(0.91ogw - 0.4)10^{0.6243pd}\ For\quad w \geq 1\% \tag{2.10}$$

Where,

ρd: is the dry density in g/cm^3.

The link between thermal efficiency and water content is called a linear connection, by Johansen [26]. The researchers have designed the Kersten number ke principle, which is based on the degree of saturation, to quantify the thermal conductivity of partially saturated earth. Consistent with Johansen's Eq (Equation 2.11), the soil's thermal conductivity in a partially saturated state can be measured using linear interpolation between dry and saturated thermal conductivities.

$$k = (k_{sat} - k_{dry}).k_e + k_{dry} \tag{2.11}$$

Moisture migrates from hot to cold fields due to the thermal gradient generated by temperature differences. This occurrence appears in partly saturated soils and is caused by a variety of physical processes. Moisture movement, which happens in both liquid and vapor stages, allows thermal heat to be transported and temperature to be redistributed. In its completely combined research of air, heat and humidity in partly wet soil Thomas and Sansom [27] highlighted the importance of employing air step in soil thermal conductivity.

2.4.2. Dry Density

The thermal conductivity of soil is known for a long time to rise as its dry density is raised [28]. Soil density induces a change in the void ratio and porosity, leading to an effect on the soil's thermal conductivity. Water content addition in soil density enables the air volume in pore spaces to be replaced by higher thermal conductivity and increases the total thermal conductivity. In addition, soil particles are compressed and cumulated together, resulting in increased unit volume as the soil's dry density increases. This results in increased thermal conductivity and more heat flow pathways in the number of contact sites between solid particles. Many research on soil density and heat conductivity have been carried out. For example, the logarithm of dry density and thermal conductivity might be expressed in a linear manner, as seen in Kersten [25]. At different water contents, the linear relationship slope for a given soil is still roughly the same. Based on several experiments, he revealed the following equation (Equation 2.12):

$$k = A.(10)^{B.\gamma d} \quad (2.12)$$

Where,

A and B: the empirical parameters depend on the soil type.

2.4.3. Soil Constituents

Soil is composed of solid particles, covered with air, water or both pore spaces. The thermal conduciveness of the soil is determined largely by the thermal characteristics of the soil's mass components and their volume portion. For example, sands with high quartz levels have a greater thermal conductivity than sands of high plagioclase feldspar and pyroxene due [25]. Table 2.1 shows that particular important soil components, as described in the Alrtimi [29] research, are heat conductive. The difference of mineral composition between sand and clay soils clearly explains why sandy soils are more thermally conductive than clay soils. The conductivity is improving and when liquids or cementers are present the thermal conductivity of the soil mass is strengthened. The impact of the composition of the soil may be noticed while the wet soil is freezing. Because the major heat transfer method changes at the freezing point, from convection in liquid to ice transmission, the conductivity of the soil is considerably different [25].

Table 2.1. Thermal conductivity for some of soil constituents [29].

	Thermal conductivity (w/m.k)	References
Quartz	7.69	Horai (1971)
Kaolinite	2.64	Brigaud and vasseur (1989)
Illite	1.85	Brigaud and vasseur (1989)
Water	0.6096	Ramires et al. (1995)
Ice	2.22 @ 0 C	Engineering toolbox (2008)
Air	0.02619	Stephan and laesecke (1985)

2.4.4. Soil Structure or Texture

The soil structure is relevant because it defines the arrangement of solid primary and secondary particles in relation to one another, as well as their orientation in relation to the flowing heat direction. The thermal conductivity of fine-textured soil is lower than the coarse and angular textured ground. In addition, the heat conductivity of soils with good grades is greater than that of soils with equal grades. This is due to the fact that in well-graded soils, the voids between the large grains are filled by the smaller grains, resulting in a rise in conductivity. The level of contact resistance and the continuity of the solid phase are controlled by the formation of particles and the existence of bonding agents that impact its thermal conductance. Furthermore, the quantity and kind of interactions between soil particles impact the heat conductivity. This is because most heat flows through these contact points or regions, especially in terms of dry or somewhat dry soils [14].

The shape of the soil particles and the degree of compaction have a clear relationship with the number of these interactions. The clay soil parts are flat, platform shaped, with the flat surface having a negative charge and the corners having a positive charge. As a consequence, depending on whether positive or negative surface charges are in contact, attraction or repulsion forces create. Figure 2.2 shows the types of bond between plate-like clay particles. The hydration of clay soils (parallel or perpendicular) and the presence of water are dependent upon the orientation of the flat plates.

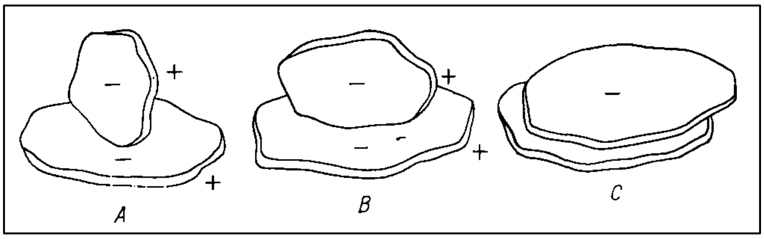


Figure 2.2. Types of bond between plate-like clay particles.

These forces can be influenced by compaction and the presence of absorbed water molecules. The influence of the structure of the soil matrix on heat and heat conductivity in geomaterials with two stages showed that the thermal conducting of more connected material is higher than that of the loosed particle material [26]. Furthermore, theoretical investigations revealed that as particle sphericity increases, particle packs' thermal conductivity decreases [30]. Clay or another binder can enhance the bonds between the sand solids. The thermal conductivity is considerably enhanced due to a better interaction between the particles. Although kaolinite has lower heat conductivity than quartz. Farouki [14] discovered that by adding a small amount of clay, the thermal conductivity of cohesion-less granular material could be significantly increased. In this study, lime would be used.

2.4.5. Article Size

The distribution of grain size is associated with the density and porosity of any soil. This characteristic so affects heat conductivity directly. The distribution of the grain size of the soil mass is linked to the number of interactions between soil particles. Many researchers have acknowledged the importance of heat transmission in interaction with soil particles, for example [31]. They conclude that the most crucial aspect governing the whole conduction is touch transport on dry or almost dry ground. For the heat transmission in complete types and situations of soils, interfacial effects between soil (air, liquid and solid) are still vital [14]. Particle size also affects the thickness of water films around the soil particles. The precise surface area, which depends on the size and shape of particles (the surface area for each unit weight or volume, is the quantity of water that is necessary to form films of a certain thickness. Clay particles have a much higher specific surface area than sands, so a film of a given thickness requires more water [32]. Thermal conductivity of soils increases as grain size increases, according to research. Tavman [33] states that this characteristic results in more particle absorption, which results in higher heat resistance between the particles, as the size of the grain declines. The outcome is more grain. The similar finding was reached when Nusier and Abu-Hamdeh [5] found that loam soil at large densities had a reduction in thermal conductivity than the sandy soil.

2.4.6. Temperature

Every ingredient has different thermal characteristics and can alter the thermal conductivity of the soil depending on temperature. If the majority of crystalline minerals in soils are evaluated as a solid phase material, then the temperature is decreasing and thermal conductivity is increased [34]. Heat is supposed to flow through compressed and longitudinal waves through crystalline materials which, as the temperature rises, become less talkative. On the other hand, gas and water thermal conductivity grows with increasing temperature [35]. Collisions in both fluids and gas between the molecules transmit heat. Any increase in molecular crashes induced by an increase in temperature hence permits an increase in thermal conductivity. The soil thermal conductivity temperature dependence has been investigated, for example, extensively [36,37]. The thermal conductivity of soils was shown to increase as the temperature increased. The increase also depends heavily on the soil water content. The heat conduction of dry sand rises when temperature drops, and vice versa, according to Brandon and Mitchill [34]. This effect has also been seen when the thermal conductivity of sand from Toyoura is roughly dry [38]. In most engineering applications, the temperature dependence of soils' thermal conductivity at temperatures above 0°C can be overlooked without a significant mistake [36]. The similar finding was reached by Hamuda [39] that the increase by 1.6 percent in the wet sand specimens' average temperatures from 25.49 °C to 38.92 °C increases thermal conductivity.

2.5. FIELD THERMAL CONDUCTIVITY MEASUREMENTS

TRT is the main method used for measuring in situ soil thermal conductivity. It was initially created in the United States and Sweden in 1995 and utilized in various regions of the world [40]. This test is an effective way of determining the thermal characteristics of the soil. This test may be carried out by inducing the heat exchanger with a set heat load, which records accurate capacity of the intake and exit of the circulating fluid. TRT can only offer a medium thermal conductivity value and a heat exchanger well, and this test usually takes 50 hours. In accordance with the line-source theory, the analysis of data depends. The approach uses the analysis solution to react in an unending, isotropic and homogenous medium to an endless constant-strength line source. At constant lateral heat flow, the w temperature field only depends on time t and radial distance from the borehole r. Garslaw and Jaeger [41] introduced the temperature field as the equation below Equation (2.13):

$$T_{(r,t)} = T_i + \frac{Q/_H}{4\pi k} \int_{\frac{r^2}{4\alpha t}}^{\infty} \frac{e^{-u}}{u} du \cong T_i + \frac{Q/_H}{4\pi k} \left[ln(\frac{4\alpha t}{r^2}) - \gamma \right] \tag{2.13}$$

Where,

Ti: the initial undisturbed ground temperature.
α: the thermal diffusivity and its equal to $k\rho c$.
Q: the constant heat injection.
H: the length of the borehole.
γ: the Euler's constant and its equal to 0.577.4

This method's error is approximately ±10%, and this error is acceptable for a reasonable prediction for theriogenology heat yield [42]. In several research this approach was explored extensively. The tests, test results, analytical models, numerical models and case studies in various nations were conducted to define the test method [43,44]. The TRT main disadvantages is a long time required to perform the test and the high cost.

2.6. LABORATORY THERMAL CONDUCTIVITY MEASUREMENTS

For the calculation of thermal conductivity, stable and transient static techniques are utilized. In both these procedures, a range of experimental techniques are utilized.

2.6.1. Steady State Experimental Techniques

When the heat flow in the soil is approaching a constant level and the temperature of the soil specimen at each site is stable over time, thermal conductivity may be calculated by using stable-state methods. For stable-state methods, it is desirable to establish a temperature differential between the sides of the soil specimen [14]. The temperature downturn across the specimen and the heat flow is the only thing necessary to determine the thermal conductivity [45]. The key disadvantage of stabilization is the amount of time needed to reach the steady-state conditions, resulting in humidity migrating from hot to cold regions.

The soils thermal conductivity is estimated by two methods based on the steady-state condition (steady flux methods): The hot plate techniques, heat flow meter apparatus, and comparative method are all part of the steady-state linear heat flow approach. The steady-state radial heat flow approach, which involves the cylindrical and spherical concentric systems, is the second. The direction of heat flux defines this classification. Total and comparable approaches can be used to identify steady flux techniques. Examples of the previous include the protected hot plate system and the methodology of the heat flow meter. In this scenario, calculations of the input power are utilized to calculate the power directly via the probe. The above is a protected technique for relative longitudinal heat flow, which uses the specimen to be studied in a sequence of thermal conductance references [37]. These two categories are based on applying Fourier's law to one-dimensional heat transport. In all cases the temperature drops through the specimen and the thermal flow is necessary [45].

2.6.2. Hot Plate Methods

The method for measuring the thermal conductivity of insulating materials has been in existence since 1898 in a variety of ways [46]. In these procedures, the specimen is sandwiched between two smooth warm and cold plates. Due to the temperature difference, a thermal gradient is created through the samples. The heat flow is the total of the heat input. The power input and cross-sectional area of the specimen are used to measure how much energy the specimen receives. The unidirectional heat transfer law of Fourier allows the use of temperature decrease, heat flow and specimen volume to estimate thermal conductivity. Accurate thermal flux measurement by the specimen depends entirely on the measurement of thermal conductivity as described above. Different devices have been created to measure soil thermal conduction, and each technique depends on the correct design of the equipment, in particular the degree to which all boundary conditions are measured.

2.6.3. Guarded Hot Plate (Ghp)

This technique is recognized for evaluating the thermal conductivity of the insulating materials and is considered to be the most trustworthy one. The method has been utilized as a standard measure by many organizations, including ASTM C177, ISO 8302, BS 874, and DIN 612 [46]. This method operates on the theory of producing a known unidirectional heat flux through an infinitely large specimen bounded by parallel planes. The heat flux is created by a heater plate, which comprises a center plate ringed by the ring guard heater plate with a small air gap. The purpose of the measuring heater is to apply the heat flow to maintain the desired temperature gradient through the surface of the specimen. The guarded heater proposes to minimize radial heat losses from the metering segment by maintaining a temperature similar to that of the metering field. On the other side of the specimen, a cold plate with a temperature lower than the hot plate is used as a heat sink. Figure 2.3 shows that main features of the guarded hot plate apparatus.

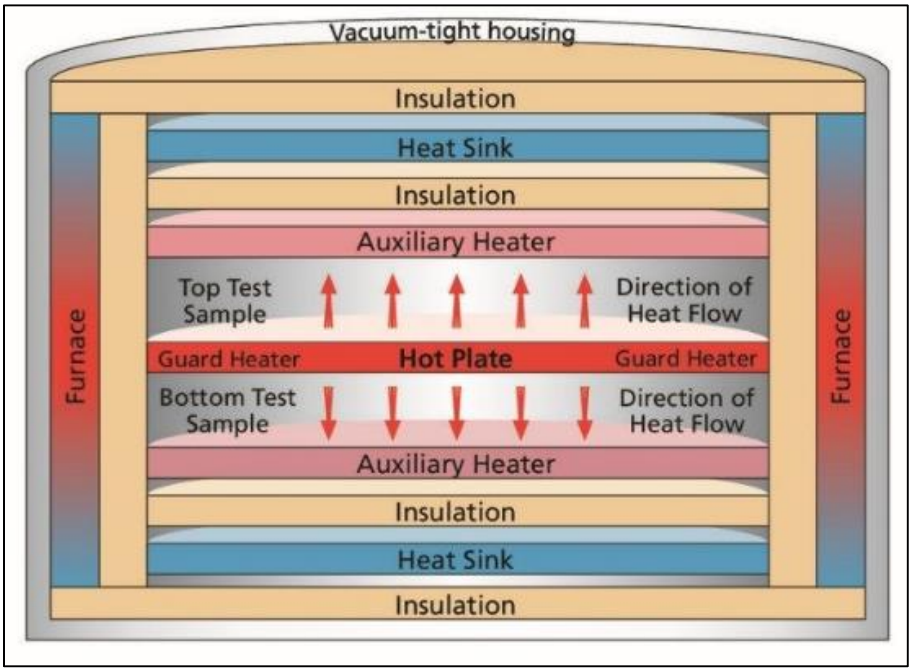


Figure 2.3. Principle characteristics of GHP apparatus [47].

Utilizing the Fourier's heat transmission equation, the efficient thermal conductance (k) is determined by using Equation 2.14 for one-dimensional thermal flows in stationary conditions:

$$k = q\, L / A\, \Delta T \tag{2.14}$$

Where,

q: the rate of heat transfer.

ΔT: the temperature drops.

L: the specimen thickness.

A: the cross – sectional area.

More advancements have recently been made to this technique. Despite the fact that these innovations are based on the same principle, there are several major variations. These improvements are related to the apparatus's size or scale; as thicker insulation has become more prevalent in tandem with instrumentation developments. Additionally, by adding external guards, radial heat losses have been limited. Furthermore, the influence of computer technology for data processing and acquisition has been important [46]. GHP is the most reliable and accurate approach used to determine thermal conductivity of isolating materials between absolute methods [48]. The major downside of this technique is the time it takes to reach a stable condition, which applies especially to materials with low heat conductivity. Furthermore, the transmission of heat across the gap through the exemplars resulting from the erroneous balancing state may be required, especially for materials with high thermal conductivity (more than 0.75 (W/m.K)).Furthermore, the procedure is only applicable to large collections [49].

2.6.4. Unguarded Hot Plate Method

This method for determining insulating homogeneous solid materials' thermal conductivity is defined in British Standard BS 874 -2-2 [50]. Since a reference material with established thermal conductivity is needed to calibrate the apparatus, the method is not considered absolute. The plates should be designed to the exact dimensions as the guarded hot plate to allow calibration by sharing specimens with the guarded hot plate. This approach is only valid for conductivity values of 0.15 (W/m.K) to 2.0 (W/m.K) according to BS guidelines, which would not encompass the full spectrum of soil thermal conductivities.

2.6.5. Heat Flow Meter Apparatus

Since the calculations are based on reference samples' thermal conductivity, the heat flow meter approach is an indirect technique. It was standardized by ASTM C 518 [51] and is usually used to estimate the thermal conductivity of insulating materials. This approach may also be categorized as a comparative, as the apparatus is calibrated using specimens with proven thermal transmission properties. Single or double specimen setups with single or double heat flux transducers sandwiched between hot and cold plates can be used in most situations. The configurations of the two forms of heat flow meter equipment are shown in Figure 2.4. The apparatus's testing should be performed with reference materials that have similar thermal conductivities and dimensions to the specimen being examined. Fourier's one-dimension thermal transfer law is applied for the calibration factor acquired with reference materials to estimate the thermal conductivity of the specimen after thermoflood through the exemplar is measured by heat flow transduc tons. According to Hostler et al. [52], this approach works well for low thermal conductivity. However, it is clear that calibrating the flow meter apparatus for all soil thermal conductivities using reference specimens is problematic for soil measurements.

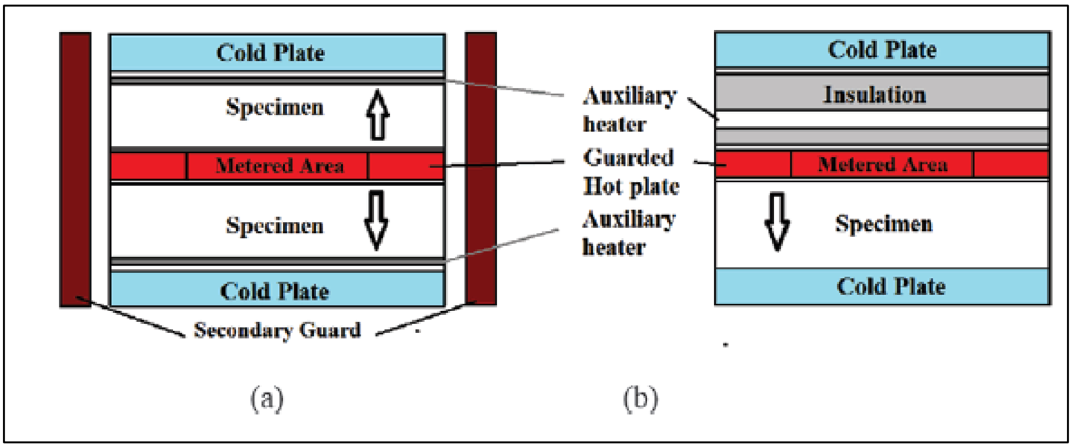


Figure 2.4. Configuration of two types of heat meter apparatus [53].

2.6.6. Guarded Comparative – Longitudinal Heat Flow Technique

Two equal specimens of standard material with thermal conductivity as described by ASTM E 1225 [54] are clamped into one test specimen. In a one-dimensional heat flow, the power per unit area is equivalent in any cross-sectional area with the column. A temperature gradient is established in the test stack and the temperature decrease is determined for each of the three specimens. Parallelly, heat losses are decreased by utilizing a longitudinal guard with a temperature differential close to that of the measuring column and isolated from it by adequate insulation. A different design is to position a heater disk in the column's center, between the specimen, meter bar, and heat sink on either side. One-half of the power will be passed into each specimen in this situation. Various metals can be used as reference material, but due to significant variations in thermocouple readings, more precise calculations can be done with comparatively low thermal [45]. It is also worth noting that the reference specimens should have a thermal conductivity that's as near as possible to the measured specimen's predicted thermal conductivity [54].

2.6.7. Concentric Cylinder Method

At the turn of the century, this approach has been used. This methodology consists of a constant thermal flow of the specimen through the radial direction instead of the linear direction of the hot plate method. When hot, the apparatus consists predominantly of an inner cylinder that serves as a line heat source and an outer cooling cylinder that serves as a drain. The apparatus diagram presented in the study of Yüksel is illustrated in Figure 2.5 [55].

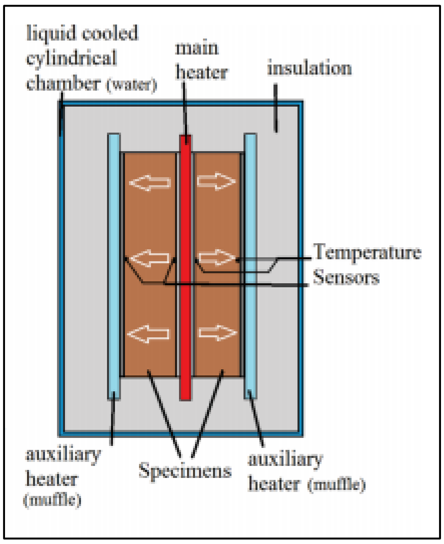


Figure 2.5. Schematic of concentric cylinder method [55].

The sample is positioned in the middle, which results in a radial thermal gradient by virtue of the temperature differential between the two cylinders. In comparison to the radius, the device is designed to reduce axial heat losses through edge supports of the cylinders. In order to estimate the thermal conductivity of the specimen after a device enters a permanent condition, Fourier's one-dimensional radial heat flow law should be utilized. This can be measured using the input power, the specimen's length and radius, and the temperature differential between the specimen's inner and outer faces in the radial direction. This approach can be used in both hot and cold environments [14]. The technique is also suitable for powdered or granular materials. The heat conductivity of glass microsphers and aerogel perls was measured at temperatures below 180 K and 80 K [56].

2.6.8. Concentric Spheres Method

The heat losses associated with the guarded hot plate and concentric cylinder methods are eliminated using this process. The heat source is situated at the centre of a spherical specimen, and all flow is directed through the control volume. In order to estimate soil specimens' thermal conductivity, Fourier's one-dimensional radial flow law may be used to the knowledge of internal and outside radius of the specimen and reduction in the temperature. This method can technically be considered the most accurate, particularly for powder and granular materials. However, spheres are costly and time-consuming to produce [39].

2.6.9. Transient State Methods

The thermal conductivity is measured using unsteady-state methods (transient methods) during the transient state. A line heat source and a temperature sensor are used in these processes. They use the fact that thermal conductivity results from the heat dissipation rate in the surrounding soil. A theoretical solution of conductor heat flux from the heat source line must be used for the thermal conductivity of the soil sample. These strategies are more versatile than static procedures, as they are easy to apply and require only a short time to calculate. They can directly assess thermal diffusivity, although they are not as precise as steady-state approaches [57]. The most popular transitory techniques are hot wiring, thermal needle (single sample) and dual sample approaches. Probe techniques, on the other hand, are more general. For more than 50 years, the probe approach has been used.

2.6.10. Transient Hot Wire Method

During this technique, a thin straight wire is inserted into the center of a soil sample in a steel container. The soil sample acts as a semi-infinite homogeneous isotropic medium, with the wire serving as a heat source. Since the wire has reached equilibrium, a steady current is applied to it. Thermocouples are used to measure the radial temperature difference in the soil. Temperature increase recorded at different diameters from the warming wire and the input power are estimated using thermal conductivity as equation 2.15:

$$K = \frac{q}{4\pi(T2 - T1)} ln(\frac{t2}{t1}) \tag{2.15}$$

Where,

q: represents power per unit length.

T1: represents time t1 temperature.

T2: represents time t2 temperature.

2.6.11. Thermal Needle Method (Single Probe)

One of the quickest and easiest techniques of evaluating the thermal characteristics of the soil is the thermal needle procedure. Hooper and Lepper utilized this technique to evaluate the soil's thermal conductivity. The thermal probes are identified and two benefits are indicated by employing a secured heating platform [58]. The thermal needle ensures less moisture migration and the process is used to analyse non-disrupted field samples. It also offers some advantages for direct measuring of thermal resistance from the data without knowing the heat capacity of the surface. The main downsides of this technique, on the other hand, are that a small change in the current delivered via the test will result in a substantial inaccuracy, with a major influence on interaction resistance with the medium [59]. The heat needle system hinges on the idea of an isotropic semi-infinite media around a line of heat supply. The rate of rise of the sensor is determined by the thermal conductivity of the attached material. The temperature increase of the sensor should be linear, if plotted against the time log, if the constant current is supplied in the thermal needle. The thermal conductivity is calculated using Equation 2.16.

$$\mathrm{k} = \frac{\mathrm{q}}{4\pi(\mathrm{T2}-\mathrm{T1})} ln\left(\frac{t2}{\mathrm{t1}}\right) \tag{2.16}$$

Where,

q: represents power per unit length.

$T1$: represents time t1 temperature.

$T2$: represents time t2 temperature.

2.7. PREVIOUS STUDIES REGARDING THE THERMAL CONDUCTIVITY OF THE SOIL

The widespread assessment of the sand models of thermal conductivity was done by Jiaming Wang et al. [60]. In addition, different sand types from dry to saturated may be evaluated by the performances of these thermal conductivity models with a broad dataset. They collect a large dataset by collecting through personal communications or by digitalizing literature data. 14 models were designed to predict the thermal conductivity of sands, and the models were evaluated using a huge collection of 1025 measures from 62 sand samples of 20 investigations. Comparing the 14 models, they aimed to find the best estimation of the thermal conductivity. After the analysis, they found 2 out of 14 models can be used for the estimation work. These two models are used to evaluate the thermal conductivity of the sand properly.

Yejiao WANG et al. [9] carried out a practical research to investigate changes in thermal conductivity of lime-treated silty soil samples. The soil samples prepared were optimum 2% dry (17%) and wet (22%) compressed and lime-dry. And at different curing periods, they have measured the thermal conductivity of soil samples, complete suction and the distribution of pores. The study results indicated that the thermal conductivity of the soil throughout curative period depends on the moulding water content of the soil. With a decreasing time for the dry compact samples, the thermal conductivity marginally rises. For the compacted samples, the impact of time curing on the thermal conductivity is insignificant.

Somenath Mondal et al. [61] investigated and described the conventional method and the thermal flux measurement method. By utilizing thermal flux dimensions, they calculate the thermal conductivity of soils and compare it with the conceptual technique. The soil investigated in this research is the sands in their dry form. The investigation demonstrated that the traditional approach to heat is homogeneous and unreasonable, which passes through the full bulk. The thermal flux measuring technique allows the difference in flux intensity to be measured together at multiple parts and multiplied uncovered temperature increases. They conclude that the thermal conductivity calculation could simply be illustrated by measuring thermal flow, as it consists of factors which can be directed. They also noted that it is very encouraging to justify thermal conductivity values based on the measurement method of thermal flow compared to those obtained from the conventional method.

The transient methods employed by Nusier and Abu-Hamdeh [5] were to study thermal conductivity of two soils based on bulk density. Sand and loam were divided into two groups. They found that the two soils enhanced the thermal conductivity of the bulk density.

Singh and Devid [24] suggested several analytical equations for estimating soils' thermal resistivity in dry and moist environments (resistivity is the inverse of conductivity). The absolute discrepancy between the thermal conductivity values of the suggested equations and test results utilizing the transient needle method was less than 15 to 20%. They also discovered that the predicted and experimental results were quite comparable when study on dry soils was conducted.

The impact of density, moisture, salt and organic matter on soil conductivity was investigated by Nidal H. Abu-Hamdeh et al. [10]. The heat conductivity of the soles was determined utilizing the single sample approach during their experimental study. The soil conductivity was discovered to change with the organic content, salt concentration, water content and soil texture. Increased volume density with a particular humidity level, increased therapeutic conductivity and increased moisture content with a specific large mass density amplified thermal conductivity were also found.

We can notice that all the mentioned studies have been implemented out of Libya and no of them were implemented in Libya and specifically in Tripoli. Jiaming Wang et al. [60] have assessed the sand model of thermal conductivity. They used 14 models of sand to test the thermal conductivity and it is shown that only 2 of them can be used to estimate the work. While Yejiao WANG et al. [9] studied the changes in thermal conductivity of lime-treated silty soil samples. The study found that the thermal conductivity of soil throughout curative periods depends on the moulding water content of soil. The study used time period and it is shown that decreasing the time for the dry compact samples, the thermal conductivity marginally rises. In our study, we have not used a time period and the period was stable with 24 hours. Also, they used the silty soil in the study and our study used sandy soil. Somenath Mondal et al. [61] studied the thermal flux measurement method by the use of thermal flux dimensions. They used the thermal conductivity of soil and compare it with the conceptual technique. They conclude that the thermal conductivity can simply be illustrated by measuring thermal flow. They also noted that it is very encouraging to justify thermal conductivity values based on the measurement method of thermal flow compared to those obtained from the conventional method. We have not used the conventional method to measure the thermal conductivity but instead steady state method has been used. Nusier and Abu-Hamdeh [5] studied the thermal conductivity of two soils based on bulk density. It is found that two soils enhanced the thermal conductivity of the bulk density. The study differs than our study where we have used one type of soil which is the sandy soil. Singh and Devid [24] suggested various analytical equations to estimate the thermal resistivity of soil in dry and moist environment. It is shown that thermal conductivity values equations and test results use the transient needle method less than 15 to 20%. In addition, it is shown that the results were quite comparable when study on dry soils. The researchers used the transient needle method while we used the steady state method and the thermal conductivity values were between 10 to 20%.

Nidal Abu Hamda and others. [10] The one-sample approach was used to study the effect of density, moisture, salt, and organic matter on soil conductivity. It is proven that increasing the volume of the density with a certain moisture level, increases the therapeutic conductivity. So, the results of our study found that increasing the density and water content will increase the thermal conductivity

PART 3

EXPERIMENTAL PROGRAM

3.1. MATERIAL

3.1.1. Tripoli Soil

In order to test the thermal conductivity of such soil, the Soil Sample has been extracted from Tripoli, Libya. The sample was taken exactly from the University of Tripoli campus, and it was obtained from one location to eliminate variations in its properties, and the whole experimental program was performed at the same university. The sample was taken from 1m depth. And after taking the sample, sieve analysis was performed to classify the soil type. And the specific gravity of the sample was tested. Figure 3.1 shows the soil extraction from the University of Tripoli campus.

Figure 3.1. Soil extraction from the University of Tripoli campus.

Sieve test findings indicated that the sand of the soil is poorly graded, with a specific soil gravity of 2,658, with a uniformity coefficient of 1.58474 and gradation coefficient of 0.88674. Table 3.1 shows the sieve analysis test results and Figure 3-2 illustrates the Tripoli soil sample particle diameter.

Table 3.1. The sieve analysis test results.

SIEVE ANALYSIS							
Sieve NO	**Sieve opening (mm)**	**Weight of the sieve is empty**	**Weight of the sieve is full**	**Soil Mass Retained(g)**	**Cumulative Mass Retained (g)**	**Percent Retained (%)**	**Percent Finer (%)**
4	4.750	591.60	591.60	0	0	0	100
10	2.0	540.20	540.30	0.1	0.1	0.01999	99.98
20	0.850	432.40	438.00	5.6	5.7	1.13932	98.86
40	0.425	461.00	472.00	11	16.7	3.33800	96.66
60	0.250	438.70	467.20	28.5	45.2	9.03458	90.97
100	0.150	427.60	485.70	58.1	103.3	20.64761	79.35
200	0.075	423.70	776.10	352.4	455.7	91.08535	8.91
Pan		383.00	427.60	44.6	500.3	100	0
Total soil mass retained				500.3			
effective size				**D10 = 0.08014 mm**			
				D30 = 0.095 mm			
				D60 = 0.127 mm			
Cu=D60/D10				**Cu =1.58474**	**< 6 → poorly graded soil**		
Cc=D30^2/(D60*D10)				**Cc =0.88674**	**don′t locate between 1.3**		

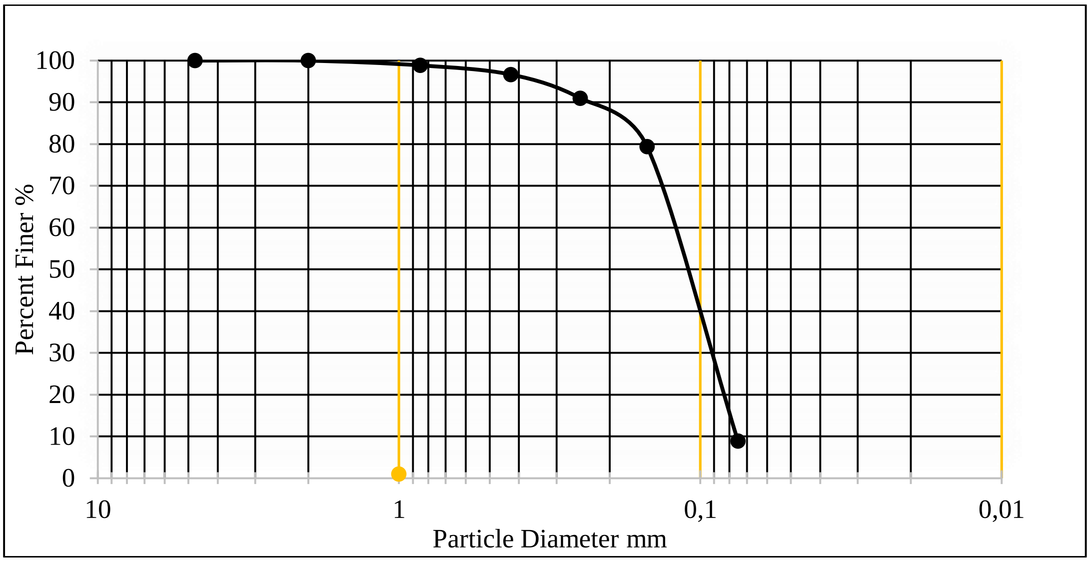


Figure 3.2. Tripoli soil sample particle diameter.

3.1.2. Lime

In this investigation, powdered lime (Calcium hydroxide ($Ca(OH)^2$)), with high reactivity (min.90% $Ca(OH)^2$), leaving a maximum of 5% residue above 90 microns with a density of about 1.5g/cm^3 was used. The lime has been used in this study because it may give good results in thermal conductivity. Also, this material is widely available and chip in Libya. Figure 3.3 show the powdered lime used in this study.

Figure 3.3. Powdered lime.

3.2. TESTS AND EQUIPMENT

3.2.1. Sieve Analysis

After taking a sample from 1 m depth from the University of Tripoli campus, sieve analysis test was performed according to BS 1377. The sample was dried for one day using an oven after that the test was performed. The tests equipment is including oven (Figure 3.4), sieves with different opining diameters, receiving pan, balance, and shaking machine. Figure 3.5 shows a sieve while is weighted.

Figure 3.4. Samples inside the oven.

Figure 3.5. Sieve while is weighted.

The test starts with cleaning the sieves using to extract any stuck particles and weight each sieve and the receiving pan. Then the sieves were arranged as the maximum opening dimeter (4.750 mm) was at the top and the minimum (0.075 mm) was at the bottom. After that, the shaking machine worked for 10-15 min to classify the soil. And then the sieves were removed again and weighted with the soil at each sieve and the settled at the pan. Figure 3.6 shows all the sieves and the receiving pan above the shaker machine.

Figure 3.6. Sieves and the receiving pan above the shaker machine.

The percent of soil retained on the n^{th} was calculated as Equation 3.1:

$$Rn = \frac{Wn}{W} \times 100 \tag{3.1}$$

Where, Rn = soil retained, Wn = mass retained, and W = total mass. Equation 3.2 estimated the cumulative percentage of dirt held on the n^{th} sieve.

$$= \sum_{i=1}^{n=i} Rn \tag{3.2}$$

The cumulative percent passing through the n^th^ sieve was calculated as Equation 3.3:

$$= 100 - \sum_{i=1}^{n=i} Rn \tag{3.3}$$

The uniformity coefficient (Cu) and the coefficient of gradations (Cc) were computed under Equation 3.4 and Equation 3.5, after providing the diameters corresponding to a percent finer of 10 percent (D_{10}), 30 percent (D_{30}) and 60 percent (D_{60}).

$$Cu = \frac{D_{60}}{D_{10}} \tag{3.4}$$

$$Cc = \frac{D_{30}^2}{D_{10} \times D_{60}} \tag{3.5}$$

3.2.2. Specific Gravity

The specific gravity of Tripoli soil in this study was determined according to the ASTM D 854 specifications. The test was made on three samples then the average of the specific gravity of the three samples was taken for more accurate results. The equipment used to calculate the specific gravity of the sample was volumetric flask, distilled water, balance, vacuum pump, funnel, and oven. The test started with weighting of the empty volumetric flask and then fill it with the distilled water and weight it again. And then a 50g of soil is filled in the flask and the flask filled again with 2/3 distilled water. And then the vacuum pump was used to remove the entrapped air and then the flask is weighted again. And then the water temperature is tested to determine its exact density. Figure 3.7 illustrates the water and soil filled flask.

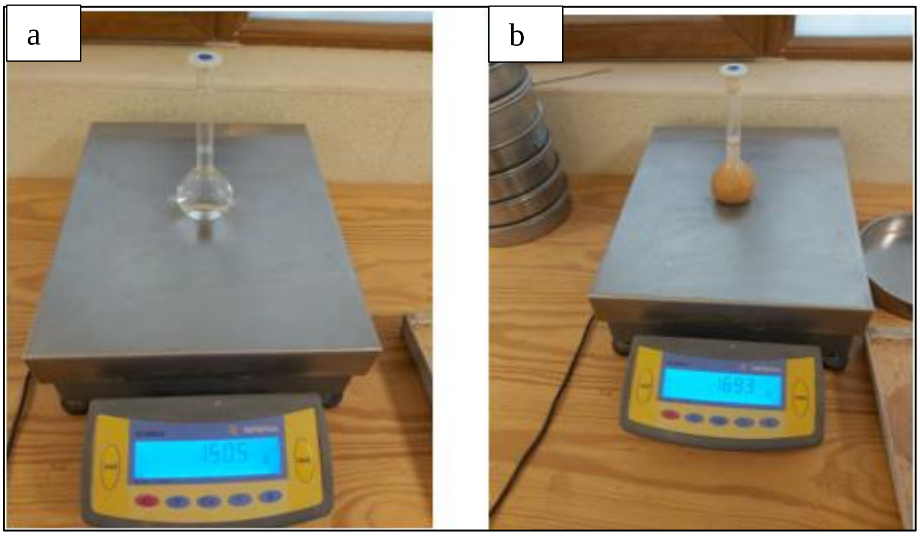


Figure 3.7. a) water filled flask. b) soil filled flask.

The specific gravity is calculated as follows Equation 3.6:

$$Gs = \frac{Gt \times Ws}{W_2 - (W_1 - Ws)} \tag{3.6}$$

Where,

Gs = specific gravity of soil.

Gt = specific gravity of water.

Ws = weight of dry soil.

W_1 =weight of pycnometer+ sample+ water.

W_2= weight of pycnometer+ water.

3.2.3. Soil Compaction

Proctor Test was done for all the samples in the three series according to ASTM D698 – 12 to ensure the well soil compaction and the equality in the compaction for them. The procedure of this test is straightforward, and the equipment needed for this procedure are mainly a standard mold with a standard hammer. Table 3.2 shows the mold and hammer specifications.

Table 3.2. Proctor Test specifications.

#	Standard
No of blows	25
No of layers	3
Mold	4″
Hammer	2.5kg
Height	12″

The test begins after the soil sample is obtained through a No. 4 sieve. The soil bulk is then weighed and the mold is weighed without a collar. The soil will then be placed in the blender and water will regularly be added to the appropriate moisture level. The dirt is subsequently taken from the mixer and placed into the mold in three layers and a compaction procedure for each layer is applied by 25 blows per layer. The blows are performed by hand and the mold must be filled with ground material and must reach a ring with eye but only 2 cm. The mold and the enclosing soil are weighed after that. The use of the Proctor test is explained in Figure 3.8a through a free fall, and Figure 3.8b clarify that the correct application of the Proctor test is verified by measuring post-test dimensions.

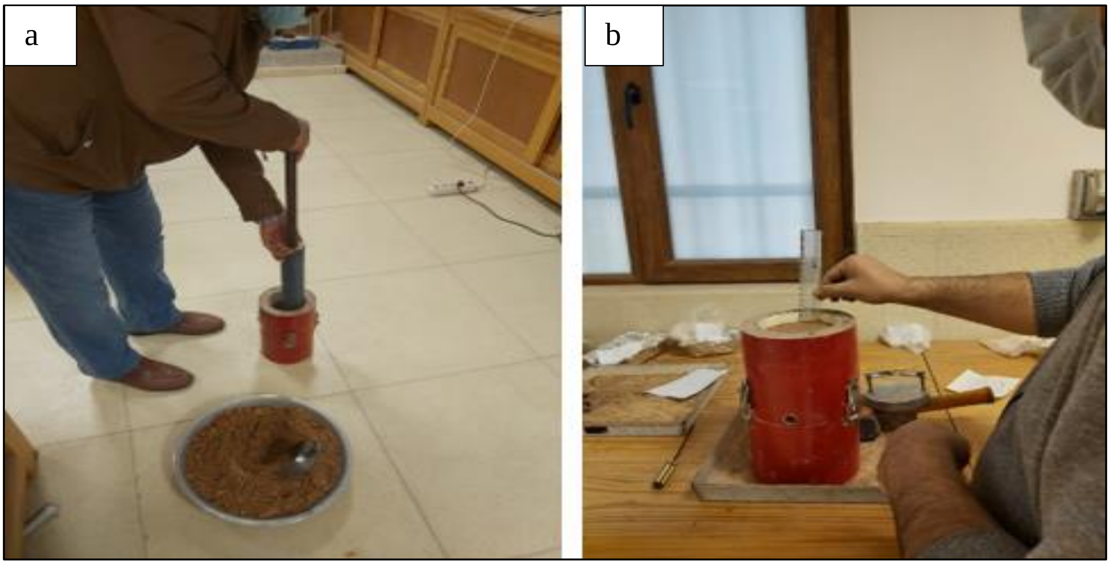


Figure 3.8. a) The application of the Proctor Test and b) The verification of the right application after the Proctor Test.

3.2.4. Thermal Conductivity

The major test of thermal conductivity for this investigation was performed using the Steady-State technique laboratory. The equipment and the software used in this test were include:

Laptop.
Removable plate (Figure 3.9).
Aluminum plate transfers the heat (Figure 3.10).
Heater device (Figure 3.11).
TC-08 thermocouple data logger (Figure 3.12).
Type K thermocouple temperature sensor (Figure 3.12).
DC power supply (Figure 3.20).
Thermal cell to place the soil samples for testing.
Silicon isolation layer.
Balance.
PL software (Figure 3.13).

Figure 3.9. Removable plate.

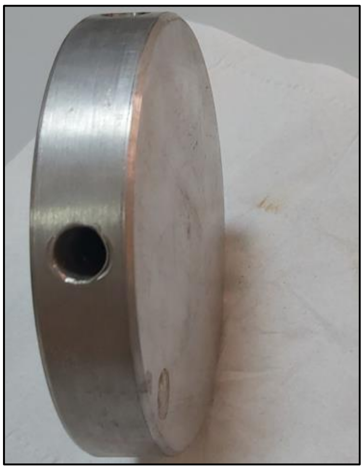


Figure 3.10. Aluminum plate transfers the heat.

Figure 3.11. Heater device.

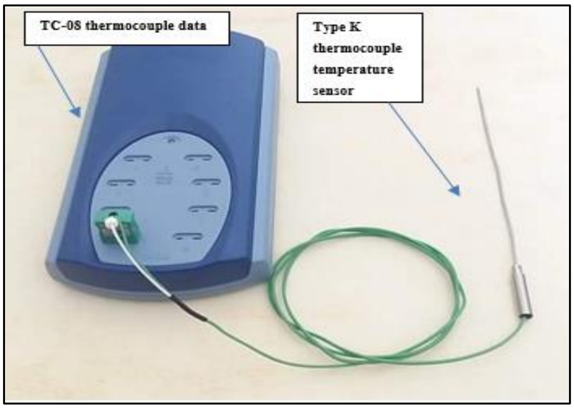


Figure 3.12. TC-08 thermocouple data logger attached with the Type K thermocouple temperature sensor.

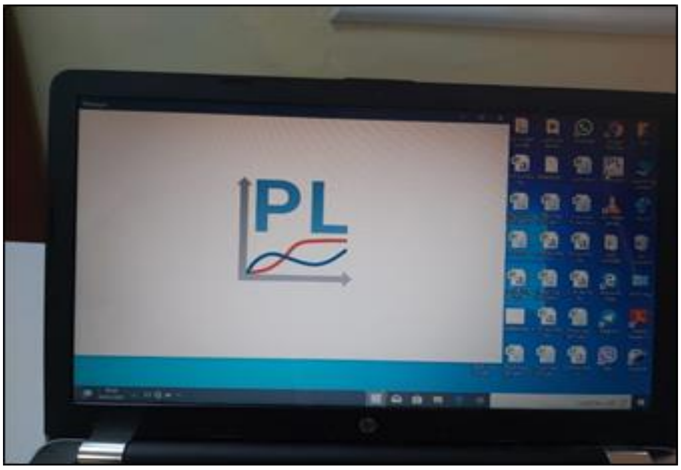


Figure 3.13. PL software.

The thermal cell used in this study was a cell with an opening diameter of 10.7cm as shown in Figure 3.14. This cell was covered with another two layers. The first layer was from silicon with a thickness of 2.5 cm; this layer was used as thermal isolation from the surrounding environment. Figure 3.16 illustrates the silicon isolation layer. And another top layer which was a pipe and mainly worked to hold all the layers together with opening diameter of 15.7cm as shown in Figure 3.15.

Figure 3.14. Inner cell with an opening diameter of 10.7cm.

Figure 3.15. Outer cover pipe with an opening dimeter of 15.7cm.

The testing cell was divided into two tubes. The first was 13 cm long and the second was 15 cm long. Between the two tubes, the aluminum heat transfer plate was installed by pressing it in the outer edge of the first part of the 15 cm long tube so that it takes a 2 cm depth space so that the two tubes are equal. The gap between the inner tube and the outer tube for the two parts was filled with transparent silicone and tied with 4 fixing belts. The outer tube acts as a layer of protection for silicon from external factors and influences. A hole was made in the inner and outer tube at the middle of each tube with a diameter of 1 cm in a straight line and one direction. The purpose of this hole was to insert the heater inside the heating plate. Table 3.3 shows the cell dimensions. Figure 3.16 shows the testing cell with all the layers and Figure 3.17 shows a sketch for the cell layers and their dimensions.

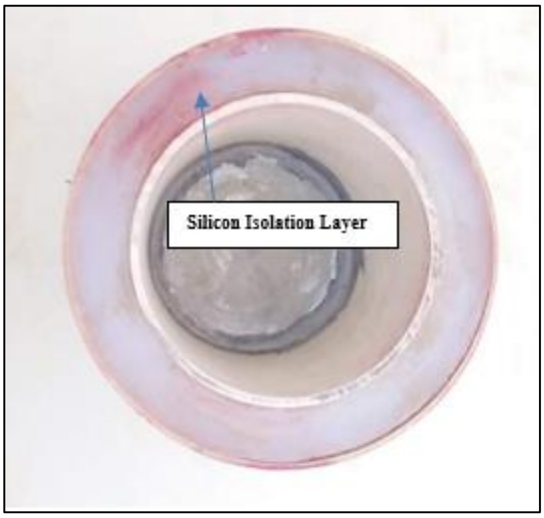


Figure 3.16. The silicon isolation layer inside the inner and the outer cover.

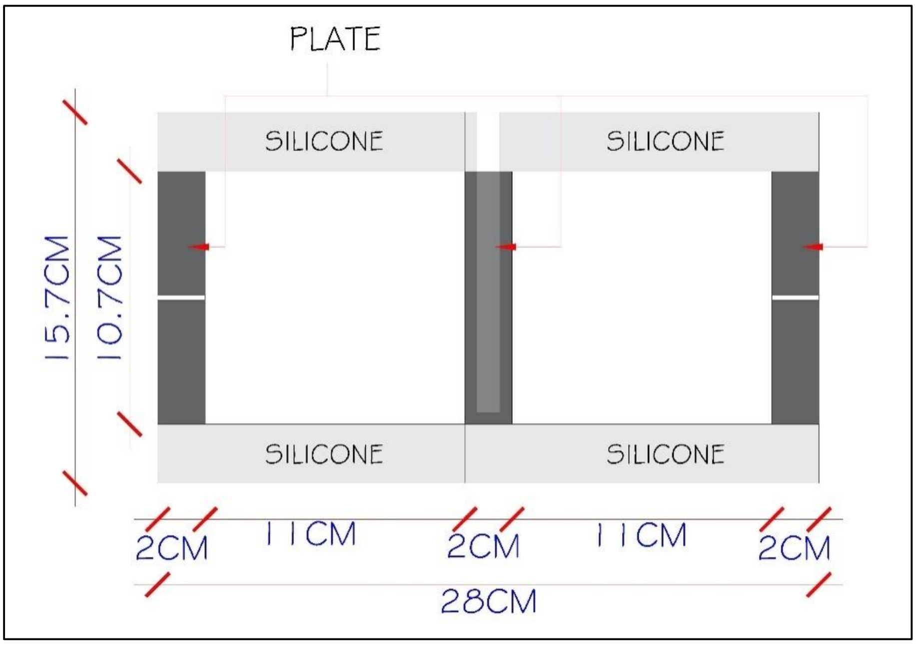


Figure 3.17. Sketch for the cell layers and their dimensions.

And a TC-08 thermocouple data logger was used attached to a type K thermocouple temperature sensor with a length of 150mm and a thickness of 1.5mm. A DC-type power supply (shown in Figure 3.20) was used attached to a DC cartridge heater with 100mm length and 10mm diameter. Figure 3.18 shows the insulation and the removal of the removable plate. The cell was opened from the two sides, and these ends were closed during the test with the removable plate. This plate had a hole in its middle to inject the sensor inside it and measure the temperature. Figure 3.21 illustrates the equipment used for measuring the soil thermal conductivity.

Figure 3.18. The insulation and the removal of the removable plate.

Figure 3.19. The testing cell with all the layers.

Figure 3.20. DC-type power supply.

Table 3.3. The cell dimensions.

Cell Dimensions	
D (mm)	107
A (m^2)	0.008992
V (m^3)	0.0009879

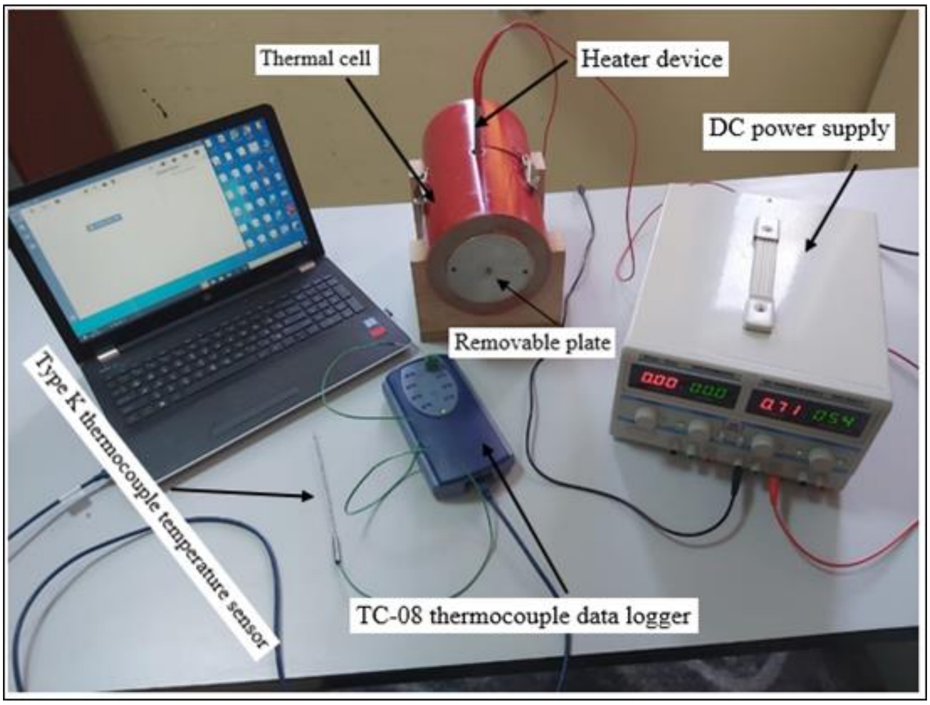


Figure 3.21. The equipment used for measuring the thermal conductivity of soil.

3.2.4.1. Test Procedure

Before starting the test, the weight of empty cells should be measured. After that, the cells are filled with soil and the entire cells are weighted again. The test starts with the power supply supplementing a DC current to the attached heater. The attached heater, which is placed in the middle of the two cells, starts heating for one day. This heater is transferring the heat horizontally and equally for both of the cells. It must be mentioned that this method is my original method with no standard or base. Figure 3.22 illustrates the installation of the thermal conductivity test equipment and starting them to be gone with the experiment.

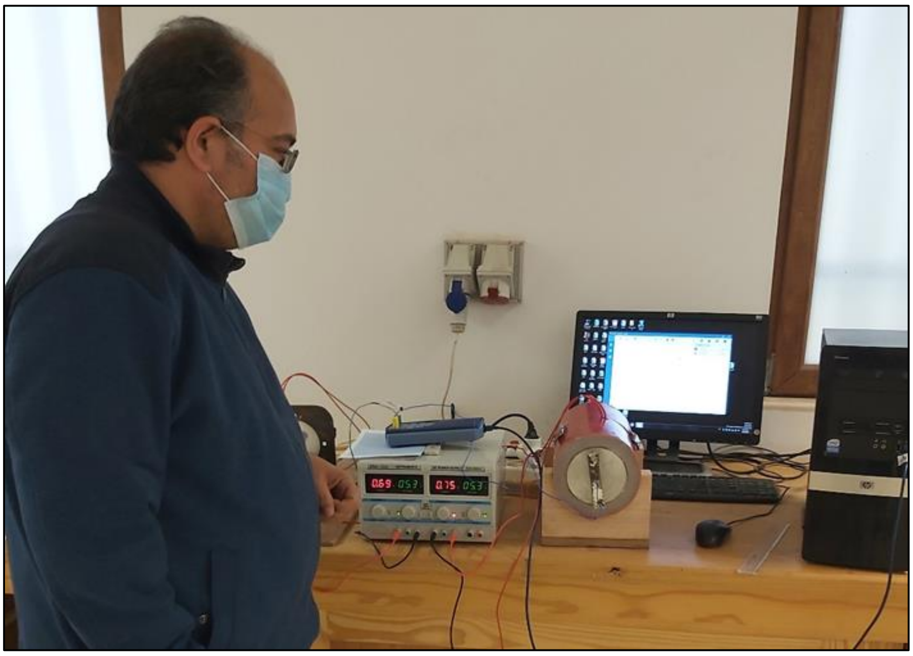


Figure 3.22. The equipment of thermal conductivity.

After one day, the sensor which is attached to the data logger starts to be injected into the soil incrementally every 4 minutes at depths of 0, 2.5, 5, 7.5, and 11 cm. At first, the temperature is measured at the surface. After 4 minutes, it is injected at a depth of 2.5cm, and then we wait again for 4 minutes to measure the data. And repeat this procedure of the sensor another three times. However, for the last one, we inject at a depth of 3.5 cm. the measuring was done from one side. The other side was to simulate the situation inside the ground. After measuring the temperature for each layer, each layer was scrapped approximately 1cm and a sample was taken to measure the water content of it. The PL software was used to collect the temperature data and transfer them to an excel sheet. Figure 3.23 shows weighing the cell and Figure 3.24 shows the sensor injection inside the cell and the heater injection inside the plate to transfer the heat.

Figure 3.23. Weighing the cell.

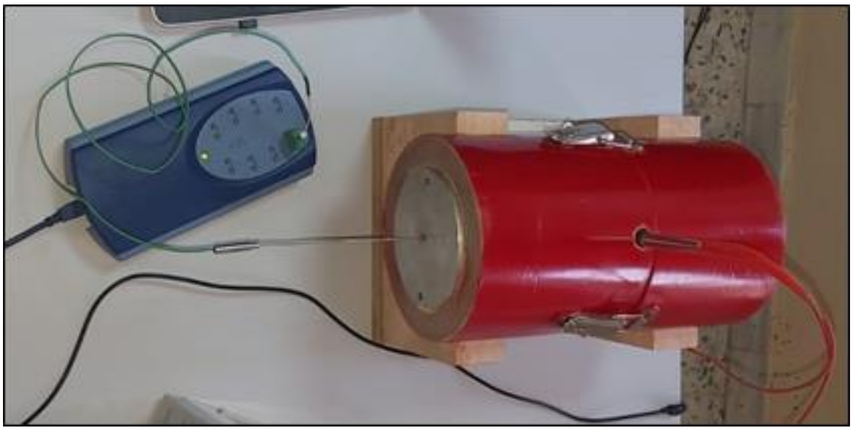


Figure 3.24. The sensor injection inside the cell and the heater injection inside the plate to transfer the heat.

The thermal conductivity according to Fourier's Law of Heat Conduction is shown in equation 3.7.

$$K_e = \frac{Q/_A}{\Delta T/_{\Delta L}} \quad (3.7)$$

Where,

K_e: is the thermal conductivity of the soil.
Q: is the power input and equal to the Current (mA) * Volt (V).
A: is the cross-sectional area.
ΔT: is the temperature difference across the length of the specimen.
ΔL: is the length of the specimen.

3.2.5. Water Content

The water content test was made on samples taken from the cell after completing the thermal conductivity test on the samples. The samples have been put in taps. Every sample was weighed individually and then placed 24 hours in the oven to dry. after that the weight of these samples was taken and to calculate the water content of each sample. To examine the change of the soil water content under the impact of the temperature and the movement of the water from the soil samples from different depths, four tests from different depths were collected. Four were used. Bulk density (**ρ**b) and Dry of density (**ρ**d) was calculated as Equation 3.8 and Equation 3.9 respectively:

$$\rho b = M/V \quad (3.8)$$

$$\rho d = \rho b/(1 + w) \quad (3.9)$$

Where:

M: Mass of soil (Kg)

V: Volume of soil (m^3)

W: Water content (%)

3.3. TESTED SAMPLES

In this study, three series with different properties were tested. Each series contains a multiple batch. The first series adjusted water contact of the loops to examine the influence on the thermal conductivity of soil of the water content and the selection of the optimal water content for the soil to transmit heat. In the second series, a variable proportion of lime is applied to the soil to test its influence on soil heat conductivity. In the third series, the soil density was modified numerous times to examine the thermal conductivity effects of the density. The three series were named as following:

W series, and the symbolizing of the series batches were as: (WTS(number)). Where, W refers to the W series, TS refers to Tripoli soil, and the number shows the percentage of the water content in each batch.

L series, and the symbolizing of the series batches were as: (LTS(number)). Where, L refers to the L series, TS refers to Tripoli soil, and the number shows the percentage of the lime content in each batch.

D series, and the symbolizing of the series batches were as: (DTS(number)). Where, D refers to the D series, TS refers to Tripoli soil, and the number shows the density of the soil rounded to the nearest ones.

3.3.1. W Series

In this series a total 7 batches were performed. The water content of the batches was 0%, 1%, 3%, 7%, 10%, 15%, and 20%. Table 3.4 clarification provides the symbols for the batches of the W series and the percentage of water content and the number of blows for each lot to compress the layers of soil. In order to examine its impact on soil thermal conductivity and determine the optimal proportion of water content in the next two sets at an optimal percentage, soil water content was altered several times. In this series, the Proctor Compaction Test was applied for all the batches. Besides, the compaction was applied with 25 blows on each layer.

Table 3.4. W series batches and the number of blows applied to compact each soil layer for each batch.

NO	Batch	Water Content (%)	Compaction (%)
1	WTS0	0%	100% (25 blows)
2	WTS1	1%	
3	WTS3	3%	
4	WTS7	7%	
5	WTS10	10%	
6	WTS15	15%	
7	WTS20	20%	

3.3.2. L Series

In this series a total of 5 batches were performed. The lime content of the batches was 3%, 5%, 10%, 15%, and 30%. Table 3.5 shows the symbolizing of the L series batches with the lime content percentage and the number of blows applied to compact each soil layer for each batch. Lime was added into the soil to examine the effect of adding the lime to the soil on the heat transfer. The water content for all batches was 10% as it found to be the optimum percentage of heat transfer. This percentage was the optimum because after the compaction, the soil particles were attached well together and thermal conductivity were increased. In this series, the Proctor Compaction Test was applied for all the batches. Besides, the compaction was applied with 25 blows on each layer.

Table 3 5. L series batches and the number of blows applied to compact each soil layer for each batch.

NO	Batch	Lime Content (%)	Water content (%)	Compaction (%)
1	LTS3	3%	10%	100% (25 blows)
2	LTS5	5%		
3	LTS10	10%		
4	LTS15	15%		
5	LTS30	30%		

3.3.3. D Series

In this series a total of 6 batches were performed. The density of the batches in Kg/m^3 was 724.703, 901.832, 1038.51, 1092.78, 1223.94, and 1466.89. Table 3.6 shows the symbolizing of the D series batches with the density and the number of blows applied to compact each soil layer for each batch. The density was changed several times to examine its effect on the soil thermal conductivity and the heat transfer. The water content for all batches was 10% as it found to be the optimum percentage of heat transfer. This percentage was the optimum because after the compaction, the soil particles were attached well together and thermal conductivity were increased. In this series, the Proctor Compaction Test was applied for all the batches. The blows number in each layer were differ depending on the desired density. Increasing the number of blows led to increase the density of the soil.

Table 3.6. D series batches and the number of blows applied to compact each soil layer for each batch.

NO	Batch	Density (Kg/m^3)	Water content (%)	Compaction (blows)
1	DTS724	724.703	10%	10
2	DTS901	901.832		13
3	DTS1038	1038.51		15
4	DTS1092	1092.78		16
5	DTS1223	1223.94		18
6	DTS1466	1466.89		20

PART 4

RESULTS AND DISCUSSION

There are three primary components in the results and discussion section. The findings of the examination of the thermal conductivity of Tripoli soil samples with varied water levels will be shown in the first part (W Series). The second part shows the results of the test of Tripoli soil conductivity with the addition of lime to the samples and a consistent water level of 10 percent for all samples The second section illustrates the (L Series). And the third part shows the findings of the thermal conductivity of the Tripoli soil samples at varying densities and ensures that the water contents for all samples are 10 percent constant (D Series).

4.1. W SERIES

This section shows the results of a study on the thermal conductivity of Tripoli soil samples of various water in each sample (W Series). The findings of the temperature, thermal conductivity and average water content of the soil, as well as density of the Tripoli W series tested samples, are shown in Table 4.1. And the figures depict and represent results for additional comparison of batches of series W from figures 4.1 to Figure 4.5. Table 4.1. In this section, the representative of the results and the discussion starts with a compression of the thermal conductivity of all the batches from the W series, the water content of the batches after applying the heat on it are compared.

Table 4.1. The results of the temperature of the soil, thermal conductivity, average water content, and the density of the tested samples from the Tripoli soil for the W Series.

Penetration Depth (m)	L (m)	Volt (V)	Current (mA)	Power Q (wat)	T1 Heater (C)	T2 (C)	K(W/m K)	corrected K (W/m.C)	W (%)	W aveg. (%)	ρb (Kg/m^3)	ρd (Kg/m^3)
WTS0, Room Temperature = 17°C												
0	0.11	5.50	0.71	1.95	33.63	18.80	1.61	0.60	0.00	0.00	1499.19	1499.19
0.025	0.085					20.29	1.38		0.00			
0.05	0.06					22.42	1.16		0.00			
0.075	0.035					25.36	0.92		0.00			
WTS1, Room Temperature = 23°C												
0	0.11	5.20	0.73	1.90	38.75	24.50	1.63	1.05	1.05	1.00	1508.76	1493.82
0.025	0.085					26.88	1.51		1.03			
0.05	0.06					29.60	1.38		1.00			
0.075	0.035					32.74	1.23		0.92			
WTS3, Room Temperature = 20°C												
0	0.11	5.20	0.73	1.90	34.79	25.43	2.48	1.85	3.06	3.02	1587.26	1540.77
0.025	0.085					27.30	2.40		3.03			
0.05	0.06					29.14	2.24		3.00			
0.075	0.035					31.15	2.03		2.98			
WTS7, Room Temperature = 20°C												
0	0.11	5.20	0.73	1.90	31.13	26.14	4.65	3.06	7.20	7.00	1695.17	1584.23
0.025	0.085					26.99	4.33		7.12			
0.05	0.06					27.96	4.00		7.00			
0.075	0.035					29.04	3.53		6.69			

Penetration Depth (m)	L (m)	Volt (V)	Current (mA)	Power Q (wat)	T1 Heater (C)	T2 (C)	K(W/m K)	corrected K (W/m.C)	W (%)	W aveg. (%)	ρb (Kg/m^3)	ρd (Kg/m^3)
WTS10, Room Temperature = 21°C												
0	0.11	5.20	0.73	1.90	31.68	26.06	4.13	3.28	10.36	10.00	1806.77	1642.52
0.025	0.085					27.20	4.00		10.25			
0.05	0.06					28.30	3.75		10.03			
0.075	0.035					29.60	3.55		9.36			
WTS15, Room Temperature = 20°C												
0	0.11	5.40	0.72	1.94	29.75	25.24	5.27	3.38	15.31	15.06	1888.62	1641.45
0.025	0.085					25.96	4.85		15.05			
0.05	0.06					26.81	4.41		15.02			
0.075	0.035					27.85	3.98		14.85			
WTS20, Room Temperature = 17°C												
0	0.11	5.50	0.71	1.95	25.71	21.38	5.52	3.41	20.36	20.14	1880.32	1565.07
0.025	0.085					22.20	5.26		20.28			
0.05	0.06					22.94	4.70		20.12			
0.075	0.035					23.82	4.02		19.81			

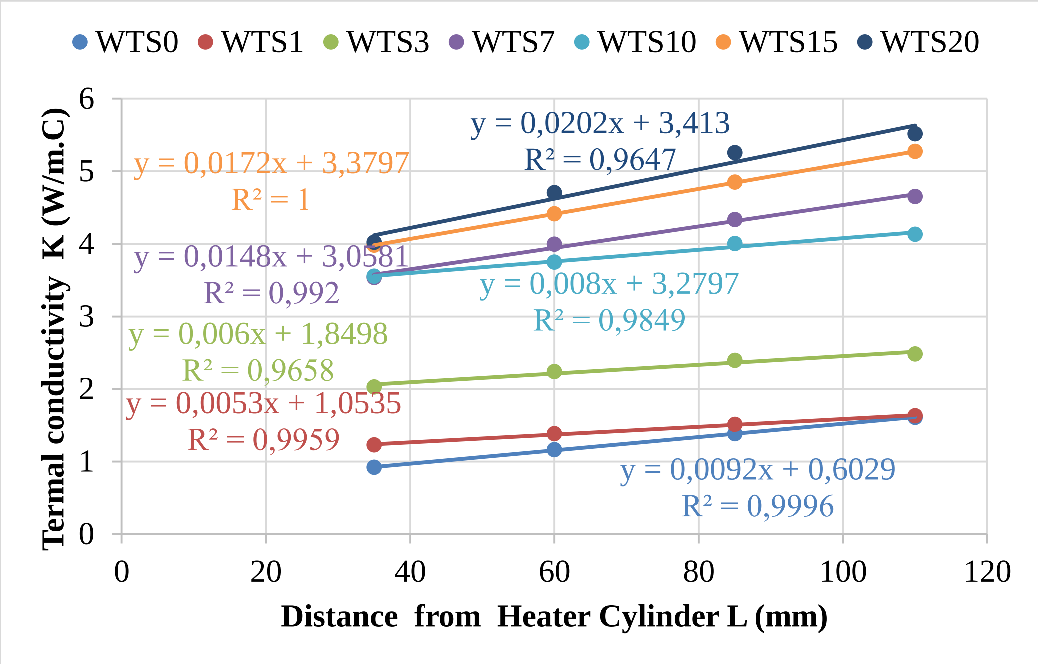


Figure 4.1. The results of the thermal conductivity of Tripoli soil samples in each penetration distance for the W series.

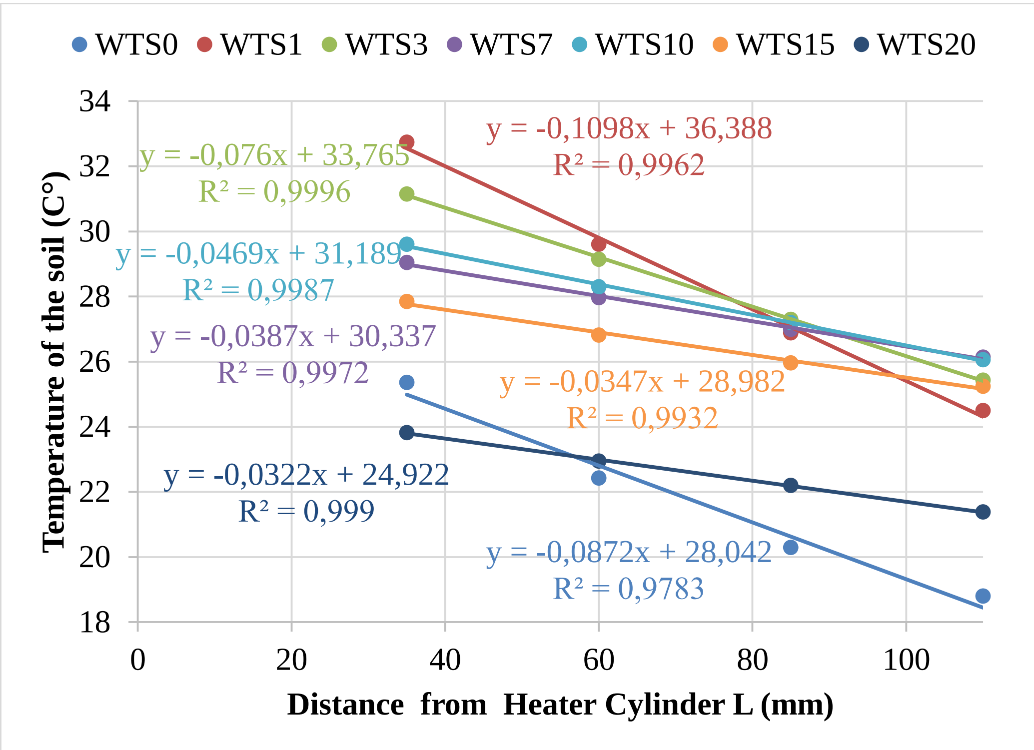


Figure 4.2. The results of the Tripoli soil samples' temperature in each penetration depth for the W series.

Tripoli soil samples for each penetration distance in the series W clarify the findings of thermal conductivity in Figure 4.1, and Figure 4.2 illumines the outcome of the temperatures of Tripoli soil samples for each W serial penetration depth. Figures 4.1 and 4.2 are explored in the following results:

The room temperature when the tests were conducted was approximately the same. The temperatures were between 20-23℃ except for the batch WTS20, WTS0 the temperature was 17℃. However, as the temperature difference had no effect and due to the presence of two isolation materials (the silicon and the outer pipe), the thermal conductivity tests of the batches did not affect and the results were considered to be accurate.

The thermal conductivity of soil samples with water content of 1%, 3%, 7%, 10%, 15%, 20% was improved by 74.74%, 206.82%, 407.23%, 443.99%, 460.57%, and 466.10% compared to the sample with water content. 0%. Increasing the water content leads to increase the thermal conductivity and also adding water to the samples helped in soil cohesion, which leads to reducing the spaces between soil particles helped to increase the conductivity.

The maximum corrected thermal conductivity appeared with the batch containing 20% water content (WTS20 batch), and it was 3.41 W/m.℃. And the minimum corrected thermal conductivity appeared with the batch containing 0% water content (WTS0 batch), and it was 0.60 W/m.℃.

The optimum water content between all batches was 10% (WTS10 batch), and the thermal conductivity of the soil was about 3.28 W/m. This ideal ratio is found because after this ratio the increase starts to grow slowly (horizontal increase) plus 10% water content (WTS10 batch) is the most suitable for compression because the higher the water content, the harder it is to compress. the soil.

The maximum temperature of the soil's when the heater was applied for 24 hours for all batches were between 23.82℃ - 32.74℃ at a penetration depth of 0.075 m inside the cell. And the minimum temperature of the soils when the heater was applied for 24 hours for all batches were between 18.8℃ - 21.38℃ at a penetration depth of 0 m inside the cell.

The maximum temperature of the soil's samples for all batches when the heater was applied for 24 hours were found for all batches when the penetration depth was 0.075m inside the cell. And the minimum temperature of the soil's samples for all batches when the heater was applied for 24 hours were found for all batches when the penetration depth was 0m inside the cell. This refers to the nearness and farness from the heater. The more the penetration depth increased the more the section is near to the heater. Thus, 0.075m penetration depth gives the maximum temperature, and 0m depth (the farest measurement from the sample) gives the minimum temperature.

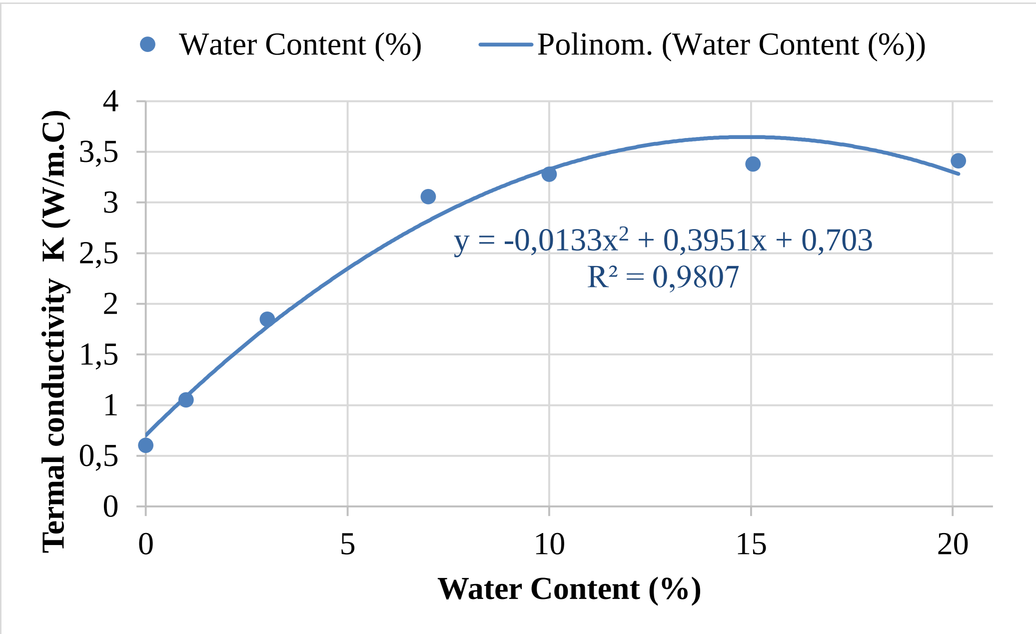


Figure 4.3. Comparison between the thermal conductivity of Tripoli soil samples results with different water contents.

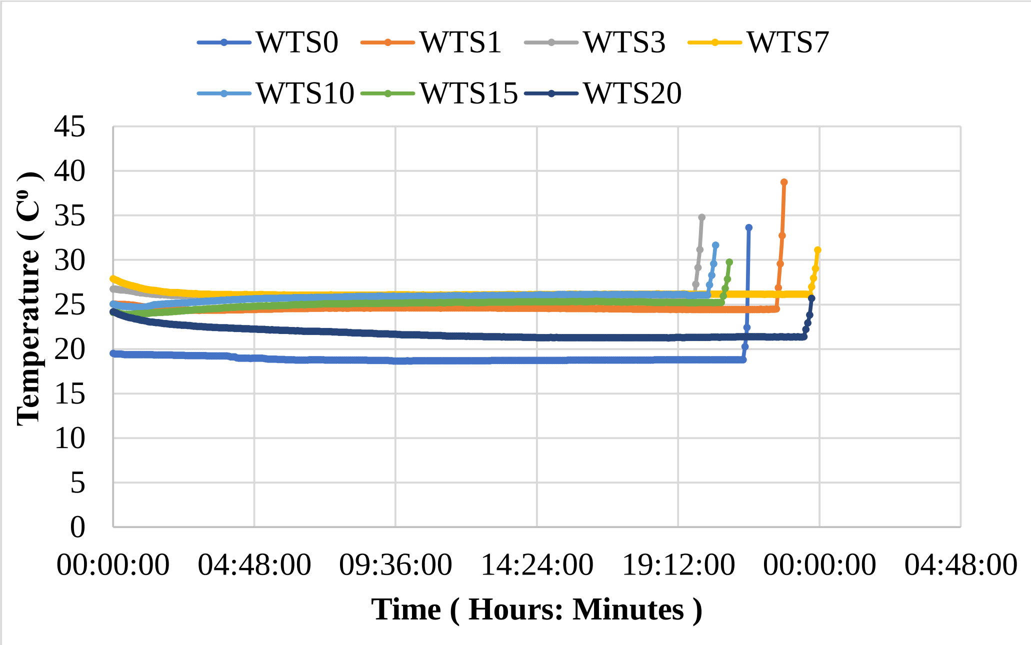


Figure 4.4. The temperature of the soil samples while applying the heat within 24 hours.

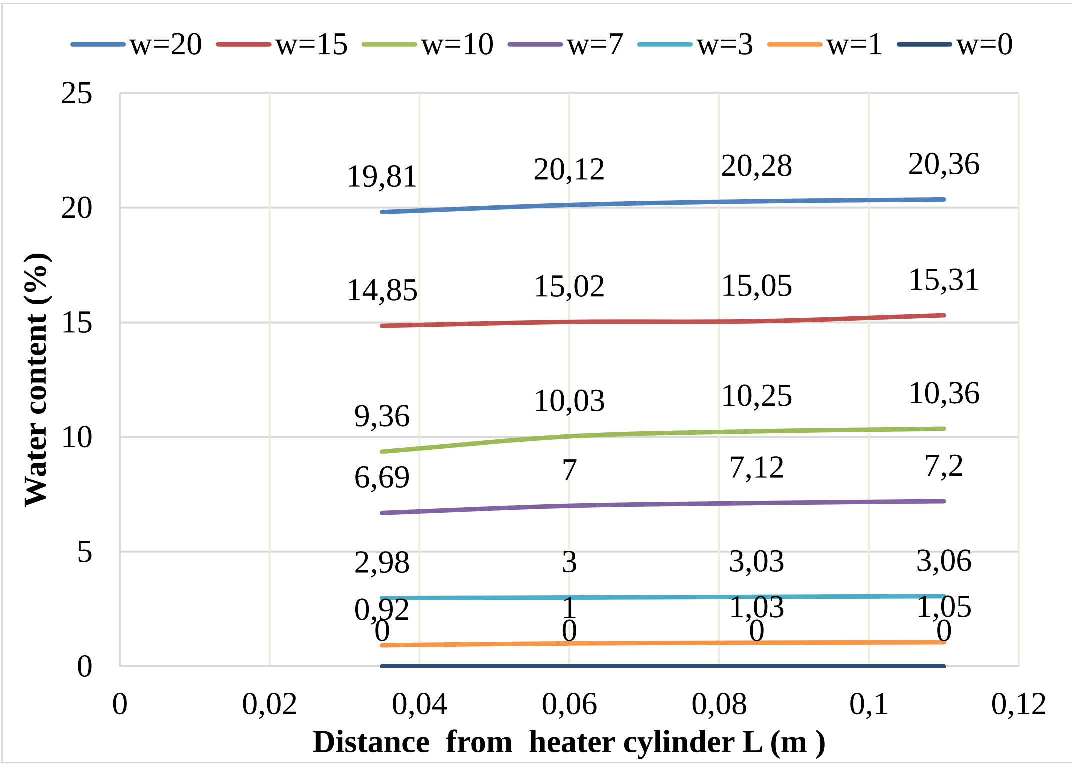


Figure 4.5. The results of the water content in each part of the testing cell.

Figure 4.3 shows a comparison between the thermal conductivity of Tripoli soil samples results with different water contents, Figure 4.4 illustrates the results of the water content in each part of the testing cell, and Figure 4.5 illustrates the results the soil samples' temperature while applying the heat within 24 hours. The following could be seen and concluded from Table 4.1 and Figure 4.1, Figure 4.2, Figure 4.3, and Figure 4.4 above:

The results reveal a non-linear rise in thermal conductivity for soils with low to medium water content. While the thermal conductivity of soils with high water content has progressively grown linearly, the heat flow of soil has continued, and the water content of soil has changed which influences the heat conductivity of the soil positively.

The water content after applying the heat from the heater was varied from one section to another in the same batch. The maximum water content was at the first section from the heater and the minimum water content was at the nearest section from the heater for all batches. This referred to the movement of the water from the side that is near to the heater to the side that is far from the heater.

W series have shown good results for improving the Tripoli soil's thermal conductivity.

4.2. L SERIES

This section shows the results of a thermal conductivity study on Tripoli soil samples with various limestones in each specimen (L Series). Table 4.2 gives soil temperature findings, thermal conductivity, mean water content and density for L Series of Tripoli tested soil samples, and Figures 4.6 to Figure 4.9 displays the results of Table 4.2 for a comparison of L Series batch data. Table 4.2 provides more results. In this section, the representative of the results and the discussion starts with a compression of the thermal conductivity of all the batches from the L series, then the lime addition in the samples after applying the heat on it is compared.

Table 4.2. The results of the temperature of the soil, thermal conductivity, average water content, and the density of the tested samples from the Tripoli soil for the L Series.

Penetration Depth (m)	L (m)	Volt (V)	Current (mA)	Power Q (wat)	T1 Heater (C)	T2 (C)	K(W/m K)	corrected K (W/m.C)	W (%)	W avg. (%)	*ρ*b (Kg/m³)	*ρd* (Kg/m³)
LTS3, Room Temperature = 19°C												
0	0.11	5.40	0.72	1.94	29.30	24.40	4.85	2.72	10.21	10.00	1828.59	1662.32
0.025	0.085					25.27	4.56		10.13			
0.05	0.06					26.09	4.04		10.02			
0.075	0.035					27.03	3.33		9.65			
LTS5, Room Temperature = 20°C												
0	0.11	5.40	0.72	1.94	29.42	24.35	4.69	2.63	10.03	9.99	1816.54	1651.51
0.025	0.085					25.17	4.32		10.00			
0.05	0.06					26.04	3.84		10.00			
0.075	0.035					27.09	3.25		9.94			
LTS10, Room Temperature = 18°C												
0	0.11	5.50	0.71	1.95	26.78	21.53	4.55	2.58	10.01	10.00	1801.00	1637.28
0.025	0.085					22.38	4.19		10.01			
0.05	0.06					23.19	3.63		10.00			
0.075	0.035					24.42	3.22		9.98			
LTS15, Room Temperature = 18°C												
0	0.11	5.40	0.72	1.94	27.31	21.63	4.19	2.25	10.03	10.01	1735.91	1578.03
0.025	0.085					22.63	3.93		10.01			
0.05	0.06					23.47	3.38		10.00			

Penetration Depth (m)	L (m)	Volt (V)	Current (mA)	Power Q (wat)	T1 Heater (C)	T2 (C)	K(W/m K)	corrected K (W/m.C)	W (%)	W aveg. (%)	ρb (Kg/m^3)	ρd (Kg/m^3)
0.075	0.035					24.64	2.83		9.98			
LTS30, Room Temperature = 18°C												
0	0.11	5.20	0.72	1.87	27.05	20.12	3.30	1.75	10.17	10.00	1495.95	1359.93
0.025	0.085					21.08	2.96		10.05			
0.05	0.06					22.24	2.60		10.00			
0.075	0.035					23.81	2.25		9.79			

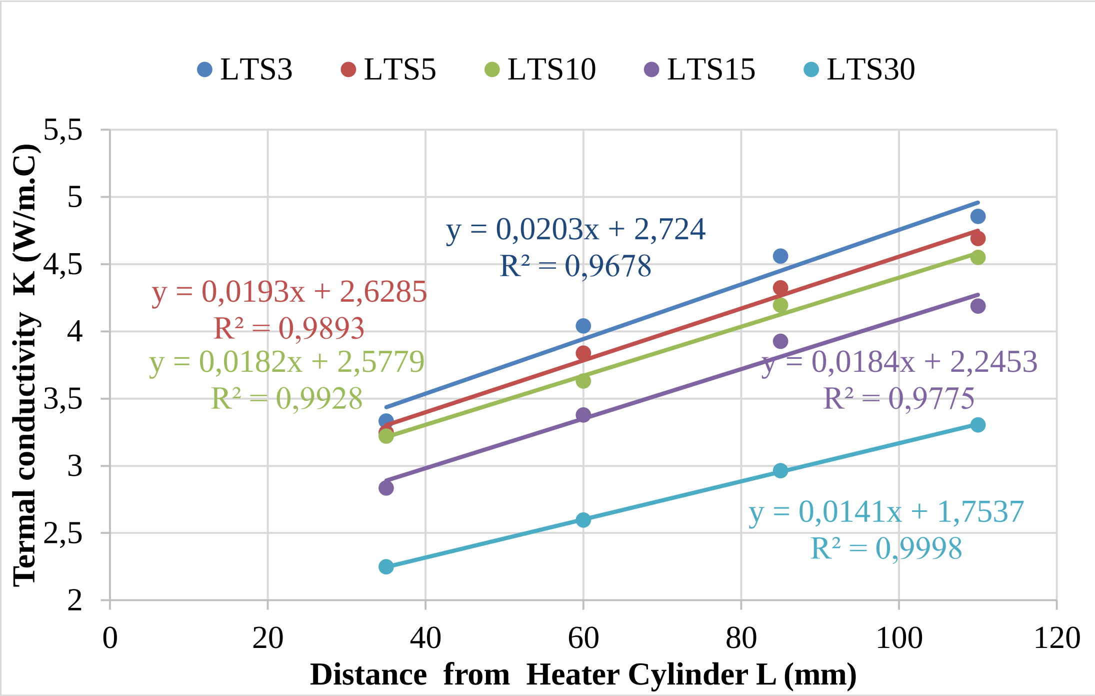


Figure 4.6. The results of the thermal conductivity of Tripoli soil samples in each penetration depth for the L series.

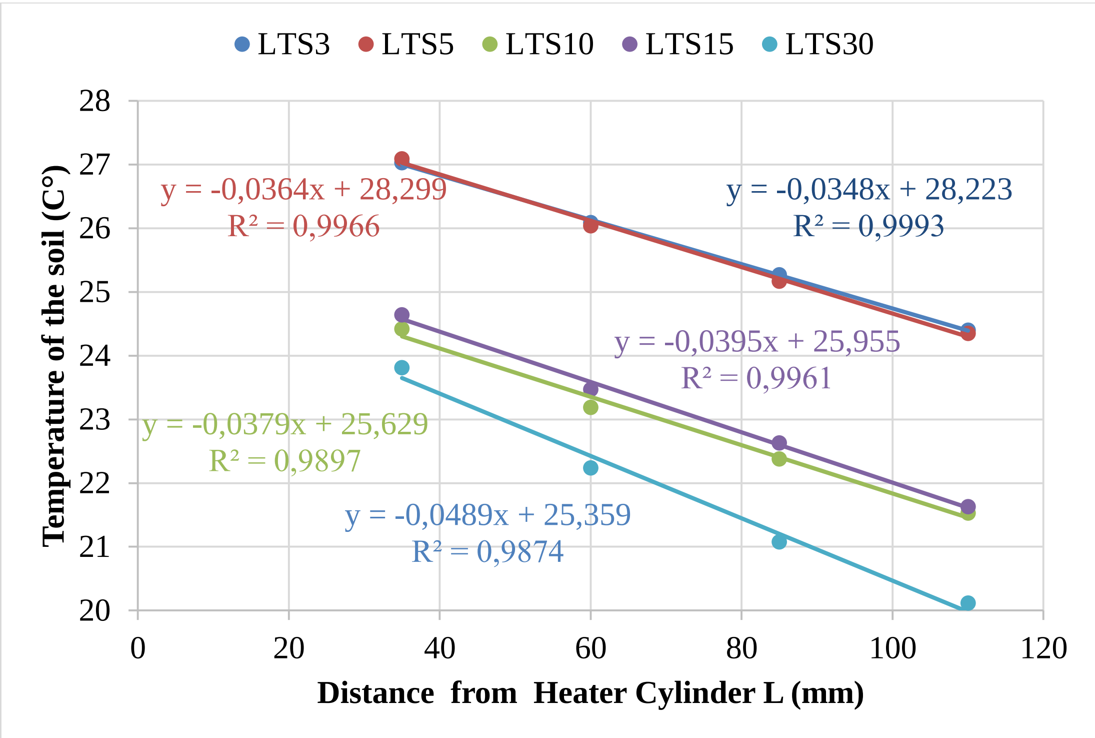


Figure 4.7. The results of the Tripoli soil samples' temperature in each penetration depth for the L series.

Figure 4.6 illustrates the result of the thermal conductivity of Tripoli soil samples in each penetration distance for the L series and Figure 4.7 clarifies the result of the Tripoli soil samples' temperature in each penetration depth for the L series. The results of Table 4.2, Figure 4.6, and Figure 4.7 are discussed below:

The room temperature when the tests were performed was approximately the same. The temperatures were between 18-20. However, as the temperature difference had no effect and due to the presence of two isolation materials (silicon and outer pipe), the thermal conductivity tests of the batches were not affected and the results were considered to be accurate.

The maximum corrected thermal conductivity appeared with the batch containing 3% lime content (LTS3 batch), and it was 2.72 W/m.℃. And the minimum corrected thermal conductivity appeared with the batch containing 30% lime content (LTS30 batch), and it was 1.75 W/m.℃.

The thermal conductivity of the soil samples with adding lime by 5%, 10%, 15%, and 30% was decreased by -3.51%, -5.36%, -17.57%, and -35.62% comparing to the sample with 3% lime content Increasing the lime content of the soil led to decrease in the thermal conductivity of the soil, as particular heat of the lime differs from the soil. The soil had a better heat conductivity than the lime.

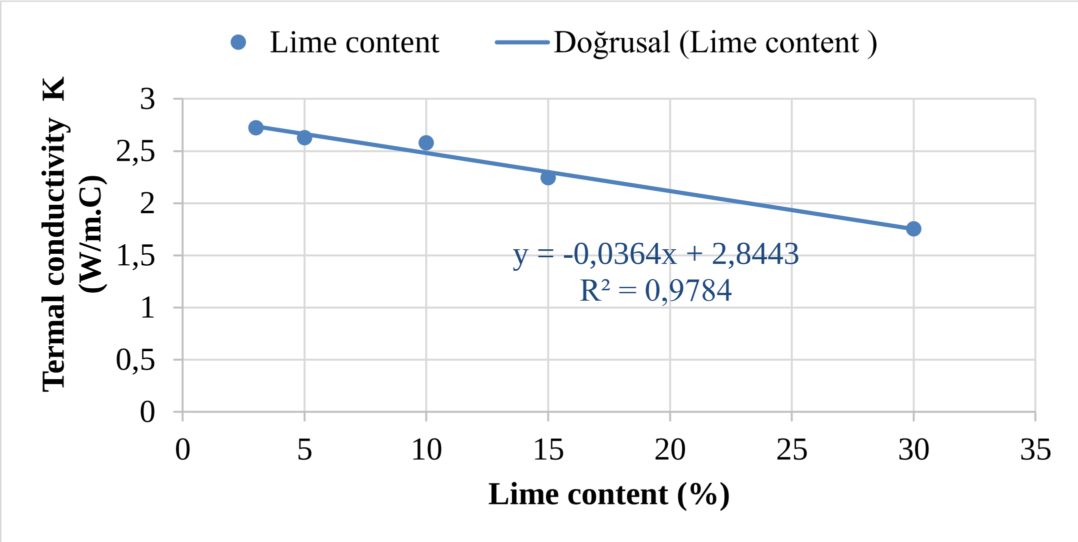


Figure 4.8. Comparison between the thermal conductivity of Tripoli soil samples results with different lime contents.

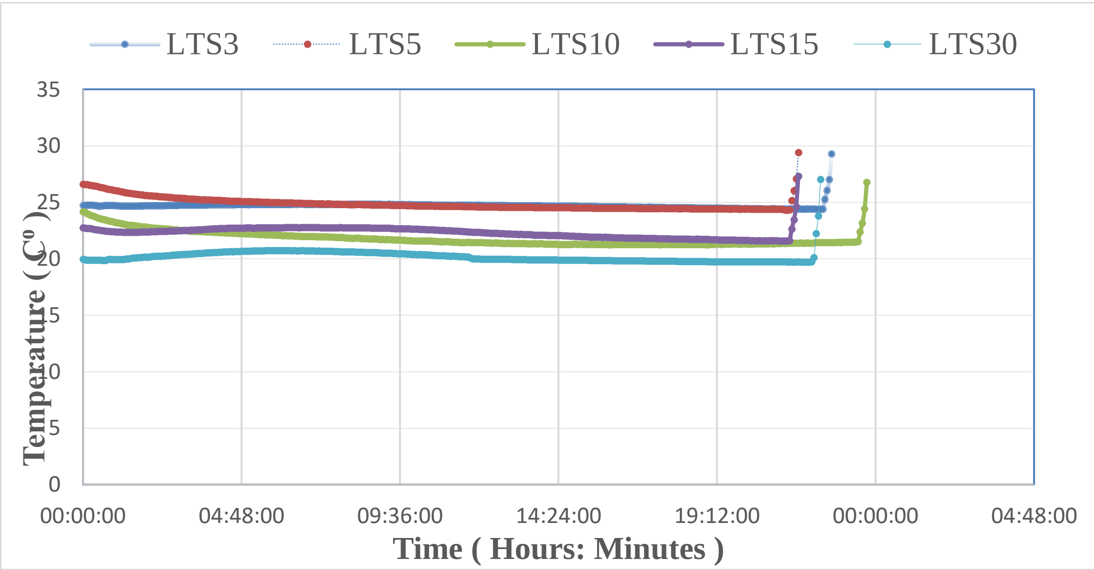


Figure 4.9. The temperature of the soil samples while applying the heat within 24 hours.

Figure 4.8 shows a comparison between the thermal conductivity of Tripoli soil samples results with different lime contents. Figure 4.9 illustrates the results of the soil samples' temperature while applying the heat within 24 hours. The following could be seen and concluded from Figure 4.8, and Figure 4.9 above:

The maximum temperature of the soil's when the heater was applied for 24 hours for all batches were between 23.81℃ - 27.09℃ at a penetration depth of 0.075 m inside the cell. And the minimum temperature of the soils when the heater was applied for 24 hours for all batches were between 20.12℃ - 24.4℃ at a penetration depth of 0 m inside the cell.

The maximum temperature of the soil's samples for all batches when the heater was applied for 24 hours were found for all batches when the penetration depth was 0.075m inside the cell. And the minimum temperature of the soil's samples for all batches when the heater was applied for 24 hours were found for all batches when the penetration depth was 0 m inside the cell. This refers to the nearness and farness from the heater. The more the penetration depth increased the more the section is near to the heater. Thus, 0.075m penetration depth gives the maximum temperature, and 0 m depth (the farest measurement from the sample) gives the minimum temperature.

The water content for all batches in the L series toward 10%, as it found the optimum percentage from the W series.

L series exhibited poor results in terms of improving Tripoli soil thermal conductivity. In general, lime had a poor role with regard to thermal conductivity.

4.3. D SERIES

This section shows the results of the thermal conductivity of Tripoli soil samples with a range of soil densities (D Series). Table 4.3 displays the temperature and conductivity findings of the soil, average water content and the D-series density samples tested in Tripoli, illustrating the figures of Figure 4.10 to Figure 4.13, and represents the results of Table 4.3 for a further comparison of batches in the D-series. In this section, the representative of the results and the discussion starts with a compression of the thermal conductivity of all the batches from the D series, then the density changes in the samples after applying the heat on it is compared.

Table 4.3. The results of the temperature of the soil, thermal conductivity, average water content, and the density of the tested samples from the Tripoli soil for the D Series.

Penetration Depth (m)	L (m)	Volt (V)	Current (mA)	Power Q (wat)	T1 Heater (C)	T2 (C)	K(W/m K)	corrected K (W/m.C)	W (%)	W avg. (%)	*ρ*b (Kg/m³)	*ρd* (Kg/m³)
DTS724, Room Temperature = 19℃												
0	0.11	5.40	0.71	1.92	28.35	22.21	3.82	2.03	10.15	10.00	797.17	724.70
0.025	0.085					23.35	3.62		10.10			
0.05	0.06					24.30	3.16		10.02			
0.075	0.035					25.40	2.53		9.73			
DTS901, Room Temperature = 20℃												
0	0.11	5.40	0.71	1.92	29.83	23.33	3.61	2.18	10.21	10.00	992.04	901.83
0.025	0.085					24.45	3.37		10.12			
0.05	0.06					25.62	3.04		10.00			
0.075	0.035					26.96	2.60		9.68			
DTS1038, Room Temperature = 20												
0	0.11	5.40	0.71	1.92	29.81	23.88	3.95	2.21	10.12	10.00	1142.36	1038.51
0.025	0.085					24.77	3.60		10.09			
0.05	0.06					25.81	3.20		10.02			
0.075	0.035					27.10	2.75		9.77			
DTS1092, Room Temperature = 19℃												
0	0.11	5.40	0.71	1.92	29.36	23.48	3.99	2.22	10.23	10.00	1202.09	1092.78
0.025	0.085					24.45	3.69		10.12			
0.05	0.06					25.43	3.25		10.08			
0.075	0.035					26.65	2.75		9.58			

Penetration Depth (m)	L (m)	Volt (V)	Current (mA)	Power Q (wat)	T1 Heater (C)	T2 (C)	K(W/m K)	corrected K (W/m.C)	W (%)	W aveg. (%)	**ρ**b (Kg/m^3)	***ρd*** (Kg/m^3)
DTS1223, Room Temperature = 19℃												
0	0.11	5.40	0.71	1.92	28.47	22.87	4.19	2.34	10.19	10.00	1346.34	1223.94
0.025	0.085					23.70	3.80		10.09			
0.05	0.06					24.68	3.38		10.03			
0.075	0.035					25.91	2.91		9.69			
DTS1466, Room Temperature = 20℃												
0	0.11	5.40	0.71	1.92	28.03	23.25	4.91	2.81	10.11	10.00	1613.58	1466.89
0.025	0.085					24.03	4.53		10.07			
0.05	0.06					24.84	4.01		10.01			
0.075	0.035					25.87	3.45		9.81			

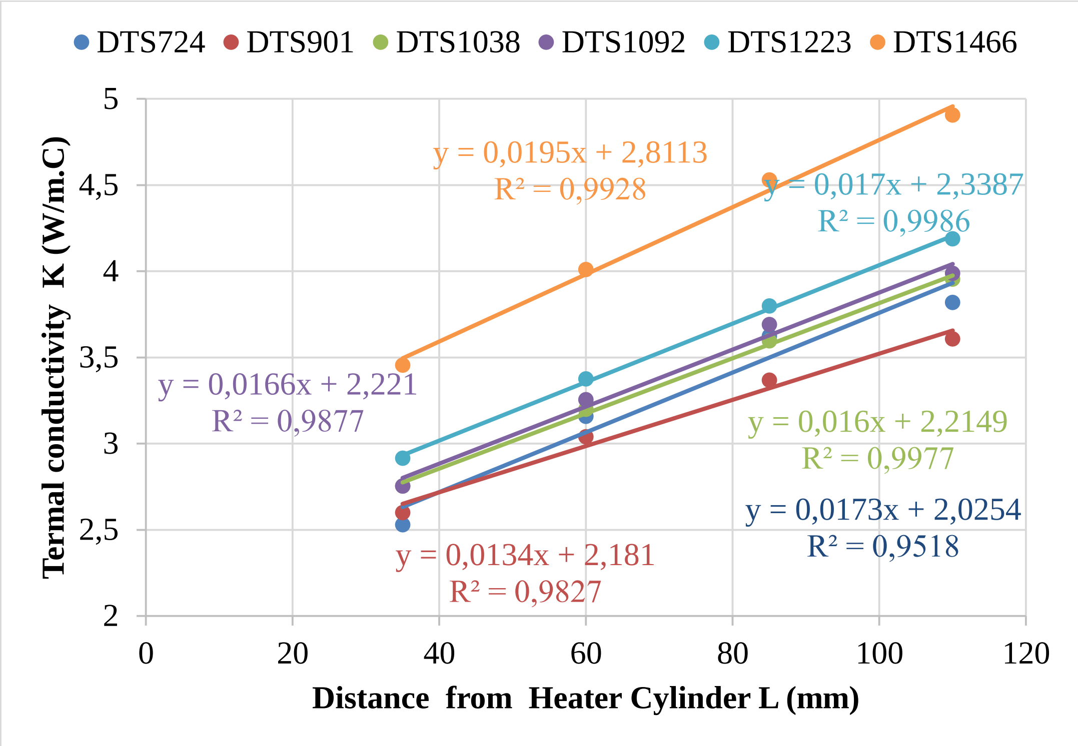


Figure 4.10. The results of the thermal conductivity of Tripoli soil samples in each penetration distance for the D series.

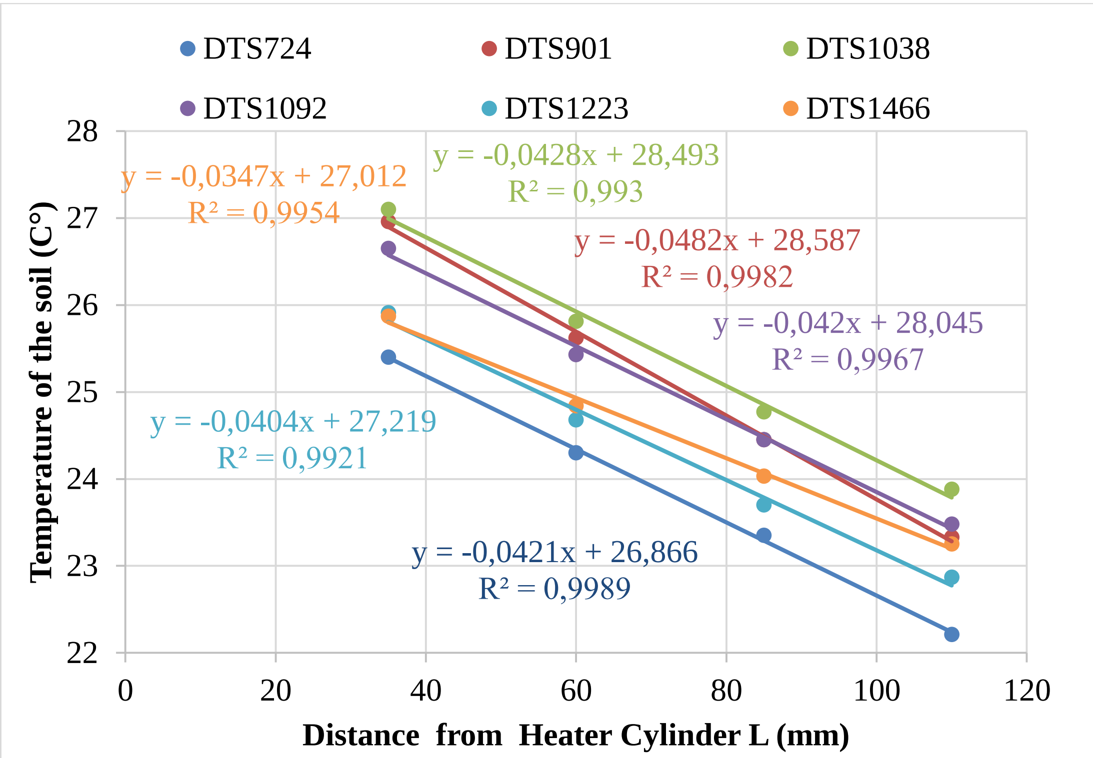


Figure 4.11. The results of the Tripoli soil samples' temperature in each penetration depth for the D series.

Figure 4.10 illustrates the result of the thermal conductivity of Tripoli soil samples in each penetration distance for the D series and Figure 4.7 clarifies the results of the Tripoli soil samples' temperature in each penetration depth for the D series. The results of Table 4.3, Figure 4.10, and Figure 4.11 are discussed below:

The room temperature when the tests were conducted was approximately the same. The temperatures were between 19-20℃. However, as the temperature difference had no effect and due to the presence of two isolation materials (the silicon and the outer pipe), the thermal conductivity tests of the batches were not affected and the results were considered to be accurate.

The maximum corrected thermal conductivity appeared 2.81 W/m.℃. When the batch density was approximately 1466 kg/m^3. The water content was 10% and the lowest corrected thermal conductivity appeared 2.03 W/m^3.℃ when the density of the containing batch was about 724 kg/m^3. The water content was 10%.

Generally, increasing the density of the batches leads to make the soil particles close to each other, leading to increase the soil thermal conductivity.

The maximum temperature of the soil's when the heater was applied for 24 hours for all batches were between 25.4℃ - 27.1℃ at a penetration depth of 0.075 m inside the cell. And the minimum temperature of the soils when the heater was applied for 24 hours for all batches were between 22.21℃ - 23.88℃ at a penetration depth of 0 m inside the cell.

The maximum temperature of the soil's samples for all batches when the heater was applied for 24 hours were found for all batches when the penetration depth was 0.075m inside the cell. And the minimum temperature of the soil's samples for all batches when the heater was applied for 24 hours were found for all batches when the penetration depth was 0m inside the cell. This refers to the nearness and farness from the heater. The more the penetration depth increased the more the section is near to the heater. Thus, 0.075m penetration depth gives the maximum temperature, and 0m depth (the farest measurement from the sample) gives the minimum temperature.

The thermal conductivity of DTS901, DTS1038, DTS1092, DTS1223, and DTS1466 samples was improved by 7.68%, 9.36%, 9.66%, 15.47% and 38.80% compared to the DTS724 sample. The higher the density of the samples, the higher their ability to conduct heat. This refers to the proximity of soil particles to each other which leads to the facilitation of heat transfer.

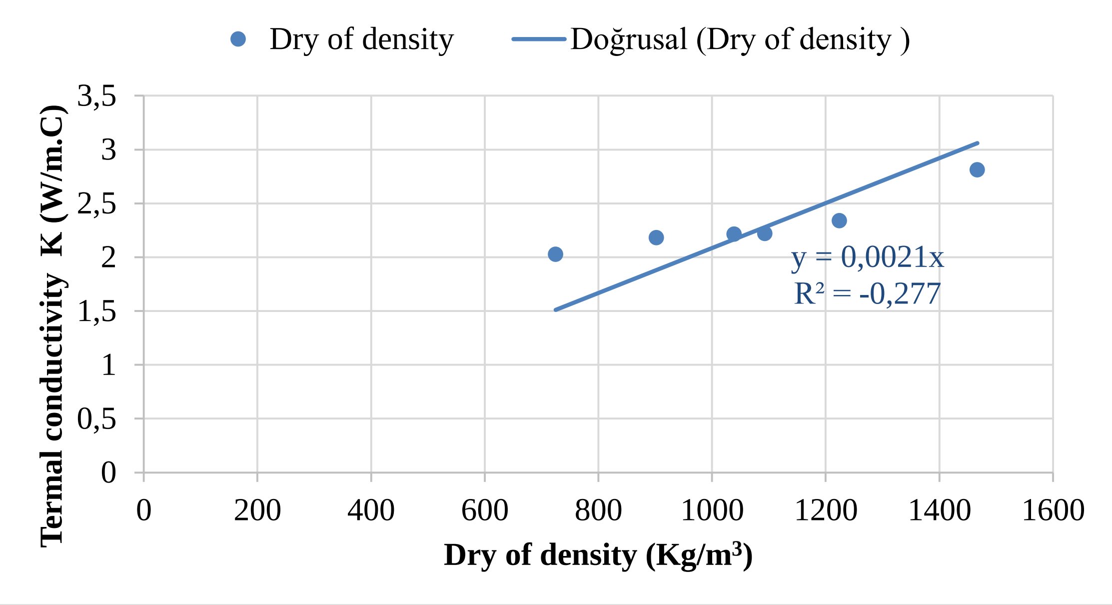


Figure 4.12. Comparison between the thermal conductivity of Tripoli soil samples results with different dry densities.

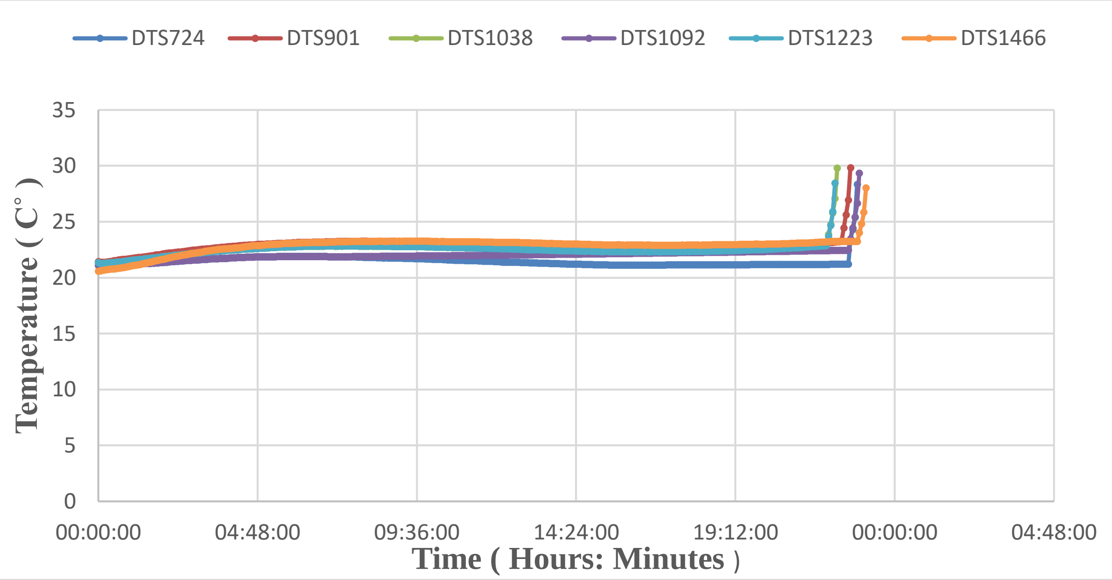


Figure 4.13. The temperature of the soil samples while applying the heat within 24 hours.

Figure 4.12 shows a Comparison between the thermal conductivity of Tripoli soil samples results with different dry densities. Figure 4.13 illustrates the results of the soil samples' temperature while applying the heat within 24 hours. The following could be seen and concluded from Figure 4.12, and Figure 4.13 above:

The water content for all batches in the D series we 10%, as it found the optimum percentage from the W series.

D series pressed positive results in improving Tripoli soil thermal conductivity. In addition, increased soil density led to an increase in heat conductivity. It was found.

The increase in blows during the proctor compaction examination resulted in an increase in the conductivity of the soil. The heat conductivity through the soil is hence greater the soil density.

PART 5

CONCLUSION

The aim of this study is to establish Tripoli soil's thermal conductivity in Libya. The thermal conductivity of Tripoli soil is determined using stationary laboratory methods. Three series were examined in this study, and each series had a unique matrix. Those series are: examining the Tripoli soil samples' thermal conductivity with different water content in each sample (W Series), examining the Tripoli soil samples' thermal conductivity with adding lime to the samples, and keeping the water content of the sample's constant at 10% for all samples (L Series), and examining the Tripoli soil samples' thermal conductivity with different densities and keeping the water content of the sample's constant at 10% for all samples (D Series). Based on the results of this study, the following observation and conclusions could be drawn:

Between all the batches from the three series, the maximum soil thermal conductivity was found in the W series and WTS20 batch and the corrected thermal conductivity was 3.41 W/m.℃.

The increase in sample water content had a beneficial impact on the thermal conductivity of the soil.

The water content after applying the heat from the heater was varied from one section to another in the same batch. The maximum water content was at the farest section from the heater and the minimum water content was at the nearest section from the heater for all batches. This referred to the movement of the water from the side that is near to the heater to the side that is far from the heater.

The optimum water content between all batches was 10% (WTS10 batch), and the thermal conductivity of the soil was about 3.28 W/m.℃. This ideal percentage was found because after this percentage e the increase starts to grow slowly. Moreover, water content of 10% is considered the optimum ratio so as to obtain a homogeneous soil and also the possibility of obtaining good compaction process of the soil.

10% water content were used for all the batches from the L series and the D series as it found the optimum percentage.

Lime added to the soil has a detrimental influence on the thermal conductivity of the soil. Increasing the amount of lime reduces the thermal conductivity of the soil.

The soil density had a beneficial influence on the heat conductivity of the soil. The higher the density of the soil the hotter.

Increases the water content and increase the density give considerable increase to thermal conductivity.

The series that showed the best results regarding the soil thermal conductivity were the W series then D series then L series.

In terms of adding the lime to the soil, it is shown that it is not useful and led to decrease the thermal conductivity.

The results provided in this study can be used in all construction projects.

REFERENCES

1. United Nations, "World population prospects: The 2002 revision", ***United Nations Publications,*** New York, 45-56 (2004).

2. Cengel, Y. A., Boles, M. A., & Kanoglu, M., "Thermodynamics: an engineering approach", ***McGraw-hill,*** New York, 445 (2011).

3. Cass, A., Campbell, G. S., and Jones, T. L., "Hydraulic and Thermal Properties of Soil Samples from the Buried Waste Test Facility", ***United States Departemtn of Energy***, 23 (1981).

4. Hillel, D., "Introduction to environmental soil physics", ***Elsevier,*** Germany, 67-83 (2003).

5. Nusier, O., & Abu-Hamdeh, N., "Laboratory techniques to evaluate thermal conductivity for some soils", ***Heat and Mass Transfer,*** 39(2): 119-123 (2003).

6. Gehlin, S., "Thermal Response Test", ***Lulea University of Technology***, ***Doctoral Thesis,*** Sweden, 1402–1544 (2002).

7. Abuel-Naga, H. M., Bergado, D. T., Bouazza, A., and Pender, M. J., "Thermal conductivity of soft Bangkok clay from laboratory and field measurements", ***Engineering Geology***, 105 (3): 211–219 (2009).

8. Low, J. E., Loveridge, F. A., and Powrie, W., "Measuring soil thermal properties for use in energy foundation design", ***The 18th International Conference on Soil Mechanics and Geotechnical Engineering***, UK, 3375–3378 (2003).

9. Wang, Y., Cui, Y. J., Tang, A. M., Tang, C. S., & Benahmed, N., "Changes in thermal conductivity, suction and microstructure of a compacted lime-treated silty soil during curing", ***Engineering Geology,*** 20(2): 114-121 (2016).

10. Abu-hamdeh, N. H. and Reeder, R. C., "Soil Thermal Conductivity: Effects of Density, Moisture, Salt Concentration, and Organic Matter", ***SOIL SCI. SOC. AM. J.***, 6(4): 1285–1290 (2000).

11. Hamdhan, I. N. and Clarke, B. G., "Determination of Thermal Conductivity of Coarse and Fine Sand Soils", ***Proceedings World Geothermal Congress***, Bali, Indonesia, 225–29 (2010).

12. Holman, V., "Heat Transfer", ***Visual Resources***, 15(3): 34-41 (1999).

13. Bonetto, F., Lebowitz, J. L., & Rey-Bellet, L., "Fourier's law: a challenge to theorists", ***In Mathematical Physics 2000,*** France, 128-150 (2000).

14. Farouki, O., "Thermal Properties of Soils", ***Trans Tech, Clausthal-Zellerfeld,*** Germany, 23-67 (1986).

15. Welty, J. R., "Engineering heat transfer", ***John Wiley and Sons, Inc.,*** New York, 524 (1974).

16. Rees, S. W., Adjali, M. H., Zhou, Z., Davies, M., and Thomas, H. R., "Ground heat transfer effects on the thermal performance of earth-contact structures", ***Renewable and Sustainable Energy Reviews***, 4 (3): 213–265 (2000).

17. Hillel, D., "Fundamentals of soil physics", ***Academic Press***, San Diego, 23-31(1980).

18. Abu-Hamdeh, N. H., "Thermal properties of soils as affected by density and water content", ***Biosystems Engineering***, 86(1): 97–102 (2003).

19. Banks, D. “An introduction to thermogelogy: Ground source heating and cooling”, ***Wiley-Blackwell,*** USA, 13, 2008

20. Abu-Hamdeh, N., Khdair, A., and Reeder, R., "Comparison of two methods used to evaluate thermal conductivity for some soils", ***International Journal of Heat and Mass Transfer***, 44: 1073–1078 (2001).

21. Penner, E., Johnston, G. H., and Goodrich, L. E., "Thermal Conductivity Laboratory Studies of Some Mackenzie Highway Soils", ***Canadian Geotechnical Journal***, 12(3): 271–288 (1975).

22. Krishnaiah, S. and Singh, D. N., "Determination of influence of various parameters on thermal properties of soils", ***International Communications In Heat And Mass Transfer***, 30(6): 861–870 (2003).

23. Hall, M. and Allinson, D., "Assessing the effects of soil grading on the moisture content-dependent thermal conductivity of stabilised rammed earth materials", ***Applied Thermal Engineering***, 29(4): 740–747 (2009).

24. Singh, D. N. and Devid, K., "Generalized relationships for estimating soil thermal resistivity", ***Experimental Thermal and Fluid Science***, 22(3): 133–143 (2000).

25. States, U., and Kersten, M., "Laboratory Research For the Determination of the Thermal Properties of Soils, Final Report", ***Arctic Construction and Frost Effects Laboratory,*** USA, 23 (1949).

26. Johansen, O., "Thermal conductivity of soils", ***Nature***, 179(63): 778–779 (1975).

27. Rhys, T. H. and Robert, S. M., "Fully Coupled Analysis of Heat, Moisture, and Air Transfer in Unsaturated Soil", ***Journal of Engineering Mechanics***, 121(3): 392–405 (1995).

28. Smith, W. O. and Byers, H. G., "The Thermal Conductivity of Dry Soils", ***Soil Science Society of America Journal***, 3(2): 13–19 (1942).

29. Alrtimi, A. A., "Experimental investigation of thermal conductivity of soils and borehole grouting materials", ***Doctoral Dissertation, Newcastle University,*** UK, 45-67 (2014).

30. Côté, J. and Konrad, J.-M., "A generalized thermal conductivity model for soils and construction materials", ***Canadian Geotechnical Journal***, 42 (2): 443–458 (2005).

31. Tarnawski, V. R., Gori, F., Wagner, B., and Buchan, G. D., "Modelling approaches to predicting thermal conductivity of soils at high temperatures", ***International Journal of Energy Research***, 24(5): 403–423 (2000).

32. Sepaskhah, A. R. and Boersma, L., "Thermal Conductivity of Soils as a Function of Temperature and Water Content", ***Soil Science Society of America Journal***, 43(3): 439-444 (1979).

33. Tavman, I. H., "Effective thermal conductivity of granular porous materials", ***International Communications in Heat and Mass Transfer***, 23(2): 169–176 (1996).

34. Brandon, T. L., & Mitchell, J. K. "Factors Influencing Thermal Resistivity of Sands", ***Journal of Geotechnical Engineering***, 115(12): 1683–1698 (1989).

35. Rooyen, M. and Winterkorn, H. F., "Theoretical and Practical Aspects of the Thermal Conductivity of Soils and Similar Granular Systems", ***Highway Research Board Bulletin 168 - Fundamental and Practical Concepts of Soil Freezing***, 16(8): 143–205 (1957).

36. Andersland, O. B. and Anderson, D. M., "Geotechnical Engineering for Cold Regions", ***McGraw-Hill***, New York, 45-51 (1978).

37. Momose, T., Sakaguchi, I., and Kasubuchi, T., "Development of an apparatus for measuring one-dimensional steady-state heat flux of soil under reduced air pressure", ***European Journal of Soil Science***, 5(9): 982–989 (2008).

38. Momose, T. and Kasubuchi, T., "Effect of reduced air pressure on soil thermal conductivity over a wide range of water content and temperature", ***European Journal of Soil Science***, 53(4): 599–606 (2002).

39. Hamuda, S., "The relation between soil composition and its thermal characteristics", ***PhD Disertation***, ***University of Newcastle,*** UK, 32-39 (2009).

40. Austin, W. A., "Development of an in situ system for measuring ground thermal properties", ***Doctoral Dissertation, Oklahoma State University,*** USA, 67-77 (1998).

41. Carslaw, H. S. and Jaeger, J. C., "Conduction of Heat in Solids", ***Clarendon Press***, Oxford, 23-29 (1959).

42. Witte, H. J. L., Van Gelder, G. J., and Spitler, J. D., "In situ measurement of ground thermal conductivity: A dutch perspective", ***ASHRAE Transactions***, 1(1): 263–272 (2002).

43. Al-Khoury, R., Kölbel, T., and Schramedei, R., "Efficient numerical modeling of borehole heat exchangers", ***Computers and Geosciences***, 36(10): 1301–1315 (2010).

44. Wang, H., Qi, C., Du, H., and Gu, J., "Improved method and case study of thermal response test for borehole heat exchangers of ground source heat pump system", ***Renewable Energy***, 35(3): 727–733 (2010).

45. Tan, J. C., Tsipas, S. A., Golosnoy, I. O., Curran, J. A., Paul, S., and Clyne, T. W., "A steady-state Bi-substrate technique for measurement of the thermal conductivity of ceramic coatings", ***Surface and Coatings Technology***, 201(3): 1414–1420 (2006).

46. Salmon, D., "Thermal conductivity of insulations using guarded hot plates, including recent developments and sources of reference materials", ***Measurement Science and Technology***, 12(12): 89–98 (2001).

47. Internet: "Guarded Hot Plate -NETZSCH Analiz & Test", **https://www.netzsch-thermal-analysis.com/tr/enduestrilerbranslar/ methods/guarded-hot- plate-ghp/** (2021).

48. Xamán, J., Lira, L., and Arce, J., "Analysis of the temperature distribution in a guarded hot plate apparatus for measuring thermal conductivity", ***Applied Thermal Engineering***, 29(4): 617–623 (2009).

49. Clarke, B. G., Agab, A., and Nicholson, D., "Model specification to determine thermal conductivity of soils", ***Proceedings of the Institution of Civil Engineers-Geotechnical Engineering***, 161(3): 161–168 (2008).

50. Institution, B. S., "Bs 874: Part 2 : Section 2.2 : 1988", ***BSI***, UK, 12-16 (1988).

51. International, A., "ASTM C518: Standard Test Method for Steady-State Thermal Transmission Properties", ***Cookevilla,*** USA, 10-14 (2004)

52. Hostler, S. R., Abramson, A. R., Gawryla, M. D., Bandi, S. A., and Schiraldi, D. A., "Thermal conductivity of a clay-based aerogel", ***International Journal of Heat and Mass Transfer***, 52(3): 665–669 (2009).

53. Czichos, H., Saito, T., & Smith, L. E. "Springer Handbook of Metrology and Testing", ***Springer Science & Business Media,*** USA, 90-98 (2006).

54. Stand, A. S. T. M., "Test Method for Thermal Conductivity of Solid by Means of the Guarded Comparative Longitudinal Heat-Flow Technique", ***ASTM E1225,*** 7(4): 91-102 (1987).

55. Yüksel, N., "Methods and Techniques for Measuring the Thermal Conductivity of Insulation Materials", ***Intech Open Science***, 2(3): 115–123 (2016).

56. Choi, Y. S., Barrios, M. N., Chang, H. M., and Van Sciver, S. W., "Thermal conductivity of powder insulations for cryogenic storage vessels", ***AIP Conference Proceedings***, 823(2008): 480–487 (2006).

57. Mohsenin, N. N., "Thermal properties of foods and agricultural materials", ***Gordon and Breach, Science Publishers, Inc,*** New York, USA, 21-26 (1980).

58. Standard, A. S. T. M., "C177. Standard test method for steady-state heat flux measurements and thermal transmission properties by means of the guarded-hot-plate apparatus", ***ASTM International,*** USA, 45-67 (2004).

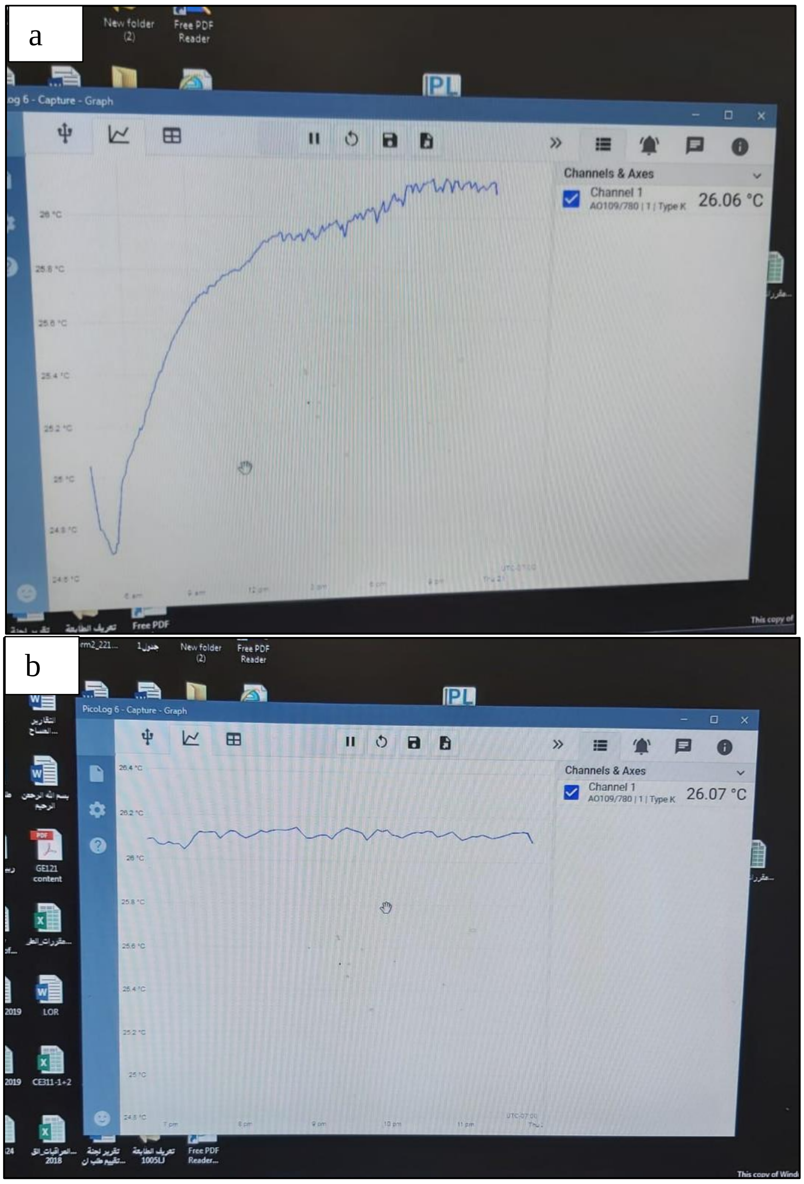
59. Mitchell, J. K., & Kao, T. C., "Measurement of soil thermal resistivity", ***Journal of the Geotechnical Engineering Division,*** *104*(10): 1307-1320 (1978).

60. Wang, J., He, H., Dyck, M., & Lv, J., "A review and evaluation of predictive models for thermal conductivity of sands at full water content range", ***Energies,*** 13(5): 1083 (2020).

61. Mondal, S., Padmakumar, G. P., Sharma, V., Singh, D. N., & Baghini, M. S., "A methodology to determine thermal conductivity of soils from flux measurement", ***Geomechanics and Geoengineering,*** 11(1): 73-85 (2016).

APPENDIX A

PL SOFTWARE'S SAMPLE RESULTS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Channels & Axes
Channel 1
26.06 °C
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26.07 °C

c

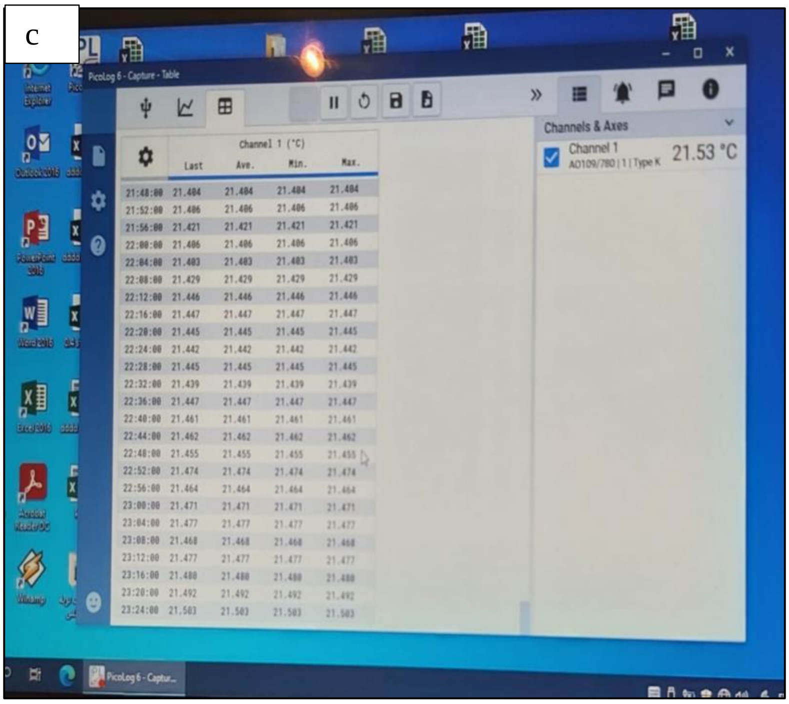

Figure Appendix 1. a and b shows a PL software's sample results and c shows the date arrangement at the software.

Table Appendix 1. Shows the soil temperature (T) results during the thermal conductivity test (t) for the tested samples from the W series.

NO	WTS0		WTS1		WTS3		WTS7		WTS10		WTS15		WTS20	
	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer
1	0:00:00	19.513	0:00:00	25.058	0:00:00	26.738	0:00:00	27.897	0:00:00	25.047	0:00:00	24.115	0:00:00	24.186
2	0:04:00	19.437	0:04:00	25.04	0:04:00	26.744	0:04:00	27.8	0:04:00	24.984	0:04:00	24.107	0:04:00	24.114
3	0:08:00	19.435	0:08:00	25.027	0:08:00	26.716	0:08:00	27.7	0:08:00	24.942	0:08:00	24.117	0:08:00	23.996
4	0:12:00	19.434	0:12:00	25.035	0:12:00	26.677	0:12:00	27.6	0:12:00	24.883	0:12:00	24.051	0:12:00	23.914
5	0:16:00	19.431	0:16:00	25.037	0:16:00	26.654	0:16:00	27.499	0:16:00	24.837	0:16:00	23.989	0:16:00	23.838
6	0:20:00	19.41	0:20:00	25.022	0:20:00	26.651	0:20:00	27.421	0:20:00	24.791	0:20:00	23.923	0:20:00	23.77
7	0:24:00	19.388	0:24:00	25.024	0:24:00	26.642	0:24:00	27.359	0:24:00	24.793	0:24:00	23.892	0:24:00	23.696
8	0:28:00	19.386	0:28:00	24.997	0:28:00	26.612	0:28:00	27.283	0:28:00	24.785	0:28:00	23.892	0:28:00	23.612
9	0:32:00	19.384	0:32:00	24.973	0:32:00	26.549	0:32:00	27.199	0:32:00	24.768	0:32:00	23.9	0:32:00	23.557
10	0:36:00	19.383	0:36:00	24.942	0:36:00	26.517	0:36:00	27.125	0:36:00	24.755	0:36:00	23.915	0:36:00	23.492
11	0:40:00	19.381	0:40:00	24.932	0:40:00	26.481	0:40:00	27.089	0:40:00	24.747	0:40:00	23.905	0:40:00	23.457
12	0:44:00	19.379	0:44:00	24.895	0:44:00	26.446	0:44:00	27.038	0:44:00	24.721	0:44:00	23.933	0:44:00	23.401
13	0:48:00	19.377	0:48:00	24.875	0:48:00	26.393	0:48:00	26.984	0:48:00	24.703	0:48:00	23.961	0:48:00	23.354
14	0:52:00	19.375	0:52:00	24.845	0:52:00	26.367	0:52:00	26.915	0:52:00	24.692	0:52:00	23.964	0:52:00	23.313
15	0:56:00	19.373	0:56:00	24.815	0:56:00	26.33	0:56:00	26.851	0:56:00	24.697	0:56:00	23.964	0:56:00	23.26
16	1:00:00	19.37	1:00:00	24.783	1:00:00	26.311	1:00:00	26.805	1:00:00	24.698	1:00:00	23.978	1:00:00	23.209
17	1:04:00	19.369	1:04:00	24.737	1:04:00	26.282	1:04:00	26.759	1:04:00	24.734	1:04:00	23.999	1:04:00	23.177
18	1:08:00	19.367	1:08:00	24.713	1:08:00	26.25	1:08:00	26.722	1:08:00	24.734	1:08:00	24.009	1:08:00	23.146
19	1:12:00	19.364	1:12:00	24.692	1:12:00	26.227	1:12:00	26.672	1:12:00	24.805	1:12:00	24.027	1:12:00	23.096
20	1:16:00	19.362	1:16:00	24.651	1:16:00	26.201	1:16:00	26.641	1:16:00	24.857	1:16:00	24.044	1:16:00	23.059
21	1:20:00	19.361	1:20:00	24.625	1:20:00	26.17	1:20:00	26.607	1:20:00	24.904	1:20:00	24.076	1:20:00	23.026
22	1:24:00	19.358	1:24:00	24.61	1:24:00	26.156	1:24:00	26.583	1:24:00	24.969	1:24:00	24.093	1:24:00	22.989
23	1:28:00	19.355	1:28:00	24.583	1:28:00	26.149	1:28:00	26.549	1:28:00	24.994	1:28:00	24.087	1:28:00	22.974
24	1:32:00	19.353	1:32:00	24.553	1:32:00	26.147	1:32:00	26.533	1:32:00	25.003	1:32:00	24.112	1:32:00	22.956
25	1:36:00	19.351	1:36:00	24.536	1:36:00	26.111	1:36:00	26.493	1:36:00	25.015	1:36:00	24.119	1:36:00	22.921
26	1:40:00	19.347	1:40:00	24.522	1:40:00	26.118	1:40:00	26.457	1:40:00	25.052	1:40:00	24.137	1:40:00	22.896
27	1:44:00	19.345	1:44:00	24.501	1:44:00	26.097	1:44:00	26.421	1:44:00	25.069	1:44:00	24.149	1:44:00	22.868
28	1:48:00	19.341	1:48:00	24.49	1:48:00	26.085	1:48:00	26.407	1:48:00	25.079	1:48:00	24.162	1:48:00	22.852
29	1:52:00	19.326	1:52:00	24.48	1:52:00	26.069	1:52:00	26.391	1:52:00	25.088	1:52:00	24.174	1:52:00	22.828
30	1:56:00	19.324	1:56:00	24.448	1:56:00	26.061	1:56:00	26.36	1:56:00	25.101	1:56:00	24.196	1:56:00	22.8
31	2:00:00	19.323	2:00:00	24.438	2:00:00	26.043	2:00:00	26.355	2:00:00	25.115	2:00:00	24.203	2:00:00	22.785
32	2:04:00	19.318	2:04:00	24.43	2:04:00	26.023	2:04:00	26.34	2:04:00	25.14	2:04:00	24.219	2:04:00	22.769
33	2:08:00	19.316	2:08:00	24.416	2:08:00	26.041	2:08:00	26.335	2:08:00	25.15	2:08:00	24.235	2:08:00	22.74
34	2:12:00	19.313	2:12:00	24.409	2:12:00	26.04	2:12:00	26.333	2:12:00	25.154	2:12:00	24.25	2:12:00	22.724
35	2:16:00	19.3	2:16:00	24.409	2:16:00	26.035	2:16:00	26.317	2:16:00	25.169	2:16:00	24.279	2:16:00	22.713
36	2:20:00	19.289	2:20:00	24.387	2:20:00	26.026	2:20:00	26.298	2:20:00	25.191	2:20:00	24.289	2:20:00	22.692
37	2:24:00	19.287	2:24:00	24.383	2:24:00	26.017	2:24:00	26.275	2:24:00	25.184	2:24:00	24.305	2:24:00	22.674
38	2:28:00	19.285	2:28:00	24.38	2:28:00	26.026	2:28:00	26.26	2:28:00	25.2	2:28:00	24.325	2:28:00	22.672
39	2:32:00	19.283	2:32:00	24.376	2:32:00	26.014	2:32:00	26.251	2:32:00	25.207	2:32:00	24.33	2:32:00	22.649
40	2:36:00	19.282	2:36:00	24.371	2:36:00	26.002	2:36:00	26.245	2:36:00	25.244	2:36:00	24.355	2:36:00	22.637
41	2:40:00	19.279	2:40:00	24.375	2:40:00	25.996	2:40:00	26.225	2:40:00	25.261	2:40:00	24.383	2:40:00	22.603
42	2:44:00	19.277	2:44:00	24.37	2:44:00	25.988	2:44:00	26.223	2:44:00	25.269	2:44:00	24.401	2:44:00	22.586
43	2:48:00	19.275	2:48:00	24.359	2:48:00	25.97	2:48:00	26.226	2:48:00	25.279	2:48:00	24.429	2:48:00	22.574
44	2:52:00	19.273	2:52:00	24.356	2:52:00	25.96	2:52:00	26.199	2:52:00	25.302	2:52:00	24.437	2:52:00	22.552
45	2:56:00	19.27	2:56:00	24.352	2:56:00	25.972	2:56:00	26.186	2:56:00	25.322	2:56:00	24.436	2:56:00	22.54
46	3:00:00	19.267	3:00:00	24.355	3:00:00	25.951	3:00:00	26.186	3:00:00	25.331	3:00:00	24.45	3:00:00	22.529
47	3:04:00	19.263	3:04:00	24.373	3:04:00	25.948	3:04:00	26.17	3:04:00	25.343	3:04:00	24.482	3:04:00	22.517

NO	WTS0		WTS1		WTS3		WTS7		WTS10		WTS15		WTS20	
	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer
48	3:08:00	19.261	3:08:00	24.363	3:08:00	25.972	3:08:00	26.17	3:08:00	25.37	3:08:00	24.495	3:08:00	22.491
49	3:12:00	19.248	3:12:00	24.362	3:12:00	25.983	3:12:00	26.153	3:12:00	25.382	3:12:00	24.504	3:12:00	22.473
50	3:16:00	19.247	3:16:00	24.374	3:16:00	25.96	3:16:00	26.161	3:16:00	25.394	3:16:00	24.521	3:16:00	22.459
51	3:20:00	19.245	3:20:00	24.365	3:20:00	25.951	3:20:00	26.15	3:20:00	25.41	3:20:00	24.524	3:20:00	22.451
52	3:24:00	19.24	3:24:00	24.364	3:24:00	25.953	3:24:00	26.135	3:24:00	25.409	3:24:00	24.539	3:24:00	22.441
53	3:28:00	19.238	3:28:00	24.37	3:28:00	25.947	3:28:00	26.132	3:28:00	25.424	3:28:00	24.565	3:28:00	22.433
54	3:32:00	19.236	3:32:00	24.365	3:32:00	25.945	3:32:00	26.134	3:32:00	25.448	3:32:00	24.569	3:32:00	22.429
55	3:36:00	19.231	3:36:00	24.359	3:36:00	25.938	3:36:00	26.146	3:36:00	25.458	3:36:00	24.576	3:36:00	22.41
56	3:40:00	19.229	3:40:00	24.369	3:40:00	25.938	3:40:00	26.141	3:40:00	25.473	3:40:00	24.597	3:40:00	22.404
57	3:44:00	19.226	3:44:00	24.382	3:44:00	25.951	3:44:00	26.142	3:44:00	25.487	3:44:00	24.623	3:44:00	22.392
58	3:48:00	19.224	3:48:00	24.388	3:48:00	25.954	3:48:00	26.134	3:48:00	25.492	3:48:00	24.642	3:48:00	22.388
59	3:52:00	19.221	3:52:00	24.403	3:52:00	25.956	3:52:00	26.118	3:52:00	25.511	3:52:00	24.654	3:52:00	22.393
60	3:56:00	19.21	3:56:00	24.41	3:56:00	25.936	3:56:00	26.13	3:56:00	25.527	3:56:00	24.664	3:56:00	22.358
61	4:00:00	19.126	4:00:00	24.398	4:00:00	25.948	4:00:00	26.121	4:00:00	25.535	4:00:00	24.679	4:00:00	22.349
62	4:04:00	19.124	4:04:00	24.395	4:04:00	25.96	4:04:00	26.114	4:04:00	25.55	4:04:00	24.685	4:04:00	22.346
63	4:08:00	19.121	4:08:00	24.405	4:08:00	25.94	4:08:00	26.114	4:08:00	25.555	4:08:00	24.694	4:08:00	22.333
64	4:12:00	19.012	4:12:00	24.406	4:12:00	25.95	4:12:00	26.103	4:12:00	25.567	4:12:00	24.72	4:12:00	22.327
65	4:16:00	18.998	4:16:00	24.423	4:16:00	25.96	4:16:00	26.1	4:16:00	25.575	4:16:00	24.729	4:16:00	22.319
66	4:20:00	18.995	4:20:00	24.422	4:20:00	25.971	4:20:00	26.102	4:20:00	25.586	4:20:00	24.75	4:20:00	22.308
67	4:24:00	18.992	4:24:00	24.413	4:24:00	25.968	4:24:00	26.097	4:24:00	25.593	4:24:00	24.745	4:24:00	22.293
68	4:28:00	18.984	4:28:00	24.439	4:28:00	25.954	4:28:00	26.132	4:28:00	25.605	4:28:00	24.761	4:28:00	22.297
69	4:32:00	18.975	4:32:00	24.442	4:32:00	25.942	4:32:00	26.123	4:32:00	25.614	4:32:00	24.774	4:32:00	22.288
70	4:36:00	18.964	4:36:00	24.451	4:36:00	25.945	4:36:00	26.106	4:36:00	25.625	4:36:00	24.764	4:36:00	22.282
71	4:40:00	18.946	4:40:00	24.443	4:40:00	25.932	4:40:00	26.095	4:40:00	25.639	4:40:00	24.776	4:40:00	22.267
72	4:44:00	18.989	4:44:00	24.446	4:44:00	25.923	4:44:00	26.083	4:44:00	25.64	4:44:00	24.803	4:44:00	22.257
73	4:48:00	18.983	4:48:00	24.453	4:48:00	25.936	4:48:00	26.094	4:48:00	25.654	4:48:00	24.798	4:48:00	22.242
74	4:52:00	18.979	4:52:00	24.457	4:52:00	25.94	4:52:00	26.086	4:52:00	25.66	4:52:00	24.794	4:52:00	22.238
75	4:56:00	18.975	4:56:00	24.466	4:56:00	25.923	4:56:00	26.109	4:56:00	25.674	4:56:00	24.823	4:56:00	22.219
76	5:00:00	18.969	5:00:00	24.474	5:00:00	25.915	5:00:00	26.128	5:00:00	25.674	5:00:00	24.822	5:00:00	22.219
77	5:04:00	18.965	5:04:00	24.475	5:04:00	25.912	5:04:00	26.118	5:04:00	25.675	5:04:00	24.831	5:04:00	22.223
78	5:08:00	18.953	5:08:00	24.48	5:08:00	25.905	5:08:00	26.106	5:08:00	25.694	5:08:00	24.845	5:08:00	22.212
79	5:12:00	18.912	5:12:00	24.468	5:12:00	25.898	5:12:00	26.109	5:12:00	25.694	5:12:00	24.86	5:12:00	22.196
80	5:16:00	18.876	5:16:00	24.475	5:16:00	25.901	5:16:00	26.092	5:16:00	25.704	5:16:00	24.848	5:16:00	22.182
81	5:20:00	18.872	5:20:00	24.476	5:20:00	25.917	5:20:00	26.09	5:20:00	25.704	5:20:00	24.852	5:20:00	22.162
82	5:24:00	18.861	5:24:00	24.487	5:24:00	25.916	5:24:00	26.091	5:24:00	25.707	5:24:00	24.859	5:24:00	22.172
83	5:28:00	18.872	5:28:00	24.508	5:28:00	25.904	5:28:00	26.089	5:28:00	25.715	5:28:00	24.868	5:28:00	22.152
84	5:32:00	18.86	5:32:00	24.512	5:32:00	25.9	5:32:00	26.08	5:32:00	25.711	5:32:00	24.875	5:32:00	22.144
85	5:36:00	18.842	5:36:00	24.518	5:36:00	25.895	5:36:00	26.077	5:36:00	25.707	5:36:00	24.882	5:36:00	22.129
86	5:40:00	18.829	5:40:00	24.528	5:40:00	25.895	5:40:00	26.067	5:40:00	25.729	5:40:00	24.905	5:40:00	22.123
87	5:44:00	18.826	5:44:00	24.525	5:44:00	25.893	5:44:00	26.063	5:44:00	25.738	5:44:00	24.907	5:44:00	22.12
88	5:48:00	18.824	5:48:00	24.534	5:48:00	25.884	5:48:00	26.081	5:48:00	25.738	5:48:00	24.918	5:48:00	22.108
89	5:52:00	18.819	5:52:00	24.544	5:52:00	25.883	5:52:00	26.074	5:52:00	25.738	5:52:00	24.916	5:52:00	22.102
90	5:56:00	18.815	5:56:00	24.554	5:56:00	25.894	5:56:00	26.067	5:56:00	25.735	5:56:00	24.919	5:56:00	22.112
91	6:00:00	18.81	6:00:00	24.541	6:00:00	25.887	6:00:00	26.077	6:00:00	25.74	6:00:00	24.932	6:00:00	22.083
92	6:04:00	18.789	6:04:00	24.545	6:04:00	25.885	6:04:00	26.069	6:04:00	25.754	6:04:00	24.965	6:04:00	22.062
93	6:08:00	18.785	6:08:00	24.558	6:08:00	25.887	6:08:00	26.069	6:08:00	25.757	6:08:00	24.983	6:08:00	22.069
94	6:12:00	18.781	6:12:00	24.552	6:12:00	25.881	6:12:00	26.065	6:12:00	25.757	6:12:00	24.991	6:12:00	22.054

NO	WTS0		WTS1		WTS3		WTS7		WTS10		WTS15		WTS20	
	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer
95	6:16:00	18.78	6:16:00	24.565	6:16:00	25.866	6:16:00	26.041	6:16:00	25.768	6:16:00	24.967	6:16:00	22.055
96	6:20:00	18.778	6:20:00	24.552	6:20:00	25.874	6:20:00	26.045	6:20:00	25.777	6:20:00	24.974	6:20:00	22.043
97	6:24:00	18.777	6:24:00	24.548	6:24:00	25.875	6:24:00	26.063	6:24:00	25.777	6:24:00	25.002	6:24:00	22.027
98	6:28:00	18.776	6:28:00	24.553	6:28:00	25.878	6:28:00	26.054	6:28:00	25.777	6:28:00	24.986	6:28:00	22.017
99	6:32:00	18.769	6:32:00	24.55	6:32:00	25.871	6:32:00	26.057	6:32:00	25.781	6:32:00	24.999	6:32:00	22.006
100	6:36:00	18.782	6:36:00	24.565	6:36:00	25.858	6:36:00	26.065	6:36:00	25.78	6:36:00	25.026	6:36:00	21.999
101	6:40:00	18.789	6:40:00	24.579	6:40:00	25.878	6:40:00	26.054	6:40:00	25.789	6:40:00	25.019	6:40:00	21.996
102	6:44:00	18.789	6:44:00	24.578	6:44:00	25.895	6:44:00	26.045	6:44:00	25.793	6:44:00	25.018	6:44:00	21.999
103	6:48:00	18.787	6:48:00	24.577	6:48:00	25.863	6:48:00	26.06	6:48:00	25.791	6:48:00	25.022	6:48:00	21.995
104	6:52:00	18.792	6:52:00	24.587	6:52:00	25.857	6:52:00	26.055	6:52:00	25.798	6:52:00	25.033	6:52:00	21.99
105	6:56:00	18.796	6:56:00	24.589	6:56:00	25.857	6:56:00	26.056	6:56:00	25.798	6:56:00	25.046	6:56:00	21.995
106	7:00:00	18.791	7:00:00	24.588	7:00:00	25.839	7:00:00	26.065	7:00:00	25.795	7:00:00	25.052	7:00:00	21.983
107	7:04:00	18.784	7:04:00	24.588	7:04:00	25.839	7:04:00	26.065	7:04:00	25.797	7:04:00	25.069	7:04:00	21.975
108	7:08:00	18.787	7:08:00	24.59	7:08:00	25.837	7:08:00	26.063	7:08:00	25.795	7:08:00	25.09	7:08:00	21.964
109	7:12:00	18.763	7:12:00	24.609	7:12:00	25.853	7:12:00	26.069	7:12:00	25.803	7:12:00	25.084	7:12:00	21.962
110	7:16:00	18.767	7:16:00	24.611	7:16:00	25.827	7:16:00	26.066	7:16:00	25.811	7:16:00	25.089	7:16:00	21.963
111	7:20:00	18.764	7:20:00	24.6	7:20:00	25.82	7:20:00	26.076	7:20:00	25.815	7:20:00	25.078	7:20:00	21.963
112	7:24:00	18.761	7:24:00	24.602	7:24:00	25.851	7:24:00	26.08	7:24:00	25.818	7:24:00	25.077	7:24:00	21.949
113	7:28:00	18.758	7:28:00	24.61	7:28:00	25.831	7:28:00	26.057	7:28:00	25.827	7:28:00	25.077	7:28:00	21.941
114	7:32:00	18.771	7:32:00	24.599	7:32:00	25.836	7:32:00	26.057	7:32:00	25.832	7:32:00	25.086	7:32:00	21.935
115	7:36:00	18.767	7:36:00	24.597	7:36:00	25.841	7:36:00	26.052	7:36:00	25.828	7:36:00	25.08	7:36:00	21.923
116	7:40:00	18.771	7:40:00	24.609	7:40:00	25.835	7:40:00	26.048	7:40:00	25.84	7:40:00	25.087	7:40:00	21.906
117	7:44:00	18.77	7:44:00	24.61	7:44:00	25.831	7:44:00	26.057	7:44:00	25.846	7:44:00	25.079	7:44:00	21.909
118	7:48:00	18.772	7:48:00	24.604	7:48:00	25.828	7:48:00	26.069	7:48:00	25.857	7:48:00	25.102	7:48:00	21.905
119	7:52:00	18.76	7:52:00	24.611	7:52:00	25.838	7:52:00	26.072	7:52:00	25.866	7:52:00	25.106	7:52:00	21.9
120	7:56:00	18.76	7:56:00	24.605	7:56:00	25.811	7:56:00	26.063	7:56:00	25.866	7:56:00	25.108	7:56:00	21.879
121	8:00:00	18.759	8:00:00	24.601	8:00:00	25.816	8:00:00	26.076	8:00:00	25.878	8:00:00	25.094	8:00:00	21.843
122	8:04:00	18.755	8:04:00	24.622	8:04:00	25.816	8:04:00	26.069	8:04:00	25.879	8:04:00	25.1	8:04:00	21.855
123	8:08:00	18.764	8:08:00	24.62	8:08:00	25.816	8:08:00	26.05	8:08:00	25.89	8:08:00	25.122	8:08:00	21.832
124	8:12:00	18.763	8:12:00	24.622	8:12:00	25.806	8:12:00	26.055	8:12:00	25.898	8:12:00	25.12	8:12:00	21.819
125	8:16:00	18.755	8:16:00	24.631	8:16:00	25.807	8:16:00	26.059	8:16:00	25.906	8:16:00	25.12	8:16:00	21.836
126	8:20:00	18.767	8:20:00	24.632	8:20:00	25.784	8:20:00	26.061	8:20:00	25.908	8:20:00	25.125	8:20:00	21.837
127	8:24:00	18.757	8:24:00	24.627	8:24:00	25.778	8:24:00	26.058	8:24:00	25.904	8:24:00	25.138	8:24:00	21.816
128	8:28:00	18.758	8:28:00	24.618	8:28:00	25.784	8:28:00	26.045	8:28:00	25.903	8:28:00	25.132	8:28:00	21.801
129	8:32:00	18.751	8:32:00	24.605	8:32:00	25.763	8:32:00	26.051	8:32:00	25.915	8:32:00	25.137	8:32:00	21.796
130	8:36:00	18.753	8:36:00	24.615	8:36:00	25.751	8:36:00	26.07	8:36:00	25.916	8:36:00	25.149	8:36:00	21.802
131	8:40:00	18.746	8:40:00	24.608	8:40:00	25.766	8:40:00	26.075	8:40:00	25.923	8:40:00	25.121	8:40:00	21.777
132	8:44:00	18.724	8:44:00	24.602	8:44:00	25.773	8:44:00	26.074	8:44:00	25.926	8:44:00	25.116	8:44:00	21.773
133	8:48:00	18.742	8:48:00	24.617	8:48:00	25.756	8:48:00	26.066	8:48:00	25.925	8:48:00	25.123	8:48:00	21.779
134	8:52:00	18.719	8:52:00	24.616	8:52:00	25.765	8:52:00	26.068	8:52:00	25.928	8:52:00	25.13	8:52:00	21.76
135	8:56:00	18.733	8:56:00	24.618	8:56:00	25.736	8:56:00	26.066	8:56:00	25.926	8:56:00	25.134	8:56:00	21.751
136	9:00:00	18.732	9:00:00	24.617	9:00:00	25.75	9:00:00	26.071	9:00:00	25.937	9:00:00	25.122	9:00:00	21.716
137	9:04:00	18.724	9:04:00	24.62	9:04:00	25.77	9:04:00	26.066	9:04:00	25.942	9:04:00	25.138	9:04:00	21.727
138	9:08:00	18.732	9:08:00	24.624	9:08:00	25.726	9:08:00	26.062	9:08:00	25.938	9:08:00	25.157	9:08:00	21.715
139	9:12:00	18.724	9:12:00	24.63	9:12:00	25.738	9:12:00	26.072	9:12:00	25.908	9:12:00	25.156	9:12:00	21.722
140	9:16:00	18.716	9:16:00	24.636	9:16:00	25.733	9:16:00	26.072	9:16:00	25.91	9:16:00	25.161	9:16:00	21.698
141	9:20:00	18.714	9:20:00	24.633	9:20:00	25.68	9:20:00	26.081	9:20:00	25.919	9:20:00	25.151	9:20:00	21.696

NO	WTS0		WTS1		WTS3		WTS7		WTS10		WTS15		WTS20	
	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer
142	9:24:00	18.7	9:24:00	24.626	9:24:00	25.698	9:24:00	26.082	9:24:00	25.932	9:24:00	25.15	9:24:00	21.686
143	9:28:00	18.685	9:28:00	24.63	9:28:00	25.699	9:28:00	26.082	9:28:00	25.935	9:28:00	25.15	9:28:00	21.668
144	9:32:00	18.671	9:32:00	24.635	9:32:00	25.676	9:32:00	26.095	9:32:00	25.936	9:32:00	25.156	9:32:00	21.673
145	9:36:00	18.67	9:36:00	24.645	9:36:00	25.694	9:36:00	26.099	9:36:00	25.923	9:36:00	25.151	9:36:00	21.677
146	9:40:00	18.671	9:40:00	24.627	9:40:00	25.7	9:40:00	26.095	9:40:00	25.913	9:40:00	25.158	9:40:00	21.653
147	9:44:00	18.672	9:44:00	24.624	9:44:00	25.7	9:44:00	26.083	9:44:00	25.912	9:44:00	25.177	9:44:00	21.637
148	9:48:00	18.673	9:48:00	24.612	9:48:00	25.675	9:48:00	26.083	9:48:00	25.919	9:48:00	25.175	9:48:00	21.622
149	9:52:00	18.674	9:52:00	24.635	9:52:00	25.668	9:52:00	26.081	9:52:00	25.931	9:52:00	25.172	9:52:00	21.612
150	9:56:00	18.675	9:56:00	24.641	9:56:00	25.676	9:56:00	26.084	9:56:00	25.924	9:56:00	25.189	9:56:00	21.616
151	10:00:00	18.676	10:00:00	24.644	10:00:00	25.658	10:00:00	26.085	10:00:00	25.938	10:00:00	25.18	10:00:00	21.604
152	10:04:00	18.674	10:04:00	24.64	10:04:00	25.664	10:04:00	26.086	10:04:00	25.934	10:04:00	25.199	10:04:00	21.592
153	10:08:00	18.675	10:08:00	24.631	10:08:00	25.659	10:08:00	26.078	10:08:00	25.908	10:08:00	25.193	10:08:00	21.592
154	10:12:00	18.676	10:12:00	24.638	10:12:00	25.654	10:12:00	26.083	10:12:00	25.915	10:12:00	25.2	10:12:00	21.594
155	10:16:00	18.677	10:16:00	24.625	10:16:00	25.678	10:16:00	26.075	10:16:00	25.925	10:16:00	25.205	10:16:00	21.59
156	10:20:00	18.678	10:20:00	24.635	10:20:00	25.667	10:20:00	26.075	10:20:00	25.941	10:20:00	25.194	10:20:00	21.591
157	10:24:00	18.679	10:24:00	24.622	10:24:00	25.682	10:24:00	26.07	10:24:00	25.955	10:24:00	25.187	10:24:00	21.6
158	10:28:00	18.68	10:28:00	24.625	10:28:00	25.683	10:28:00	26.072	10:28:00	25.94	10:28:00	25.183	10:28:00	21.586
159	10:32:00	18.681	10:32:00	24.635	10:32:00	25.669	10:32:00	26.083	10:32:00	25.932	10:32:00	25.212	10:32:00	21.585
160	10:36:00	18.682	10:36:00	24.641	10:36:00	25.674	10:36:00	26.072	10:36:00	25.941	10:36:00	25.233	10:36:00	21.578
161	10:40:00	18.683	10:40:00	24.626	10:40:00	25.644	10:40:00	26.066	10:40:00	25.92	10:40:00	25.221	10:40:00	21.555
162	10:44:00	18.684	10:44:00	24.634	10:44:00	25.651	10:44:00	26.066	10:44:00	25.915	10:44:00	25.207	10:44:00	21.546
163	10:48:00	18.685	10:48:00	24.633	10:48:00	25.64	10:48:00	26.062	10:48:00	25.928	10:48:00	25.193	10:48:00	21.529
164	10:52:00	18.684	10:52:00	24.63	10:52:00	25.614	10:52:00	26.065	10:52:00	25.927	10:52:00	25.202	10:52:00	21.52
165	10:56:00	18.685	10:56:00	24.617	10:56:00	25.624	10:56:00	26.071	10:56:00	25.939	10:56:00	25.21	10:56:00	21.525
166	11:00:00	18.686	11:00:00	24.616	11:00:00	25.619	11:00:00	26.066	11:00:00	25.955	11:00:00	25.198	11:00:00	21.54
167	11:04:00	18.687	11:04:00	24.615	11:04:00	25.641	11:04:00	26.072	11:04:00	25.969	11:04:00	25.219	11:04:00	21.523
168	11:08:00	18.688	11:08:00	24.6	11:08:00	25.631	11:08:00	26.085	11:08:00	25.947	11:08:00	25.219	11:08:00	21.516
169	11:12:00	18.689	11:12:00	24.624	11:12:00	25.631	11:12:00	26.076	11:12:00	25.953	11:12:00	25.202	11:12:00	21.489
170	11:16:00	18.69	11:16:00	24.617	11:16:00	25.635	11:16:00	26.063	11:16:00	25.962	11:16:00	25.207	11:16:00	21.485
171	11:20:00	18.691	11:20:00	24.63	11:20:00	25.622	11:20:00	26.054	11:20:00	25.961	11:20:00	25.227	11:20:00	21.473
172	11:24:00	18.692	11:24:00	24.621	11:24:00	25.644	11:24:00	26.066	11:24:00	25.977	11:24:00	25.221	11:24:00	21.465
173	11:28:00	18.693	11:28:00	24.618	11:28:00	25.623	11:28:00	26.062	11:28:00	25.968	11:28:00	25.221	11:28:00	21.458
174	11:32:00	18.694	11:32:00	24.612	11:32:00	25.605	11:32:00	26.062	11:32:00	25.974	11:32:00	25.235	11:32:00	21.453
175	11:36:00	18.695	11:36:00	24.626	11:36:00	25.586	11:36:00	26.082	11:36:00	25.978	11:36:00	25.26	11:36:00	21.452
176	11:40:00	18.693	11:40:00	24.612	11:40:00	25.585	11:40:00	26.086	11:40:00	25.98	11:40:00	25.266	11:40:00	21.47
177	11:44:00	18.694	11:44:00	24.618	11:44:00	25.606	11:44:00	26.082	11:44:00	25.99	11:44:00	25.256	11:44:00	21.459
178	11:48:00	18.695	11:48:00	24.624	11:48:00	25.593	11:48:00	26.076	11:48:00	25.973	11:48:00	25.266	11:48:00	21.452
179	11:52:00	18.696	11:52:00	24.618	11:52:00	25.595	11:52:00	26.08	11:52:00	25.964	11:52:00	25.262	11:52:00	21.453
180	11:56:00	18.697	11:56:00	24.619	11:56:00	25.58	11:56:00	26.086	11:56:00	25.952	11:56:00	25.221	11:56:00	21.455
181	12:00:00	18.698	12:00:00	24.618	12:00:00	25.584	12:00:00	26.082	12:00:00	25.973	12:00:00	25.199	12:00:00	21.439
182	12:04:00	18.699	12:04:00	24.62	12:04:00	25.585	12:04:00	26.094	12:04:00	25.944	12:04:00	25.213	12:04:00	21.461
183	12:08:00	18.7	12:08:00	24.627	12:08:00	25.579	12:08:00	26.102	12:08:00	25.924	12:08:00	25.23	12:08:00	21.438
184	12:12:00	18.701	12:12:00	24.624	12:12:00	25.562	12:12:00	26.086	12:12:00	25.956	12:12:00	25.228	12:12:00	21.422
185	12:16:00	18.702	12:16:00	24.618	12:16:00	25.57	12:16:00	26.086	12:16:00	25.98	12:16:00	25.229	12:16:00	21.41
186	12:20:00	18.703	12:20:00	24.616	12:20:00	25.594	12:20:00	26.1	12:20:00	25.989	12:20:00	25.225	12:20:00	21.425
187	12:24:00	18.704	12:24:00	24.616	12:24:00	25.588	12:24:00	26.089	12:24:00	25.981	12:24:00	25.213	12:24:00	21.408
188	12:28:00	18.705	12:28:00	24.624	12:28:00	25.589	12:28:00	26.079	12:28:00	25.99	12:28:00	25.231	12:28:00	21.414

NO	WTS0		WTS1		WTS3		WTS7		WTS10		WTS15		WTS20	
	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer
189	12:32:00	18.706	12:32:00	24.627	12:32:00	25.565	12:32:00	26.097	12:32:00	25.99	12:32:00	25.252	12:32:00	21.415
190	12:36:00	18.707	12:36:00	24.619	12:36:00	25.553	12:36:00	26.093	12:36:00	26.008	12:36:00	25.242	12:36:00	21.391
191	12:40:00	18.708	12:40:00	24.624	12:40:00	25.554	12:40:00	26.093	12:40:00	26.011	12:40:00	25.235	12:40:00	21.393
192	12:44:00	18.709	12:44:00	24.637	12:44:00	25.542	12:44:00	26.097	12:44:00	25.994	12:44:00	25.254	12:44:00	21.38
193	12:48:00	18.71	12:48:00	24.643	12:48:00	25.555	12:48:00	26.101	12:48:00	26.005	12:48:00	25.263	12:48:00	21.376
194	12:52:00	18.712	12:52:00	24.64	12:52:00	25.527	12:52:00	26.096	12:52:00	26.017	12:52:00	25.258	12:52:00	21.397
195	12:56:00	18.713	12:56:00	24.613	12:56:00	25.55	12:56:00	26.107	12:56:00	26.009	12:56:00	25.255	12:56:00	21.378
196	13:00:00	18.714	13:00:00	24.61	13:00:00	25.56	13:00:00	26.115	13:00:00	25.991	13:00:00	25.264	13:00:00	21.38
197	13:04:00	18.715	13:04:00	24.605	13:04:00	25.547	13:04:00	26.106	13:04:00	26.005	13:04:00	25.279	13:04:00	21.38
198	13:08:00	18.716	13:08:00	24.602	13:08:00	25.56	13:08:00	26.104	13:08:00	26.015	13:08:00	25.274	13:08:00	21.375
199	13:12:00	18.717	13:12:00	24.605	13:12:00	25.556	13:12:00	26.112	13:12:00	26.03	13:12:00	25.27	13:12:00	21.368
200	13:16:00	18.718	13:16:00	24.609	13:16:00	25.551	13:16:00	26.096	13:16:00	26.032	13:16:00	25.263	13:16:00	21.375
201	13:20:00	18.716	13:20:00	24.604	13:20:00	25.539	13:20:00	26.106	13:20:00	26.022	13:20:00	25.269	13:20:00	21.367
202	13:24:00	18.717	13:24:00	24.598	13:24:00	25.543	13:24:00	26.119	13:24:00	26.024	13:24:00	25.273	13:24:00	21.358
203	13:28:00	18.718	13:28:00	24.593	13:28:00	25.553	13:28:00	26.121	13:28:00	26.039	13:28:00	25.267	13:28:00	21.341
204	13:32:00	18.719	13:32:00	24.602	13:32:00	25.526	13:32:00	26.117	13:32:00	26.032	13:32:00	25.274	13:32:00	21.342
205	13:36:00	18.72	13:36:00	24.58	13:36:00	25.528	13:36:00	26.128	13:36:00	26.013	13:36:00	25.28	13:36:00	21.347
206	13:40:00	18.721	13:40:00	24.58	13:40:00	25.533	13:40:00	26.112	13:40:00	25.979	13:40:00	25.291	13:40:00	21.358
207	13:44:00	18.722	13:44:00	24.586	13:44:00	25.528	13:44:00	26.126	13:44:00	25.999	13:44:00	25.291	13:44:00	21.35
208	13:48:00	18.723	13:48:00	24.59	13:48:00	25.537	13:48:00	26.119	13:48:00	26.023	13:48:00	25.294	13:48:00	21.336
209	13:52:00	18.724	13:52:00	24.588	13:52:00	25.531	13:52:00	26.106	13:52:00	26.028	13:52:00	25.296	13:52:00	21.355
210	13:56:00	18.725	13:56:00	24.586	13:56:00	25.527	13:56:00	26.111	13:56:00	26.046	13:56:00	25.304	13:56:00	21.333
211	14:00:00	18.726	14:00:00	24.591	14:00:00	25.505	14:00:00	26.107	14:00:00	26.063	14:00:00	25.323	14:00:00	21.314
212	14:04:00	18.727	14:04:00	24.605	14:04:00	25.531	14:04:00	26.105	14:04:00	26.02	14:04:00	25.297	14:04:00	21.305
213	14:08:00	18.728	14:08:00	24.602	14:08:00	25.515	14:08:00	26.122	14:08:00	26.024	14:08:00	25.302	14:08:00	21.321
214	14:12:00	18.729	14:12:00	24.598	14:12:00	25.509	14:12:00	26.119	14:12:00	26.026	14:12:00	25.319	14:12:00	21.324
215	14:16:00	18.73	14:16:00	24.592	14:16:00	25.529	14:16:00	26.108	14:16:00	26.042	14:16:00	25.319	14:16:00	21.303
216	14:20:00	18.731	14:20:00	24.586	14:20:00	25.5	14:20:00	26.116	14:20:00	26.061	14:20:00	25.33	14:20:00	21.304
217	14:24:00	18.732	14:24:00	24.592	14:24:00	25.51	14:24:00	26.125	14:24:00	26.066	14:24:00	25.3	14:24:00	21.292
218	14:28:00	18.733	14:28:00	24.602	14:28:00	25.503	14:28:00	26.118	14:28:00	26.087	14:28:00	25.291	14:28:00	21.283
219	14:32:00	18.734	14:32:00	24.6	14:32:00	25.506	14:32:00	26.129	14:32:00	26.09	14:32:00	25.293	14:32:00	21.283
220	14:36:00	18.735	14:36:00	24.592	14:36:00	25.521	14:36:00	26.136	14:36:00	26.067	14:36:00	25.295	14:36:00	21.294
221	14:40:00	18.736	14:40:00	24.587	14:40:00	25.49	14:40:00	26.137	14:40:00	26.061	14:40:00	25.299	14:40:00	21.29
222	14:44:00	18.737	14:44:00	24.582	14:44:00	25.491	14:44:00	26.135	14:44:00	26.074	14:44:00	25.309	14:44:00	21.291
223	14:48:00	18.738	14:48:00	24.559	14:48:00	25.487	14:48:00	26.119	14:48:00	26.065	14:48:00	25.295	14:48:00	21.284
224	14:52:00	18.739	14:52:00	24.573	14:52:00	25.488	14:52:00	26.114	14:52:00	26.066	14:52:00	25.305	14:52:00	21.314
225	14:56:00	18.74	14:56:00	24.581	14:56:00	25.501	14:56:00	26.127	14:56:00	26.043	14:56:00	25.313	14:56:00	21.299
226	15:00:00	18.741	15:00:00	24.593	15:00:00	25.479	15:00:00	26.125	15:00:00	26.065	15:00:00	25.317	15:00:00	21.296
227	15:04:00	18.742	15:04:00	24.579	15:04:00	25.474	15:04:00	26.132	15:04:00	26.101	15:04:00	25.334	15:04:00	21.305
228	15:08:00	18.743	15:08:00	24.576	15:08:00	25.49	15:08:00	26.142	15:08:00	26.123	15:08:00	25.314	15:08:00	21.284
229	15:12:00	18.744	15:12:00	24.564	15:12:00	25.485	15:12:00	26.137	15:12:00	26.119	15:12:00	25.297	15:12:00	21.291
230	15:16:00	18.745	15:16:00	24.574	15:16:00	25.486	15:16:00	26.134	15:16:00	26.121	15:16:00	25.3	15:16:00	21.281
231	15:20:00	18.746	15:20:00	24.57	15:20:00	25.488	15:20:00	26.15	15:20:00	26.123	15:20:00	25.304	15:20:00	21.294
232	15:24:00	18.747	15:24:00	24.562	15:24:00	25.478	15:24:00	26.148	15:24:00	26.093	15:24:00	25.302	15:24:00	21.299
233	15:28:00	18.748	15:28:00	24.553	15:28:00	25.485	15:28:00	26.156	15:28:00	26.114	15:28:00	25.309	15:28:00	21.272
234	15:32:00	18.749	15:32:00	24.547	15:32:00	25.454	15:32:00	26.153	15:32:00	26.129	15:32:00	25.334	15:32:00	21.281
235	15:36:00	18.75	15:36:00	24.558	15:36:00	25.452	15:36:00	26.15	15:36:00	26.126	15:36:00	25.327	15:36:00	21.278

NO	WTS0		WTS1		WTS3		WTS7		WTS10		WTS15		WTS20	
	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer
236	15:40:00	18.751	15:40:00	24.558	15:40:00	25.471	15:40:00	26.157	15:40:00	26.108	15:40:00	25.333	15:40:00	21.278
237	15:44:00	18.752	15:44:00	24.562	15:44:00	25.457	15:44:00	26.158	15:44:00	26.097	15:44:00	25.322	15:44:00	21.289
238	15:48:00	18.753	15:48:00	24.549	15:48:00	25.466	15:48:00	26.151	15:48:00	26.106	15:48:00	25.325	15:48:00	21.287
239	15:52:00	18.754	15:52:00	24.547	15:52:00	25.482	15:52:00	26.152	15:52:00	26.117	15:52:00	25.34	15:52:00	21.271
240	15:56:00	18.755	15:56:00	24.538	15:56:00	25.474	15:56:00	26.15	15:56:00	26.131	15:56:00	25.325	15:56:00	21.265
241	16:00:00	18.756	16:00:00	24.538	16:00:00	25.486	16:00:00	26.138	16:00:00	26.124	16:00:00	25.317	16:00:00	21.265
242	16:04:00	18.757	16:04:00	24.546	16:04:00	25.484	16:04:00	26.143	16:04:00	26.132	16:04:00	25.307	16:04:00	21.276
243	16:08:00	18.758	16:08:00	24.555	16:08:00	25.443	16:08:00	26.138	16:08:00	26.136	16:08:00	25.316	16:08:00	21.283
244	16:12:00	18.759	16:12:00	24.553	16:12:00	25.452	16:12:00	26.137	16:12:00	26.136	16:12:00	25.326	16:12:00	21.276
245	16:16:00	18.76	16:16:00	24.541	16:16:00	25.462	16:16:00	26.15	16:16:00	26.135	16:16:00	25.357	16:16:00	21.291
246	16:20:00	18.761	16:20:00	24.544	16:20:00	25.452	16:20:00	26.155	16:20:00	26.14	16:20:00	25.359	16:20:00	21.284
247	16:24:00	18.762	16:24:00	24.532	16:24:00	25.455	16:24:00	26.159	16:24:00	26.149	16:24:00	25.371	16:24:00	21.286
248	16:28:00	18.76	16:28:00	24.537	16:28:00	25.467	16:28:00	26.151	16:28:00	26.123	16:28:00	25.361	16:28:00	21.291
249	16:32:00	18.762	16:32:00	24.535	16:32:00	25.45	16:32:00	26.146	16:32:00	26.101	16:32:00	25.353	16:32:00	21.292
250	16:36:00	18.763	16:36:00	24.537	16:36:00	25.436	16:36:00	26.142	16:36:00	26.101	16:36:00	25.349	16:36:00	21.279
251	16:40:00	18.764	16:40:00	24.533	16:40:00	25.43	16:40:00	26.165	16:40:00	26.11	16:40:00	25.351	16:40:00	21.28
252	16:44:00	18.765	16:44:00	24.534	16:44:00	25.432	16:44:00	26.167	16:44:00	26.116	16:44:00	25.321	16:44:00	21.279
253	16:48:00	18.766	16:48:00	24.535	16:48:00	25.455	16:48:00	26.151	16:48:00	26.114	16:48:00	25.295	16:48:00	21.274
254	16:52:00	18.767	16:52:00	24.516	16:52:00	25.468	16:52:00	26.16	16:52:00	26.098	16:52:00	25.298	16:52:00	21.278
255	16:56:00	18.768	16:56:00	24.519	16:56:00	25.453	16:56:00	26.152	16:56:00	26.123	16:56:00	25.309	16:56:00	21.294
256	17:00:00	18.769	17:00:00	24.524	17:00:00	25.434	17:00:00	26.153	17:00:00	26.139	17:00:00	25.328	17:00:00	21.273
257	17:04:00	18.77	17:04:00	24.525	17:04:00	25.445	17:04:00	26.161	17:04:00	26.149	17:04:00	25.322	17:04:00	21.284
258	17:08:00	18.771	17:08:00	24.531	17:08:00	25.448	17:08:00	26.155	17:08:00	26.14	17:08:00	25.318	17:08:00	21.277
259	17:12:00	18.772	17:12:00	24.512	17:12:00	25.439	17:12:00	26.14	17:12:00	26.135	17:12:00	25.301	17:12:00	21.273
260	17:16:00	18.77	17:16:00	24.531	17:16:00	25.443	17:16:00	26.153	17:16:00	26.127	17:16:00	25.285	17:16:00	21.286
261	17:20:00	18.771	17:20:00	24.52	17:20:00	25.458	17:20:00	26.165	17:20:00	26.095	17:20:00	25.289	17:20:00	21.278
262	17:24:00	18.772	17:24:00	24.51	17:24:00	25.458	17:24:00	26.165	17:24:00	26.119	17:24:00	25.291	17:24:00	21.281
263	17:28:00	18.773	17:28:00	24.508	17:28:00	25.443	17:28:00	26.174	17:28:00	26.143	17:28:00	25.264	17:28:00	21.267
264	17:32:00	18.774	17:32:00	24.499	17:32:00	25.464	17:32:00	26.173	17:32:00	26.135	17:32:00	25.289	17:32:00	21.275
265	17:36:00	18.775	17:36:00	24.501	17:36:00	25.484	17:36:00	26.158	17:36:00	26.142	17:36:00	25.308	17:36:00	21.295
266	17:40:00	18.776	17:40:00	24.498	17:40:00	25.476	17:40:00	26.151	17:40:00	26.12	17:40:00	25.309	17:40:00	21.293
267	17:44:00	18.777	17:44:00	24.483	17:44:00	25.457	17:44:00	26.163	17:44:00	26.115	17:44:00	25.301	17:44:00	21.268
268	17:48:00	18.778	17:48:00	24.486	17:48:00	25.463	17:48:00	26.165	17:48:00	26.107	17:48:00	25.299	17:48:00	21.273
269	17:52:00	18.776	17:52:00	24.485	17:52:00	25.475	17:52:00	26.168	17:52:00	26.119	17:52:00	25.295	17:52:00	21.294
270	17:56:00	18.777	17:56:00	24.494	17:56:00	25.451	17:56:00	26.168	17:56:00	26.128	17:56:00	25.297	17:56:00	21.295
271	18:00:00	18.778	18:00:00	24.494	18:00:00	25.441	18:00:00	26.169	18:00:00	26.133	18:00:00	25.301	18:00:00	21.292
272	18:04:00	18.779	18:04:00	24.488	18:04:00	25.445	18:04:00	26.152	18:04:00	26.13	18:04:00	25.302	18:04:00	21.275
273	18:08:00	18.78	18:08:00	24.492	18:08:00	25.442	18:08:00	26.153	18:08:00	26.139	18:08:00	25.281	18:08:00	21.277
274	18:12:00	18.781	18:12:00	24.487	18:12:00	25.428	18:12:00	26.163	18:12:00	26.136	18:12:00	25.275	18:12:00	21.277
275	18:16:00	18.782	18:16:00	24.49	18:16:00	25.411	18:16:00	26.177	18:16:00	26.113	18:16:00	25.254	18:16:00	21.287
276	18:20:00	18.783	18:20:00	24.488	18:20:00	25.431	18:20:00	26.175	18:20:00	26.118	18:20:00	25.233	18:20:00	21.296
277	18:24:00	18.784	18:24:00	24.487	18:24:00	25.403	18:24:00	26.171	18:24:00	26.128	18:24:00	25.234	18:24:00	21.285
278	18:28:00	18.785	18:28:00	24.502	18:28:00	25.411	18:28:00	26.193	18:28:00	26.137	18:28:00	25.239	18:28:00	21.285
279	18:32:00	18.786	18:32:00	24.493	18:32:00	25.416	18:32:00	26.194	18:32:00	26.116	18:32:00	25.234	18:32:00	21.289
280	18:36:00	18.784	18:36:00	24.472	18:36:00	25.419	18:36:00	26.179	18:36:00	26.099	18:36:00	25.225	18:36:00	21.291
281	18:40:00	18.785	18:40:00	24.485	18:40:00	25.424	18:40:00	26.177	18:40:00	26.106	18:40:00	25.245	18:40:00	21.284
282	18:44:00	18.787	18:44:00	24.467	18:44:00	25.414	18:44:00	26.187	18:44:00	26.117	18:44:00	25.25	18:44:00	21.277

NO	WTS0		WTS1		WTS3		WTS7		WTS10		WTS15		WTS20	
	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer
283	18:48:00	18.788	18:48:00	24.466	18:48:00	25.41	18:48:00	26.186	18:48:00	26.116	18:48:00	25.269	18:48:00	21.275
284	18:52:00	18.789	18:52:00	24.474	18:52:00	25.418	18:52:00	26.181	18:52:00	26.124	18:52:00	25.251	18:52:00	21.26
285	18:56:00	18.79	18:56:00	24.462	18:56:00	25.421	18:56:00	26.167	18:56:00	26.116	18:56:00	25.242	18:56:00	21.267
286	19:00:00	18.791	19:00:00	24.475	19:00:00	25.445	19:00:00	26.165	19:00:00	26.107	19:00:00	25.236	19:00:00	21.27
287	19:04:00	18.792	19:04:00	24.475	19:04:00	25.422	19:04:00	26.176	19:04:00	26.112	19:04:00	25.229	19:04:00	21.285
288	19:08:00	18.793	19:08:00	24.461	19:08:00	25.42	19:08:00	26.169	19:08:00	26.118	19:08:00	25.224	19:08:00	21.304
289	19:12:00	18.792	19:12:00	24.468	19:12:00	25.443	19:12:00	26.164	19:12:00	26.125	19:12:00	25.226	19:12:00	21.33
290	19:16:00	18.793	19:16:00	24.473	19:16:00	25.447	19:16:00	26.184	19:16:00	26.134	19:16:00	25.244	19:16:00	21.306
291	19:20:00	18.794	19:20:00	24.462	19:20:00	25.441	19:20:00	26.201	19:20:00	26.134	19:20:00	25.243	19:20:00	21.29
292	19:24:00	18.795	19:24:00	24.466	19:24:00	25.428	19:24:00	26.188	19:24:00	26.136	19:24:00	25.228	19:24:00	21.299
293	19:28:00	18.796	19:28:00	24.459	19:28:00	25.425	19:28:00	26.179	19:28:00	26.135	19:28:00	25.237	19:28:00	21.3
294	19:32:00	18.79	19:32:00	24.452	19:32:00	25.428	19:32:00	26.181	19:32:00	26.03	19:32:00	25.216	19:32:00	21.317
295	19:36:00	18.791	19:36:00	24.463	19:36:00	25.407	19:36:00	26.176	19:36:00	26	19:36:00	25.211	19:36:00	21.308
296	19:40:00	18.792	19:40:00	24.452	19:40:00	25.408	19:40:00	26.17	19:40:00	26.04	19:40:00	25.217	19:40:00	21.327
297	19:44:00	18.791	19:44:00	24.442	19:44:00	25.43	19:44:00	26.179	19:44:00	26.041	19:44:00	25.214	19:44:00	21.326
298	19:48:00	18.792	19:48:00	24.458	19:48:00	27.3	19:48:00	26.174	19:48:00	26.045	19:48:00	25.211	19:48:00	21.327
299	19:52:00	18.79	19:52:00	24.447	19:52:00	29.139	19:52:00	26.144	19:52:00	26.049	19:52:00	25.22	19:52:00	21.304
300	19:56:00	18.79	19:56:00	24.447	19:56:00	31.15	19:56:00	26.152	19:56:00	26.052	19:56:00	25.232	19:56:00	21.32
301	20:00:00	18.791	20:00:00	24.44	20:00:00	34.79	20:00:00	26.168	20:00:00	26.054	20:00:00	25.224	20:00:00	21.332
302	20:04:00	18.792	20:04:00	24.436	–	–	20:04:00	26.166	20:04:00	26.056	20:04:00	25.241	20:04:00	21.331
303	20:08:00	18.791	20:08:00	24.449	–	–	20:08:00	26.166	20:08:00	26.058	20:08:00	25.241	20:08:00	21.317
304	20:12:00	18.792	20:12:00	24.453	–	–	20:12:00	26.169	20:12:00	26.06	20:12:00	25.221	20:12:00	21.322
305	20:16:00	18.793	20:16:00	24.455	–	–	20:16:00	26.16	20:16:00	27.201	20:16:00	25.234	20:16:00	21.317
306	20:20:00	18.792	20:20:00	24.44	–	–	20:20:00	26.165	20:20:00	28.301	20:20:00	25.235	20:20:00	21.336
307	20:24:00	18.79	20:24:00	24.446	–	–	20:24:00	26.179	20:24:00	29.6	20:24:00	25.212	20:24:00	21.336
308	20:28:00	18.791	20:28:00	24.448	–	–	20:28:00	26.171	20:28:00	31.68	20:28:00	25.219	20:28:00	21.342
309	20:32:00	18.792	20:32:00	24.443	–	–	20:32:00	26.163	–	–	20:32:00	25.222	20:32:00	21.339
310	20:36:00	18.793	20:36:00	24.458	–	–	20:36:00	26.166	–	–	20:36:00	25.229	20:36:00	21.334
311	20:40:00	18.791	20:40:00	24.447	–	–	20:40:00	26.161	–	–	20:40:00	25.244	20:40:00	21.337
312	20:44:00	18.79	20:44:00	24.437	–	–	20:44:00	26.164	–	–	20:44:00	25.964	20:44:00	21.343
313	20:48:00	18.791	20:48:00	24.448	–	–	20:48:00	26.164	–	–	20:48:00	26.81	20:48:00	21.355
314	20:52:00	18.792	20:52:00	24.45	–	–	20:52:00	26.166	–	–	20:52:00	27.85	20:52:00	21.352
315	20:56:00	18.79	20:56:00	24.455	–	–	20:56:00	26.166	–	–	20:56:00	29.75	20:56:00	21.35
316	21:00:00	18.791	21:00:00	24.451	–	–	21:00:00	26.153	–	–	–	–	21:00:00	21.367
317	21:04:00	18.793	21:04:00	24.444	–	–	21:04:00	26.166	–	–	–	–	21:04:00	21.361
318	21:08:00	18.794	21:08:00	24.453	–	–	21:08:00	26.174	–	–	–	–	21:08:00	21.371
319	21:12:00	18.795	21:12:00	24.456	–	–	21:12:00	26.172	–	–	–	–	21:12:00	21.388
320	21:16:00	18.796	21:16:00	24.448	–	–	21:16:00	26.178	–	–	–	–	21:16:00	21.379
321	21:20:00	18.797	21:20:00	24.456	–	–	21:20:00	26.165	–	–	–	–	21:20:00	21.399
322	21:24:00	18.8	21:24:00	24.454	–	–	21:24:00	26.168	–	–	–	–	21:24:00	21.387
323	21:28:00	20.289	21:28:00	24.445	–	–	21:28:00	26.171	–	–	–	–	21:28:00	21.39
324	21:32:00	22.42	21:32:00	24.458	–	–	21:32:00	26.179	–	–	–	–	21:32:00	21.372
325	21:36:00	33.63	21:36:00	24.442	–	–	21:36:00	26.185	–	–	–	–	21:36:00	21.373
326	–	–	21:40:00	24.441	–	–	21:40:00	26.186	–	–	–	–	21:40:00	21.374
327	–	–	21:44:00	24.447	–	–	21:44:00	26.171	–	–	–	–	21:44:00	21.373

NO	WTS0		WTS1		WTS3		WTS7		WTS10		WTS15		WTS20	
	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer
328	–	–	21:48:00	24.44	–	–	21:48:00	26.156	–	–	–	–	21:48:00	21.374
329	–	–	21:52:00	24.444	–	–	21:52:00	26.163	–	–	–	–	21:52:00	21.375
330	–	–	21:56:00	24.46	–	–	21:56:00	26.158	–	–	–	–	21:56:00	21.376
331	–	–	22:00:00	24.466	–	–	22:00:00	26.154	–	–	–	–	22:00:00	21.373
332	–	–	22:04:00	24.459	–	–	22:04:00	26.153	–	–	–	–	22:04:00	21.372
333	–	–	22:08:00	24.455	–	–	22:08:00	26.145	–	–	–	–	22:08:00	21.372
334	–	–	22:12:00	24.463	–	–	22:12:00	26.159	–	–	–	–	22:12:00	21.371
335	–	–	22:16:00	24.455	–	–	22:16:00	26.168	–	–	–	–	22:16:00	21.37
336	–	–	22:20:00	24.469	–	–	22:20:00	26.164	–	–	–	–	22:20:00	21.371
337	–	–	22:24:00	24.473	–	–	22:24:00	26.159	–	–	–	–	22:24:00	21.37
338	–	–	22:28:00	24.472	–	–	22:28:00	26.151	–	–	–	–	22:28:00	21.372
339	–	–	22:32:00	24.5	–	–	22:32:00	26.15	–	–	–	–	22:32:00	21.37
340	–	–	22:36:00	26.881	–	–	22:36:00	26.155	–	–	–	–	22:36:00	21.371
341	–	–	22:40:00	29.6	–	–	22:40:00	26.155	–	–	–	–	22:40:00	21.372
342	–	–	22:44:00	32.736	–	–	22:44:00	26.151	–	–	–	–	22:44:00	21.373
343	–	–	22:48:00	38.75	–	–	22:48:00	26.149	–	–	–	–	22:48:00	21.37
344	–	–	–	–	–	–	22:52:00	26.159	–	–	–	–	22:52:00	21.371
345	–	–	–	–	–	–	22:56:00	26.168	–	–	–	–	22:56:00	21.372
346	–	–	–	–	–	–	23:00:00	26.162	–	–	–	–	23:00:00	21.371
347	–	–	–	–	–	–	23:04:00	26.172	–	–	–	–	23:04:00	21.371
348	–	–	–	–	–	–	23:08:00	26.178	–	–	–	–	23:08:00	21.375
349	–	–	–	–	–	–	23:12:00	26.177	–	–	–	–	23:12:00	21.37
350	–	–	–	–	–	–	23:16:00	26.18	–	–	–	–	23:16:00	21.372
351	–	–	–	–	–	–	23:20:00	26.182	–	–	–	–	23:20:00	21.371
352	–	–	–	–	–	–	23:24:00	26.171	–	–	–	–	23:24:00	21.37
353	–	–	–	–	–	–	23:28:00	26.164	–	–	–	–	23:28:00	21.38
354	–	–	–	–	–	–	23:32:00	26.156	–	–	–	–	23:32:00	22.2
355	–	–	–	–	–	–	23:36:00	26.118	–	–	–	–	23:36:00	22.94
356	–	–	–	–	–	–	23:40:00	26.113	–	–	–	–	23:40:00	23.82
357	–	–	–	–	–	–	23:44:00	26.99	–	–	–	–	23:44:00	25.71
358	–	–	–	–	–	–	23:48:00	27.96	–	–	–	–	–	–
359	–	–	–	–	–	–	23:52:00	29.04	–	–	–	–	–	–
360	–	–	–	–	–	–	23:56:00	31.13	–	–	–	–	–	–

Table Appendix 2. Shows the soil temperature (T) results during the thermal conductivity test (t) for the tested samples from the L series.

NO	LTS3		LTS5		LTS10		LTS15		LTS30	
	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer
1	0:00:00	24.74	0:00:00	26.621	0:00:00	24.186	0:00:00	22.753	0:00:00	19.965
2	0:04:00	24.751	0:04:00	26.599	0:04:00	24.114	0:04:00	22.735	0:04:00	19.908
3	0:08:00	24.763	0:08:00	26.573	0:08:00	23.996	0:08:00	22.706	0:08:00	19.895
4	0:12:00	24.765	0:12:00	26.531	0:12:00	23.914	0:12:00	22.705	0:12:00	19.879
5	0:16:00	24.764	0:16:00	26.502	0:16:00	23.838	0:16:00	22.677	0:16:00	19.892
6	0:20:00	24.754	0:20:00	26.469	0:20:00	23.77	0:20:00	22.624	0:20:00	19.891
7	0:24:00	24.746	0:24:00	26.437	0:24:00	23.696	0:24:00	22.589	0:24:00	19.895
8	0:28:00	24.663	0:28:00	26.394	0:28:00	23.612	0:28:00	22.564	0:28:00	19.889
9	0:32:00	24.691	0:32:00	26.341	0:32:00	23.557	0:32:00	22.528	0:32:00	19.881
10	0:36:00	24.719	0:36:00	26.295	0:36:00	23.492	0:36:00	22.493	0:36:00	19.876
11	0:40:00	24.744	0:40:00	26.246	0:40:00	23.457	0:40:00	22.48	0:40:00	19.874
12	0:44:00	24.748	0:44:00	26.2	0:44:00	23.401	0:44:00	22.439	0:44:00	19.918
13	0:48:00	24.749	0:48:00	26.163	0:48:00	23.354	0:48:00	22.434	0:48:00	19.964
14	0:52:00	24.741	0:52:00	26.125	0:52:00	23.313	0:52:00	22.429	0:52:00	19.959
15	0:56:00	24.734	0:56:00	26.089	0:56:00	23.26	0:56:00	22.41	0:56:00	19.951
16	1:00:00	24.72	1:00:00	26.047	1:00:00	23.209	1:00:00	22.395	1:00:00	19.954
17	1:04:00	24.71	1:04:00	26.012	1:04:00	23.177	1:04:00	22.386	1:04:00	19.953
18	1:08:00	24.688	1:08:00	25.966	1:08:00	23.146	1:08:00	22.377	1:08:00	19.954
19	1:12:00	24.682	1:12:00	25.922	1:12:00	23.096	1:12:00	22.365	1:12:00	19.96
20	1:16:00	24.687	1:16:00	25.891	1:16:00	23.059	1:16:00	22.374	1:16:00	19.981
21	1:20:00	24.693	1:20:00	25.853	1:20:00	23.026	1:20:00	22.369	1:20:00	20.01
22	1:24:00	24.7	1:24:00	25.814	1:24:00	22.989	1:24:00	22.367	1:24:00	20.012
23	1:28:00	24.695	1:28:00	25.787	1:28:00	22.974	1:28:00	22.367	1:28:00	20.056
24	1:32:00	24.69	1:32:00	25.76	1:32:00	22.956	1:32:00	22.363	1:32:00	20.091
25	1:36:00	24.694	1:36:00	25.735	1:36:00	22.921	1:36:00	22.36	1:36:00	20.103
26	1:40:00	24.699	1:40:00	25.71	1:40:00	22.896	1:40:00	22.372	1:40:00	20.114
27	1:44:00	24.702	1:44:00	25.685	1:44:00	22.868	1:44:00	22.381	1:44:00	20.12
28	1:48:00	24.699	1:48:00	25.667	1:48:00	22.852	1:48:00	22.384	1:48:00	20.154
29	1:52:00	24.71	1:52:00	25.635	1:52:00	22.828	1:52:00	22.393	1:52:00	20.163
30	1:56:00	24.716	1:56:00	25.615	1:56:00	22.8	1:56:00	22.395	1:56:00	20.155
31	2:00:00	24.714	2:00:00	25.599	2:00:00	22.785	2:00:00	22.399	2:00:00	20.172
32	2:04:00	24.716	2:04:00	25.589	2:04:00	22.769	2:04:00	22.41	2:04:00	20.2
33	2:08:00	24.721	2:08:00	25.569	2:08:00	22.74	2:08:00	22.426	2:08:00	20.219
34	2:12:00	24.72	2:12:00	25.554	2:12:00	22.724	2:12:00	22.42	2:12:00	20.235
35	2:16:00	24.724	2:16:00	25.54	2:16:00	22.713	2:16:00	22.436	2:16:00	20.252
36	2:20:00	24.724	2:20:00	25.521	2:20:00	22.692	2:20:00	22.437	2:20:00	20.246
37	2:24:00	24.722	2:24:00	25.512	2:24:00	22.674	2:24:00	22.436	2:24:00	20.256
38	2:28:00	24.724	2:28:00	25.493	2:28:00	22.672	2:28:00	22.439	2:28:00	20.27
39	2:32:00	24.739	2:32:00	25.479	2:32:00	22.649	2:32:00	22.442	2:32:00	20.287
40	2:36:00	24.745	2:36:00	25.466	2:36:00	22.637	2:36:00	22.476	2:36:00	20.299
41	2:40:00	24.747	2:40:00	25.445	2:40:00	22.603	2:40:00	22.485	2:40:00	20.306
42	2:44:00	24.75	2:44:00	25.419	2:44:00	22.586	2:44:00	22.476	2:44:00	20.335
43	2:48:00	24.749	2:48:00	25.404	2:48:00	22.574	2:48:00	22.484	2:48:00	20.354
44	2:52:00	24.757	2:52:00	25.392	2:52:00	22.552	2:52:00	22.489	2:52:00	20.375
45	2:56:00	24.766	2:56:00	25.384	2:56:00	22.54	2:56:00	22.499	2:56:00	20.38
46	3:00:00	24.766	3:00:00	25.371	3:00:00	22.529	3:00:00	22.513	3:00:00	20.398
47	3:04:00	24.761	3:04:00	25.356	3:04:00	22.517	3:04:00	22.523	3:04:00	20.406

NO	LTS3		LTS5		LTS10		LTS15		LTS30	
	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer
48	3:08:00	24.766	3:08:00	25.336	3:08:00	22.491	3:08:00	22.533	3:08:00	20.415
49	3:12:00	24.766	3:12:00	25.324	3:12:00	22.473	3:12:00	22.539	3:12:00	20.422
50	3:16:00	24.766	3:16:00	25.307	3:16:00	22.459	3:16:00	22.549	3:16:00	20.438
51	3:20:00	24.775	3:20:00	25.302	3:20:00	22.451	3:20:00	22.545	3:20:00	20.451
52	3:24:00	24.783	3:24:00	25.29	3:24:00	22.441	3:24:00	22.557	3:24:00	20.461
53	3:28:00	24.783	3:28:00	25.274	3:28:00	22.433	3:28:00	22.58	3:28:00	20.48
54	3:32:00	24.782	3:32:00	25.253	3:32:00	22.429	3:32:00	22.589	3:32:00	20.491
55	3:36:00	24.77	3:36:00	25.239	3:36:00	22.41	3:36:00	22.596	3:36:00	20.494
56	3:40:00	24.775	3:40:00	25.24	3:40:00	22.404	3:40:00	22.603	3:40:00	20.517
57	3:44:00	24.779	3:44:00	25.229	3:44:00	22.392	3:44:00	22.622	3:44:00	20.532
58	3:48:00	24.792	3:48:00	25.22	3:48:00	22.388	3:48:00	22.63	3:48:00	20.546
59	3:52:00	24.798	3:52:00	25.214	3:52:00	22.393	3:52:00	22.639	3:52:00	20.554
60	3:56:00	24.795	3:56:00	25.204	3:56:00	22.358	3:56:00	22.658	3:56:00	20.56
61	4:00:00	24.793	4:00:00	25.2	4:00:00	22.349	4:00:00	22.666	4:00:00	20.568
62	4:04:00	24.796	4:04:00	25.186	4:04:00	22.346	4:04:00	22.681	4:04:00	20.58
63	4:08:00	24.797	4:08:00	25.19	4:08:00	22.333	4:08:00	22.7	4:08:00	20.588
64	4:12:00	24.795	4:12:00	25.175	4:12:00	22.327	4:12:00	22.707	4:12:00	20.601
65	4:16:00	24.793	4:16:00	25.161	4:16:00	22.319	4:16:00	22.714	4:16:00	20.623
66	4:20:00	24.796	4:20:00	25.149	4:20:00	22.308	4:20:00	22.706	4:20:00	20.626
67	4:24:00	24.791	4:24:00	25.136	4:24:00	22.293	4:24:00	22.718	4:24:00	20.637
68	4:28:00	24.803	4:28:00	25.123	4:28:00	22.297	4:28:00	22.722	4:28:00	20.645
69	4:32:00	24.809	4:32:00	25.115	4:32:00	22.288	4:32:00	22.725	4:32:00	20.641
70	4:36:00	24.807	4:36:00	25.109	4:36:00	22.282	4:36:00	22.732	4:36:00	20.655
71	4:40:00	24.821	4:40:00	25.106	4:40:00	22.267	4:40:00	22.724	4:40:00	20.664
72	4:44:00	24.825	4:44:00	25.099	4:44:00	22.257	4:44:00	22.735	4:44:00	20.67
73	4:48:00	24.815	4:48:00	25.095	4:48:00	22.242	4:48:00	22.729	4:48:00	20.673
74	4:52:00	24.817	4:52:00	25.086	4:52:00	22.238	4:52:00	22.735	4:52:00	20.679
75	4:56:00	24.822	4:56:00	25.078	4:56:00	22.219	4:56:00	22.751	4:56:00	20.684
76	5:00:00	24.812	5:00:00	25.071	5:00:00	22.219	5:00:00	22.75	5:00:00	20.687
77	5:04:00	24.824	5:04:00	25.075	5:04:00	22.223	5:04:00	22.744	5:04:00	20.691
78	5:08:00	24.834	5:08:00	25.069	5:08:00	22.212	5:08:00	22.742	5:08:00	20.713
79	5:12:00	24.824	5:12:00	25.054	5:12:00	22.196	5:12:00	22.742	5:12:00	20.71
80	5:16:00	24.825	5:16:00	25.043	5:16:00	22.182	5:16:00	22.76	5:16:00	20.719
81	5:20:00	24.824	5:20:00	25.042	5:20:00	22.162	5:20:00	22.761	5:20:00	20.717
82	5:24:00	24.821	5:24:00	25.029	5:24:00	22.172	5:24:00	22.763	5:24:00	20.72
83	5:28:00	24.829	5:28:00	25.027	5:28:00	22.152	5:28:00	22.761	5:28:00	20.723
84	5:32:00	24.827	5:32:00	25.022	5:32:00	22.144	5:32:00	22.757	5:32:00	20.736
85	5:36:00	24.823	5:36:00	25.02	5:36:00	22.129	5:36:00	22.754	5:36:00	20.734
86	5:40:00	24.829	5:40:00	25.008	5:40:00	22.123	5:40:00	22.756	5:40:00	20.743
87	5:44:00	24.833	5:44:00	25.005	5:44:00	22.12	5:44:00	22.757	5:44:00	20.745
88	5:48:00	24.827	5:48:00	25.009	5:48:00	22.108	5:48:00	22.76	5:48:00	20.749
89	5:52:00	24.824	5:52:00	25.001	5:52:00	22.102	5:52:00	22.767	5:52:00	20.744
90	5:56:00	24.827	5:56:00	24.989	5:56:00	22.112	5:56:00	22.769	5:56:00	20.751
91	6:00:00	24.837	6:00:00	24.98	6:00:00	22.083	6:00:00	22.759	6:00:00	20.742
92	6:04:00	24.836	6:04:00	24.971	6:04:00	22.062	6:04:00	22.77	6:04:00	20.744
93	6:08:00	24.839	6:08:00	24.973	6:08:00	22.069	6:08:00	22.774	6:08:00	20.74
94	6:12:00	24.836	6:12:00	24.965	6:12:00	22.054	6:12:00	22.781	6:12:00	20.735

NO	LTS3		LTS5		LTS10		LTS15		LTS30	
	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer
95	6:16:00	24.84	6:16:00	24.961	6:16:00	22.055	6:16:00	22.778	6:16:00	20.738
96	6:20:00	24.835	6:20:00	24.966	6:20:00	22.043	6:20:00	22.778	6:20:00	20.722
97	6:24:00	24.843	6:24:00	24.951	6:24:00	22.027	6:24:00	22.777	6:24:00	20.735
98	6:28:00	24.835	6:28:00	24.945	6:28:00	22.017	6:28:00	22.776	6:28:00	20.723
99	6:32:00	24.843	6:32:00	24.938	6:32:00	22.006	6:32:00	22.769	6:32:00	20.725
100	6:36:00	24.846	6:36:00	24.937	6:36:00	21.999	6:36:00	22.782	6:36:00	20.729
101	6:40:00	24.85	6:40:00	24.927	6:40:00	21.996	6:40:00	22.789	6:40:00	20.732
102	6:44:00	24.833	6:44:00	24.92	6:44:00	21.999	6:44:00	22.789	6:44:00	20.72
103	6:48:00	24.831	6:48:00	24.92	6:48:00	21.995	6:48:00	22.787	6:48:00	20.715
104	6:52:00	24.839	6:52:00	24.919	6:52:00	21.99	6:52:00	22.792	6:52:00	20.706
105	6:56:00	24.835	6:56:00	24.91	6:56:00	21.995	6:56:00	22.796	6:56:00	20.709
106	7:00:00	24.842	7:00:00	24.898	7:00:00	21.983	7:00:00	22.791	7:00:00	20.712
107	7:04:00	24.844	7:04:00	24.896	7:04:00	21.975	7:04:00	22.784	7:04:00	20.7
108	7:08:00	24.832	7:08:00	24.878	7:08:00	21.964	7:08:00	22.787	7:08:00	20.704
109	7:12:00	24.838	7:12:00	24.875	7:12:00	21.962	7:12:00	22.763	7:12:00	20.686
110	7:16:00	24.837	7:16:00	24.871	7:16:00	21.963	7:16:00	22.767	7:16:00	20.688
111	7:20:00	24.842	7:20:00	24.869	7:20:00	21.963	7:20:00	22.764	7:20:00	20.681
112	7:24:00	24.836	7:24:00	24.877	7:24:00	21.949	7:24:00	22.761	7:24:00	20.68
113	7:28:00	24.84	7:28:00	24.871	7:28:00	21.941	7:28:00	22.758	7:28:00	20.677
114	7:32:00	24.843	7:32:00	24.853	7:32:00	21.935	7:32:00	22.771	7:32:00	20.672
115	7:36:00	24.844	7:36:00	24.841	7:36:00	21.923	7:36:00	22.767	7:36:00	20.662
116	7:40:00	24.834	7:40:00	24.844	7:40:00	21.906	7:40:00	22.771	7:40:00	20.658
117	7:44:00	24.835	7:44:00	24.851	7:44:00	21.909	7:44:00	22.77	7:44:00	20.656
118	7:48:00	24.85	7:48:00	24.842	7:48:00	21.905	7:48:00	22.772	7:48:00	20.633
119	7:52:00	24.836	7:52:00	24.831	7:52:00	21.9	7:52:00	22.76	7:52:00	20.628
120	7:56:00	24.842	7:56:00	24.835	7:56:00	21.879	7:56:00	22.76	7:56:00	20.633
121	8:00:00	24.848	8:00:00	24.826	8:00:00	21.843	8:00:00	22.759	8:00:00	20.632
122	8:04:00	24.851	8:04:00	24.812	8:04:00	21.855	8:04:00	22.755	8:04:00	20.628
123	8:08:00	24.849	8:08:00	24.805	8:08:00	21.832	8:08:00	22.764	8:08:00	20.622
124	8:12:00	24.848	8:12:00	24.811	8:12:00	21.819	8:12:00	22.763	8:12:00	20.616
125	8:16:00	24.853	8:16:00	24.816	8:16:00	21.836	8:16:00	22.755	8:16:00	20.601
126	8:20:00	24.856	8:20:00	24.817	8:20:00	21.837	8:20:00	22.767	8:20:00	20.599
127	8:24:00	24.851	8:24:00	24.814	8:24:00	21.816	8:24:00	22.757	8:24:00	20.592
128	8:28:00	24.848	8:28:00	24.804	8:28:00	21.801	8:28:00	22.758	8:28:00	20.596
129	8:32:00	24.851	8:32:00	24.798	8:32:00	21.796	8:32:00	22.751	8:32:00	20.582
130	8:36:00	24.854	8:36:00	24.786	8:36:00	21.802	8:36:00	22.753	8:36:00	20.57
131	8:40:00	24.847	8:40:00	24.79	8:40:00	21.777	8:40:00	22.746	8:40:00	20.57
132	8:44:00	24.844	8:44:00	24.78	8:44:00	21.773	8:44:00	22.724	8:44:00	20.576
133	8:48:00	24.846	8:48:00	24.784	8:48:00	21.779	8:48:00	22.742	8:48:00	20.563
134	8:52:00	24.847	8:52:00	24.774	8:52:00	21.76	8:52:00	22.719	8:52:00	20.562
135	8:56:00	24.849	8:56:00	24.771	8:56:00	21.751	8:56:00	22.732	8:56:00	20.554
136	9:00:00	24.846	9:00:00	24.766	9:00:00	21.716	9:00:00	22.732	9:00:00	20.542
137	9:04:00	24.836	9:04:00	24.761	9:04:00	21.727	9:04:00	22.724	9:04:00	20.529
138	9:08:00	24.842	9:08:00	24.765	9:08:00	21.715	9:08:00	22.732	9:08:00	20.519
139	9:12:00	24.837	9:12:00	24.765	9:12:00	21.722	9:12:00	22.724	9:12:00	20.52
140	9:16:00	24.843	9:16:00	24.763	9:16:00	21.698	9:16:00	22.716	9:16:00	20.514
141	9:20:00	24.831	9:20:00	24.747	9:20:00	21.696	9:20:00	22.714	9:20:00	20.502

NO	LTS3		LTS5		LTS10		LTS15		LTS30	
	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer
142	9:24:00	24.832	9:24:00	24.74	9:24:00	21.686	9:24:00	22.7	9:24:00	20.494
143	9:28:00	24.831	9:28:00	24.731	9:28:00	21.668	9:28:00	22.685	9:28:00	20.48
144	9:32:00	24.825	9:32:00	24.731	9:32:00	21.673	9:32:00	22.671	9:32:00	20.47
145	9:36:00	24.822	9:36:00	24.732	9:36:00	21.677	9:36:00	22.67	9:36:00	20.461
146	9:40:00	24.822	9:40:00	24.732	9:40:00	21.653	9:40:00	22.671	9:40:00	20.447
147	9:44:00	24.821	9:44:00	24.73	9:44:00	21.637	9:44:00	22.663	9:44:00	20.453
148	9:48:00	24.813	9:48:00	24.725	9:48:00	21.622	9:48:00	22.659	9:48:00	20.444
149	9:52:00	24.817	9:52:00	24.716	9:52:00	21.612	9:52:00	22.665	9:52:00	20.439
150	9:56:00	24.816	9:56:00	24.717	9:56:00	21.616	9:56:00	22.645	9:56:00	20.41
151	10:00:00	24.812	10:00:00	24.709	10:00:00	21.604	10:00:00	22.651	10:00:00	20.413
152	10:04:00	24.803	10:04:00	24.695	10:04:00	21.592	10:04:00	22.638	10:04:00	20.39
153	10:08:00	24.799	10:08:00	24.697	10:08:00	21.592	10:08:00	22.644	10:08:00	20.385
154	10:12:00	24.799	10:12:00	24.692	10:12:00	21.594	10:12:00	22.621	10:12:00	20.394
155	10:16:00	24.788	10:16:00	24.693	10:16:00	21.59	10:16:00	22.614	10:16:00	20.377
156	10:20:00	24.791	10:20:00	24.692	10:20:00	21.591	10:20:00	22.605	10:20:00	20.381
157	10:24:00	24.786	10:24:00	24.693	10:24:00	21.6	10:24:00	22.593	10:24:00	20.364
158	10:28:00	24.797	10:28:00	24.694	10:28:00	21.586	10:28:00	22.574	10:28:00	20.349
159	10:32:00	24.793	10:32:00	24.678	10:32:00	21.585	10:32:00	22.584	10:32:00	20.344
160	10:36:00	24.785	10:36:00	24.673	10:36:00	21.578	10:36:00	22.574	10:36:00	20.329
161	10:40:00	24.785	10:40:00	24.67	10:40:00	21.555	10:40:00	22.562	10:40:00	20.316
162	10:44:00	24.771	10:44:00	24.674	10:44:00	21.546	10:44:00	22.556	10:44:00	20.295
163	10:48:00	24.775	10:48:00	24.668	10:48:00	21.529	10:48:00	22.532	10:48:00	20.286
164	10:52:00	24.779	10:52:00	24.661	10:52:00	21.52	10:52:00	22.527	10:52:00	20.294
165	10:56:00	24.777	10:56:00	24.661	10:56:00	21.525	10:56:00	22.527	10:56:00	20.285
166	11:00:00	24.779	11:00:00	24.664	11:00:00	21.54	11:00:00	22.508	11:00:00	20.259
167	11:04:00	24.776	11:04:00	24.664	11:04:00	21.523	11:04:00	22.497	11:04:00	20.255
168	11:08:00	24.767	11:08:00	24.666	11:08:00	21.516	11:08:00	22.498	11:08:00	20.243
169	11:12:00	24.76	11:12:00	24.648	11:12:00	21.489	11:12:00	22.474	11:12:00	20.248
170	11:16:00	24.752	11:16:00	24.648	11:16:00	21.485	11:16:00	22.462	11:16:00	20.237
171	11:20:00	24.76	11:20:00	24.649	11:20:00	21.473	11:20:00	22.461	11:20:00	20.228
172	11:24:00	24.766	11:24:00	24.654	11:24:00	21.465	11:24:00	22.44	11:24:00	20.212
173	11:28:00	24.765	11:28:00	24.647	11:28:00	21.458	11:28:00	22.434	11:28:00	20.194
174	11:32:00	24.769	11:32:00	24.631	11:32:00	21.453	11:32:00	22.424	11:32:00	20.192
175	11:36:00	24.764	11:36:00	24.618	11:36:00	21.452	11:36:00	22.41	11:36:00	20.179
176	11:40:00	24.766	11:40:00	24.618	11:40:00	21.47	11:40:00	22.396	11:40:00	20.177
177	11:44:00	24.763	11:44:00	24.616	11:44:00	21.459	11:44:00	22.381	11:44:00	20.089
178	11:48:00	24.756	11:48:00	24.621	11:48:00	21.452	11:48:00	22.373	11:48:00	19.999
179	11:52:00	24.759	11:52:00	24.62	11:52:00	21.453	11:52:00	22.356	11:52:00	19.997
180	11:56:00	24.762	11:56:00	24.612	11:56:00	21.455	11:56:00	22.359	11:56:00	19.995
181	12:00:00	24.761	12:00:00	24.608	12:00:00	21.439	12:00:00	22.348	12:00:00	19.994
182	12:04:00	24.757	12:04:00	24.601	12:04:00	21.461	12:04:00	22.336	12:04:00	19.989
183	12:08:00	24.749	12:08:00	24.599	12:08:00	21.438	12:08:00	22.326	12:08:00	19.988
184	12:12:00	24.746	12:12:00	24.603	12:12:00	21.422	12:12:00	22.308	12:12:00	19.987
185	12:16:00	24.747	12:16:00	24.6	12:16:00	21.41	12:16:00	22.293	12:16:00	19.986
186	12:20:00	24.743	12:20:00	24.59	12:20:00	21.425	12:20:00	22.285	12:20:00	19.985
187	12:24:00	24.743	12:24:00	24.587	12:24:00	21.408	12:24:00	22.278	12:24:00	19.984
188	12:28:00	24.744	12:28:00	24.588	12:28:00	21.414	12:28:00	22.27	12:28:00	19.982

NO	LTS3		LTS5		LTS10		LTS15		LTS30	
	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer
189	12:32:00	24.749	12:32:00	24.587	12:32:00	21.415	12:32:00	22.262	12:32:00	19.978
190	12:36:00	24.744	12:36:00	24.58	12:36:00	21.391	12:36:00	22.249	12:36:00	19.975
191	12:40:00	24.741	12:40:00	24.582	12:40:00	21.393	12:40:00	22.243	12:40:00	19.974
192	12:44:00	24.739	12:44:00	24.582	12:44:00	21.38	12:44:00	22.233	12:44:00	19.972
193	12:48:00	24.73	12:48:00	24.575	12:48:00	21.376	12:48:00	22.23	12:48:00	19.97
194	12:52:00	24.715	12:52:00	24.576	12:52:00	21.397	12:52:00	22.222	12:52:00	19.968
195	12:56:00	24.708	12:56:00	24.575	12:56:00	21.378	12:56:00	22.206	12:56:00	19.965
196	13:00:00	24.717	13:00:00	24.569	13:00:00	21.38	13:00:00	22.196	13:00:00	19.962
197	13:04:00	24.71	13:04:00	24.567	13:04:00	21.38	13:04:00	22.19	13:04:00	19.96
198	13:08:00	24.719	13:08:00	24.57	13:08:00	21.375	13:08:00	22.181	13:08:00	19.953
199	13:12:00	24.727	13:12:00	24.576	13:12:00	21.368	13:12:00	22.173	13:12:00	19.951
200	13:16:00	24.724	13:16:00	24.562	13:16:00	21.375	13:16:00	22.184	13:16:00	19.943
201	13:20:00	24.725	13:20:00	24.562	13:20:00	21.367	13:20:00	22.161	13:20:00	19.94
202	13:24:00	24.716	13:24:00	24.567	13:24:00	21.358	13:24:00	22.149	13:24:00	19.936
203	13:28:00	24.707	13:28:00	24.566	13:28:00	21.341	13:28:00	22.152	13:28:00	19.934
204	13:32:00	24.708	13:32:00	24.565	13:32:00	21.342	13:32:00	22.155	13:32:00	19.932
205	13:36:00	24.714	13:36:00	24.565	13:36:00	21.347	13:36:00	22.132	13:36:00	19.93
206	13:40:00	24.715	13:40:00	24.557	13:40:00	21.358	13:40:00	22.114	13:40:00	19.929
207	13:44:00	24.713	13:44:00	24.549	13:44:00	21.35	13:44:00	22.117	13:44:00	19.927
208	13:48:00	24.713	13:48:00	24.543	13:48:00	21.336	13:48:00	22.101	13:48:00	19.925
209	13:52:00	24.708	13:52:00	24.544	13:52:00	21.355	13:52:00	22.101	13:52:00	19.922
210	13:56:00	24.699	13:56:00	24.549	13:56:00	21.333	13:56:00	22.092	13:56:00	19.92
211	14:00:00	24.694	14:00:00	24.535	14:00:00	21.314	14:00:00	22.105	14:00:00	19.918
212	14:04:00	24.696	14:04:00	24.54	14:04:00	21.305	14:04:00	22.078	14:04:00	19.916
213	14:08:00	24.7	14:08:00	24.544	14:08:00	21.321	14:08:00	22.083	14:08:00	19.914
214	14:12:00	24.697	14:12:00	24.548	14:12:00	21.324	14:12:00	22.083	14:12:00	19.913
215	14:16:00	24.699	14:16:00	24.541	14:16:00	21.303	14:16:00	22.07	14:16:00	19.911
216	14:20:00	24.689	14:20:00	24.539	14:20:00	21.304	14:20:00	22.072	14:20:00	19.907
217	14:24:00	24.684	14:24:00	24.55	14:24:00	21.292	14:24:00	22.063	14:24:00	19.905
218	14:28:00	24.686	14:28:00	24.549	14:28:00	21.283	14:28:00	22.067	14:28:00	19.903
219	14:32:00	24.681	14:32:00	24.543	14:32:00	21.283	14:32:00	22.049	14:32:00	19.902
220	14:36:00	24.677	14:36:00	24.543	14:36:00	21.294	14:36:00	22.045	14:36:00	19.9
221	14:40:00	24.678	14:40:00	24.533	14:40:00	21.29	14:40:00	22.045	14:40:00	19.899
222	14:44:00	24.674	14:44:00	24.534	14:44:00	21.291	14:44:00	22.026	14:44:00	19.895
223	14:48:00	24.676	14:48:00	24.518	14:48:00	21.284	14:48:00	22.019	14:48:00	19.892
224	14:52:00	24.674	14:52:00	24.523	14:52:00	21.314	14:52:00	22.011	14:52:00	19.891
225	14:56:00	24.673	14:56:00	24.522	14:56:00	21.299	14:56:00	21.996	14:56:00	19.889
226	15:00:00	24.666	15:00:00	24.526	15:00:00	21.296	15:00:00	21.992	15:00:00	19.887
227	15:04:00	24.661	15:04:00	24.522	15:04:00	21.305	15:04:00	21.985	15:04:00	19.885
228	15:08:00	24.655	15:08:00	24.515	15:08:00	21.284	15:08:00	21.972	15:08:00	19.882
229	15:12:00	24.645	15:12:00	24.517	15:12:00	21.291	15:12:00	21.96	15:12:00	19.88
230	15:16:00	24.656	15:16:00	24.518	15:16:00	21.281	15:16:00	21.949	15:16:00	19.879
231	15:20:00	24.658	15:20:00	24.518	15:20:00	21.294	15:20:00	21.941	15:20:00	19.876
232	15:24:00	24.659	15:24:00	24.516	15:24:00	21.299	15:24:00	21.937	15:24:00	19.874
233	15:28:00	24.657	15:28:00	24.498	15:28:00	21.272	15:28:00	21.945	15:28:00	19.87
234	15:32:00	24.655	15:32:00	24.483	15:32:00	21.281	15:32:00	21.937	15:32:00	19.868
235	15:36:00	24.634	15:36:00	24.492	15:36:00	21.278	15:36:00	21.931	15:36:00	19.865

NO	LTS3		LTS5		LTS10		LTS15		LTS30	
	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer
236	15:40:00	24.632	15:40:00	24.497	15:40:00	21.278	15:40:00	21.927	15:40:00	19.863
237	15:44:00	24.632	15:44:00	24.496	15:44:00	21.289	15:44:00	21.918	15:44:00	19.861
238	15:48:00	24.628	15:48:00	24.501	15:48:00	21.287	15:48:00	21.921	15:48:00	19.857
239	15:52:00	24.636	15:52:00	24.49	15:52:00	21.271	15:52:00	21.909	15:52:00	19.854
240	15:56:00	24.625	15:56:00	24.495	15:56:00	21.265	15:56:00	21.897	15:56:00	19.852
241	16:00:00	24.624	16:00:00	24.491	16:00:00	21.265	16:00:00	21.902	16:00:00	19.85
242	16:04:00	24.629	16:04:00	24.49	16:04:00	21.276	16:04:00	21.891	16:04:00	19.847
243	16:08:00	24.622	16:08:00	24.494	16:08:00	21.283	16:08:00	21.877	16:08:00	19.846
244	16:12:00	24.625	16:12:00	24.49	16:12:00	21.276	16:12:00	21.875	16:12:00	19.843
245	16:16:00	24.618	16:16:00	24.482	16:16:00	21.291	16:16:00	21.882	16:16:00	19.842
246	16:20:00	24.621	16:20:00	24.492	16:20:00	21.284	16:20:00	21.868	16:20:00	19.841
247	16:24:00	24.618	16:24:00	24.49	16:24:00	21.286	16:24:00	21.853	16:24:00	19.84
248	16:28:00	24.609	16:28:00	24.486	16:28:00	21.291	16:28:00	21.857	16:28:00	19.836
249	16:32:00	24.608	16:32:00	24.483	16:32:00	21.292	16:32:00	21.859	16:32:00	19.834
250	16:36:00	24.604	16:36:00	24.482	16:36:00	21.279	16:36:00	21.857	16:36:00	19.832
251	16:40:00	24.592	16:40:00	24.489	16:40:00	21.28	16:40:00	21.85	16:40:00	19.831
252	16:44:00	24.594	16:44:00	24.482	16:44:00	21.279	16:44:00	21.854	16:44:00	19.829
253	16:48:00	24.591	16:48:00	24.473	16:48:00	21.274	16:48:00	21.84	16:48:00	19.827
254	16:52:00	24.591	16:52:00	24.464	16:52:00	21.278	16:52:00	21.846	16:52:00	19.825
255	16:56:00	24.585	16:56:00	24.465	16:56:00	21.294	16:56:00	21.819	16:56:00	19.824
256	17:00:00	24.581	17:00:00	24.464	17:00:00	21.273	17:00:00	21.832	17:00:00	19.821
257	17:04:00	24.586	17:04:00	24.46	17:04:00	21.284	17:04:00	21.82	17:04:00	19.82
258	17:08:00	24.588	17:08:00	24.463	17:08:00	21.277	17:08:00	21.823	17:08:00	19.819
259	17:12:00	24.592	17:12:00	24.467	17:12:00	21.273	17:12:00	21.826	17:12:00	19.817
260	17:16:00	24.585	17:16:00	24.466	17:16:00	21.286	17:16:00	21.813	17:16:00	19.815
261	17:20:00	24.585	17:20:00	24.461	17:20:00	21.278	17:20:00	21.813	17:20:00	19.813
262	17:24:00	24.575	17:24:00	24.459	17:24:00	21.281	17:24:00	21.794	17:24:00	19.811
263	17:28:00	24.571	17:28:00	24.466	17:28:00	21.267	17:28:00	21.79	17:28:00	19.808
264	17:32:00	24.57	17:32:00	24.478	17:32:00	21.275	17:32:00	21.781	17:32:00	19.806
265	17:36:00	24.561	17:36:00	24.47	17:36:00	21.295	17:36:00	21.788	17:36:00	19.804
266	17:40:00	24.556	17:40:00	24.464	17:40:00	21.293	17:40:00	21.797	17:40:00	19.801
267	17:44:00	24.547	17:44:00	24.463	17:44:00	21.268	17:44:00	21.79	17:44:00	19.798
268	17:48:00	24.554	17:48:00	24.456	17:48:00	21.273	17:48:00	21.777	17:48:00	19.796
269	17:52:00	24.549	17:52:00	24.455	17:52:00	21.294	17:52:00	21.77	17:52:00	19.794
270	17:56:00	24.552	17:56:00	24.446	17:56:00	21.295	17:56:00	21.764	17:56:00	19.793
271	18:00:00	24.547	18:00:00	24.449	18:00:00	21.292	18:00:00	21.758	18:00:00	19.792
272	18:04:00	24.551	18:04:00	24.443	18:04:00	21.275	18:04:00	21.75	18:04:00	19.79
273	18:08:00	24.554	18:08:00	24.447	18:08:00	21.277	18:08:00	21.759	18:08:00	19.789
274	18:12:00	24.545	18:12:00	24.45	18:12:00	21.277	18:12:00	21.761	18:12:00	19.787
275	18:16:00	24.544	18:16:00	24.452	18:16:00	21.287	18:16:00	21.758	18:16:00	19.785
276	18:20:00	24.538	18:20:00	24.459	18:20:00	21.296	18:20:00	21.761	18:20:00	19.782
277	18:24:00	24.533	18:24:00	24.444	18:24:00	21.285	18:24:00	21.745	18:24:00	19.78
278	18:28:00	24.534	18:28:00	24.437	18:28:00	21.285	18:28:00	21.745	18:28:00	19.778
279	18:32:00	24.523	18:32:00	24.434	18:32:00	21.289	18:32:00	21.741	18:32:00	19.775
280	18:36:00	24.52	18:36:00	24.43	18:36:00	21.291	18:36:00	21.751	18:36:00	19.774
281	18:40:00	24.513	18:40:00	24.429	18:40:00	21.284	18:40:00	21.736	18:40:00	19.772
282	18:44:00	24.508	18:44:00	24.428	18:44:00	21.277	18:44:00	21.731	18:44:00	19.77

NO	LTS3		LTS5		LTS10		LTS15		LTS30	
	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer
283	18:48:00	24.507	18:48:00	24.426	18:48:00	21.275	18:48:00	21.736	18:48:00	19.767
284	18:52:00	24.508	18:52:00	24.429	18:52:00	21.26	18:52:00	21.725	18:52:00	19.765
285	18:56:00	24.509	18:56:00	24.429	18:56:00	21.267	18:56:00	21.737	18:56:00	19.763
286	19:00:00	24.504	19:00:00	24.423	19:00:00	21.27	19:00:00	21.718	19:00:00	19.761
287	19:04:00	24.499	19:04:00	24.421	19:04:00	21.285	19:04:00	21.712	19:04:00	19.76
288	19:08:00	24.508	19:08:00	24.422	19:08:00	21.304	19:08:00	21.704	19:08:00	19.759
289	19:12:00	24.508	19:12:00	24.427	19:12:00	21.33	19:12:00	21.699	19:12:00	19.757
290	19:16:00	24.508	19:16:00	24.428	19:16:00	21.306	19:16:00	21.683	19:16:00	19.755
291	19:20:00	24.502	19:20:00	24.427	19:20:00	21.29	19:20:00	21.69	19:20:00	19.753
292	19:24:00	24.498	19:24:00	24.426	19:24:00	21.299	19:24:00	21.689	19:24:00	19.751
293	19:28:00	24.495	19:28:00	24.431	19:28:00	21.3	19:28:00	21.677	19:28:00	19.749
294	19:32:00	24.486	19:32:00	24.425	19:32:00	21.317	19:32:00	21.669	19:32:00	19.748
295	19:36:00	24.49	19:36:00	24.415	19:36:00	21.308	19:36:00	21.667	19:36:00	19.747
296	19:40:00	24.49	19:40:00	24.423	19:40:00	21.327	19:40:00	21.666	19:40:00	19.746
297	19:44:00	24.489	19:44:00	24.431	19:44:00	21.326	19:44:00	21.665	19:44:00	19.748
298	19:48:00	24.484	19:48:00	24.435	19:48:00	21.327	19:48:00	21.664	19:48:00	19.747
299	19:52:00	24.483	19:52:00	24.415	19:52:00	21.304	19:52:00	21.663	19:52:00	19.748
300	19:56:00	24.464	19:56:00	24.412	19:56:00	21.32	19:56:00	21.657	19:56:00	19.747
301	20:00:00	24.465	20:00:00	24.42	20:00:00	21.332	20:00:00	21.637	20:00:00	19.746
302	20:04:00	24.476	20:04:00	24.41	20:04:00	21.331	20:04:00	21.637	20:04:00	19.745
303	20:08:00	24.463	20:08:00	24.422	20:08:00	21.317	20:08:00	21.639	20:08:00	19.744
304	20:12:00	24.469	20:12:00	24.404	20:12:00	21.322	20:12:00	21.633	20:12:00	19.746
305	20:16:00	24.452	20:16:00	24.401	20:16:00	21.317	20:16:00	21.619	20:16:00	19.747
306	20:20:00	24.446	20:20:00	24.403	20:20:00	21.336	20:20:00	21.627	20:20:00	19.746
307	20:24:00	24.447	20:24:00	24.41	20:24:00	21.336	20:24:00	21.606	20:24:00	19.745
308	20:28:00	24.451	20:28:00	24.404	20:28:00	21.342	20:28:00	21.615	20:28:00	19.744
309	20:32:00	24.448	20:32:00	24.406	20:32:00	21.339	20:32:00	21.615	20:32:00	19.743
310	20:36:00	24.437	20:36:00	24.408	20:36:00	21.334	20:36:00	21.606	20:36:00	19.742
311	20:40:00	24.44	20:40:00	24.415	20:40:00	21.337	20:40:00	21.617	20:40:00	19.743
312	20:44:00	24.445	20:44:00	24.412	20:44:00	21.343	20:44:00	21.608	20:44:00	19.744
313	20:48:00	24.445	20:48:00	24.41	20:48:00	21.355	20:48:00	21.61	20:48:00	19.743
314	20:52:00	24.447	20:52:00	24.403	20:52:00	21.352	20:52:00	21.616	20:52:00	19.742
315	20:56:00	24.446	20:56:00	24.402	20:56:00	21.35	20:56:00	21.609	20:56:00	19.741
316	21:00:00	24.439	21:00:00	24.401	21:00:00	21.367	21:00:00	21.623	21:00:00	19.74
317	21:04:00	24.444	21:04:00	24.399	21:04:00	21.361	21:04:00	21.602	21:04:00	19.739
318	21:08:00	24.444	21:08:00	24.397	21:08:00	21.371	21:08:00	21.599	21:08:00	19.738
319	21:12:00	24.44	21:12:00	24.364	21:12:00	21.388	21:12:00	21.592	21:12:00	19.737
320	21:16:00	24.442	21:16:00	24.324	21:16:00	21.379	21:16:00	21.597	21:16:00	19.736
321	21:20:00	24.43	21:20:00	24.322	21:20:00	21.399	21:20:00	21.605	21:20:00	19.735
322	21:24:00	24.42	21:24:00	24.35	21:24:00	21.387	21:24:00	21.625	21:24:00	19.736
323	21:28:00	24.425	21:28:00	25.17	21:28:00	21.39	21:28:00	22.63	21:28:00	19.735
324	21:32:00	24.43	21:32:00	26.04	21:32:00	21.389	21:32:00	23.471	21:32:00	19.734
325	21:36:00	24.421	21:36:00	27.089	21:36:00	21.401	21:36:00	24.635	21:36:00	19.735
326	21:40:00	24.428	21:40:00	29.42	21:40:00	21.405	21:40:00	27.311	21:40:00	19.736
327	21:44:00	24.422	–	–	21:44:00	21.412	–	–	21:44:00	19.735
328	21:48:00	24.415	–	–	21:48:00	21.404	–	–	21:48:00	19.734
329	21:52:00	24.423	–	–	21:52:00	21.406	–	–	21:52:00	19.735

NO	LTS3		LTS5		LTS10		LTS15		LTS30	
	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer
330	21:56:00	24.422	–	–	21:56:00	21.421	–	–	21:56:00	19.734
331	22:00:00	24.419	–	–	22:00:00	21.406	–	–	22:00:00	19.735
332	22:04:00	24.426	–	–	22:04:00	21.403	–	–	22:04:00	19.736
333	22:08:00	24.424	–	–	22:08:00	21.429	–	–	22:08:00	20.12
334	22:12:00	24.411	–	–	22:12:00	21.446	–	–	22:12:00	22.241
335	22:16:00	24.402	–	–	22:16:00	21.447	–	–	22:16:00	23.812
336	22:20:00	24.389	–	–	22:20:00	21.445	–	–	22:20:00	27.05
337	22:24:00	24.41	–	–	22:24:00	21.442	–	–	–	–
338	22:28:00	25.271	–	–	22:28:00	21.445	–	–	–	–
339	22:32:00	26.089	–	–	22:32:00	21.439	–	–	–	–
340	22:36:00	27.03	–	–	22:36:00	21.447	–	–	–	–
341	22:40:00	29.3	–	–	22:40:00	21.461	–	–	–	–
342	–	–	–	–	22:44:00	21.462	–	–	–	–
343	–	–	–	–	22:48:00	21.455	–	–	–	–
344	–	–	–	–	22:52:00	21.474	–	–	–	–
345	–	–	–	–	22:56:00	21.464	–	–	–	–
346	–	–	–	–	23:00:00	21.471	–	–	–	–
347	–	–	–	–	23:04:00	21.477	–	–	–	–
348	–	–	–	–	23:08:00	21.468	–	–	–	–
349	–	–	–	–	23:12:00	21.477	–	–	–	–
350	–	–	–	–	23:16:00	21.48	–	–	–	–
351	–	–	–	–	23:20:00	21.492	–	–	–	–
352	–	–	–	–	23:24:00	21.503	–	–	–	–
353	–	–	–	–	23:28:00	21.53	–	–	–	–
354	–	–	–	–	23:32:00	22.375	–	–	–	–
355	–	–	–	–	23:36:00	23.185	–	–	–	–
356	–	–	–	–	23:40:00	24.42	–	–	–	–
357	–	–	–	–	23:44:00	26.78	–	–	–	–

Table Appendix 3. Shows the soil temperature (T) results during the thermal conductivity test (t) for the tested samples from the D series.

NO	DTS1092		DTS1038		DTS901		DTS724		DTS1223		DTS1466	
	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer
1	0:00:00	21.106	0:00:00	21.354	0:00:00	21.448	0:00:00	21.108	0:00:00	21.354	0:00:00	20.597
2	0:04:00	21.088	0:04:00	21.263	0:04:00	21.405	0:04:00	21.089	0:04:00	21.263	0:04:00	20.618
3	0:08:00	21.099	0:08:00	21.265	0:08:00	21.383	0:08:00	21.099	0:08:00	21.265	0:08:00	20.663
4	0:12:00	21.139	0:12:00	21.307	0:12:00	21.406	0:12:00	21.139	0:12:00	21.307	0:12:00	20.702
5	0:16:00	21.146	0:16:00	21.329	0:16:00	21.425	0:16:00	21.147	0:16:00	21.329	0:16:00	20.743
6	0:20:00	21.129	0:20:00	21.336	0:20:00	21.456	0:20:00	21.129	0:20:00	21.336	0:20:00	20.76
7	0:24:00	21.125	0:24:00	21.353	0:24:00	21.486	0:24:00	21.127	0:24:00	21.353	0:24:00	20.782
8	0:28:00	21.126	0:28:00	21.37	0:28:00	21.526	0:28:00	21.127	0:28:00	21.37	0:28:00	20.805
9	0:32:00	21.137	0:32:00	21.393	0:32:00	21.547	0:32:00	21.137	0:32:00	21.393	0:32:00	20.829
10	0:36:00	21.165	0:36:00	21.411	0:36:00	21.582	0:36:00	21.166	0:36:00	21.411	0:36:00	20.858
11	0:40:00	21.187	0:40:00	21.434	0:40:00	21.616	0:40:00	21.187	0:40:00	21.434	0:40:00	20.879
12	0:44:00	21.21	0:44:00	21.457	0:44:00	21.637	0:44:00	21.22	0:44:00	21.457	0:44:00	20.902
13	0:48:00	21.225	0:48:00	21.479	0:48:00	21.656	0:48:00	21.225	0:48:00	21.479	0:48:00	20.946
14	0:52:00	21.244	0:52:00	21.503	0:52:00	21.673	0:52:00	21.245	0:52:00	21.503	0:52:00	20.981
15	0:56:00	21.25	0:56:00	21.539	0:56:00	21.709	0:56:00	21.251	0:56:00	21.539	0:56:00	21.023
16	1:00:00	21.241	1:00:00	21.557	1:00:00	21.745	1:00:00	21.241	1:00:00	21.557	1:00:00	21.066
17	1:04:00	21.255	1:04:00	21.582	1:04:00	21.754	1:04:00	21.255	1:04:00	21.582	1:04:00	21.104
18	1:08:00	21.261	1:08:00	21.597	1:08:00	21.781	1:08:00	21.261	1:08:00	21.597	1:08:00	21.142
19	1:12:00	21.267	1:12:00	21.614	1:12:00	21.817	1:12:00	21.267	1:12:00	21.614	1:12:00	21.167
20	1:16:00	21.277	1:16:00	21.638	1:16:00	21.836	1:16:00	21.278	1:16:00	21.638	1:16:00	21.205
21	1:20:00	21.282	1:20:00	21.661	1:20:00	21.861	1:20:00	21.282	1:20:00	21.661	1:20:00	21.256
22	1:24:00	21.292	1:24:00	21.697	1:24:00	21.894	1:24:00	21.292	1:24:00	21.697	1:24:00	21.298
23	1:28:00	21.293	1:28:00	21.72	1:28:00	21.922	1:28:00	21.294	1:28:00	21.72	1:28:00	21.338
24	1:32:00	21.291	1:32:00	21.749	1:32:00	21.946	1:32:00	21.291	1:32:00	21.749	1:32:00	21.386
25	1:36:00	21.314	1:36:00	21.774	1:36:00	21.967	1:36:00	21.314	1:36:00	21.774	1:36:00	21.431
26	1:40:00	21.317	1:40:00	21.778	1:40:00	22.002	1:40:00	21.318	1:40:00	21.778	1:40:00	21.48
27	1:44:00	21.327	1:44:00	21.798	1:44:00	22.039	1:44:00	21.327	1:44:00	21.798	1:44:00	21.522
28	1:48:00	21.347	1:48:00	21.83	1:48:00	22.059	1:48:00	21.349	1:48:00	21.83	1:48:00	21.57
29	1:52:00	21.365	1:52:00	21.86	1:52:00	22.085	1:52:00	21.365	1:52:00	21.86	1:52:00	21.614
30	1:56:00	21.378	1:56:00	21.872	1:56:00	22.134	1:56:00	21.378	1:56:00	21.872	1:56:00	21.654
31	2:00:00	21.385	2:00:00	21.895	2:00:00	22.155	2:00:00	21.385	2:00:00	21.895	2:00:00	21.691
32	2:04:00	21.403	2:04:00	21.914	2:04:00	22.183	2:04:00	21.405	2:04:00	21.914	2:04:00	21.739
33	2:08:00	21.415	2:08:00	21.938	2:08:00	22.212	2:08:00	21.415	2:08:00	21.938	2:08:00	21.78
34	2:12:00	21.438	2:12:00	21.967	2:12:00	22.232	2:12:00	21.438	2:12:00	21.967	2:12:00	21.822
35	2:16:00	21.454	2:16:00	21.993	2:16:00	22.254	2:16:00	21.454	2:16:00	21.993	2:16:00	21.867
36	2:20:00	21.473	2:20:00	22.011	2:20:00	22.281	2:20:00	21.473	2:20:00	22.011	2:20:00	21.914
37	2:24:00	21.489	2:24:00	22.036	2:24:00	22.304	2:24:00	21.489	2:24:00	22.036	2:24:00	21.948
38	2:28:00	21.5	2:28:00	22.053	2:28:00	22.317	2:28:00	21.5	2:28:00	22.053	2:28:00	21.986
39	2:32:00	21.514	2:32:00	22.08	2:32:00	22.343	2:32:00	21.515	2:32:00	22.08	2:32:00	22.021
40	2:36:00	21.532	2:36:00	22.091	2:36:00	22.376	2:36:00	21.533	2:36:00	22.091	2:36:00	22.052
41	2:40:00	21.558	2:40:00	22.115	2:40:00	22.398	2:40:00	21.558	2:40:00	22.115	2:40:00	22.084
42	2:44:00	21.562	2:44:00	22.147	2:44:00	22.429	2:44:00	21.564	2:44:00	22.147	2:44:00	22.133
43	2:48:00	21.569	2:48:00	22.172	2:48:00	22.46	2:48:00	21.569	2:48:00	22.172	2:48:00	22.159
44	2:52:00	21.583	2:52:00	22.181	2:52:00	22.475	2:52:00	21.583	2:52:00	22.181	2:52:00	22.192

NO	DTS1092		DTS1038		DTS901		DTS724		DTS1223		DTS1466	
	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer
45	2:56:00	21.602	2:56:00	22.2	2:56:00	22.492	2:56:00	21.602	2:56:00	22.2	2:56:00	22.233
46	3:00:00	21.606	3:00:00	22.219	3:00:00	22.513	3:00:00	21.606	3:00:00	22.219	3:00:00	22.258
47	3:04:00	21.621	3:04:00	22.231	3:04:00	22.54	3:04:00	21.621	3:04:00	22.231	3:04:00	22.289
48	3:08:00	21.639	3:08:00	22.257	3:08:00	22.561	3:08:00	21.639	3:08:00	22.257	3:08:00	22.316
49	3:12:00	21.64	3:12:00	22.275	3:12:00	22.571	3:12:00	21.641	3:12:00	22.275	3:12:00	22.366
50	3:16:00	21.66	3:16:00	22.294	3:16:00	22.592	3:16:00	21.662	3:16:00	22.294	3:16:00	22.397
51	3:20:00	21.682	3:20:00	22.313	3:20:00	22.604	3:20:00	21.682	3:20:00	22.313	3:20:00	22.436
52	3:24:00	21.694	3:24:00	22.324	3:24:00	22.636	3:24:00	21.695	3:24:00	22.324	3:24:00	22.463
53	3:28:00	21.708	3:28:00	22.362	3:28:00	22.662	3:28:00	21.708	3:28:00	22.362	3:28:00	22.493
54	3:32:00	21.702	3:32:00	22.379	3:32:00	22.679	3:32:00	21.704	3:32:00	22.379	3:32:00	22.515
55	3:36:00	21.707	3:36:00	22.384	3:36:00	22.694	3:36:00	21.707	3:36:00	22.384	3:36:00	22.535
56	3:40:00	21.728	3:40:00	22.39	3:40:00	22.718	3:40:00	21.728	3:40:00	22.39	3:40:00	22.557
57	3:44:00	21.734	3:44:00	22.414	3:44:00	22.732	3:44:00	21.734	3:44:00	22.414	3:44:00	22.578
58	3:48:00	21.743	3:48:00	22.432	3:48:00	22.75	3:48:00	21.743	3:48:00	22.432	3:48:00	22.586
59	3:52:00	21.749	3:52:00	22.455	3:52:00	22.765	3:52:00	21.749	3:52:00	22.455	3:52:00	22.61
60	3:56:00	21.764	3:56:00	22.471	3:56:00	22.786	3:56:00	21.764	3:56:00	22.471	3:56:00	22.616
61	4:00:00	21.783	4:00:00	22.484	4:00:00	22.809	4:00:00	21.783	4:00:00	22.484	4:00:00	22.636
62	4:04:00	21.785	4:04:00	22.493	4:04:00	22.822	4:04:00	21.785	4:04:00	22.493	4:04:00	22.656
63	4:08:00	21.792	4:08:00	22.501	4:08:00	22.837	4:08:00	21.792	4:08:00	22.501	4:08:00	22.682
64	4:12:00	21.811	4:12:00	22.522	4:12:00	22.853	4:12:00	21.812	4:12:00	22.522	4:12:00	22.695
65	4:16:00	21.825	4:16:00	22.538	4:16:00	22.873	4:16:00	21.825	4:16:00	22.538	4:16:00	22.712
66	4:20:00	21.828	4:20:00	22.556	4:20:00	22.883	4:20:00	21.828	4:20:00	22.556	4:20:00	22.736
67	4:24:00	21.831	4:24:00	22.574	4:24:00	22.897	4:24:00	21.833	4:24:00	22.574	4:24:00	22.764
68	4:28:00	21.838	4:28:00	22.58	4:28:00	22.911	4:28:00	21.838	4:28:00	22.58	4:28:00	22.783
69	4:32:00	21.841	4:32:00	22.593	4:32:00	22.929	4:32:00	21.841	4:32:00	22.593	4:32:00	22.817
70	4:36:00	21.847	4:36:00	22.592	4:36:00	22.937	4:36:00	21.847	4:36:00	22.592	4:36:00	22.854
71	4:40:00	21.857	4:40:00	22.605	4:40:00	22.95	4:40:00	21.857	4:40:00	22.605	4:40:00	22.869
72	4:44:00	21.871	4:44:00	22.617	4:44:00	22.964	4:44:00	21.871	4:44:00	22.617	4:44:00	22.868
73	4:48:00	21.872	4:48:00	22.625	4:48:00	22.985	4:48:00	21.872	4:48:00	22.625	4:48:00	22.872
74	4:52:00	21.872	4:52:00	22.644	4:52:00	23	4:52:00	21.872	4:52:00	22.644	4:52:00	22.889
75	4:56:00	21.872	4:56:00	22.655	4:56:00	23.007	4:56:00	21.872	4:56:00	22.655	4:56:00	22.906
76	5:00:00	21.874	5:00:00	22.664	5:00:00	23.011	5:00:00	21.874	5:00:00	22.664	5:00:00	22.945
77	5:04:00	21.873	5:04:00	22.677	5:04:00	23.025	5:04:00	21.873	5:04:00	22.677	5:04:00	22.97
78	5:08:00	21.879	5:08:00	22.691	5:08:00	23.035	5:08:00	21.879	5:08:00	22.691	5:08:00	22.982
79	5:12:00	21.885	5:12:00	22.698	5:12:00	23.036	5:12:00	21.885	5:12:00	22.698	5:12:00	23
80	5:16:00	21.883	5:16:00	22.708	5:16:00	23.051	5:16:00	21.883	5:16:00	22.708	5:16:00	23.01
81	5:20:00	21.892	5:20:00	22.722	5:20:00	23.067	5:20:00	21.892	5:20:00	22.722	5:20:00	23.005
82	5:24:00	21.897	5:24:00	22.729	5:24:00	23.077	5:24:00	21.897	5:24:00	22.729	5:24:00	23.013
83	5:28:00	21.898	5:28:00	22.739	5:28:00	23.078	5:28:00	21.898	5:28:00	22.739	5:28:00	23.028
84	5:32:00	21.899	5:32:00	22.755	5:32:00	23.086	5:32:00	21.899	5:32:00	22.755	5:32:00	23.045
85	5:36:00	21.901	5:36:00	22.753	5:36:00	23.097	5:36:00	21.901	5:36:00	22.753	5:36:00	23.077
86	5:40:00	21.91	5:40:00	22.757	5:40:00	23.107	5:40:00	21.91	5:40:00	22.757	5:40:00	23.083
87	5:44:00	21.911	5:44:00	22.77	5:44:00	23.11	5:44:00	21.911	5:44:00	22.77	5:44:00	23.076
88	5:48:00	21.913	5:48:00	22.777	5:48:00	23.116	5:48:00	21.913	5:48:00	22.777	5:48:00	23.07

NO	DTS1092		DTS1038		DTS901		DTS724		DTS1223		DTS1466	
	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer
89	5:52:00	21.911	5:52:00	22.781	5:52:00	23.136	5:52:00	21.911	5:52:00	22.781	5:52:00	23.091
90	5:56:00	21.911	5:56:00	22.781	5:56:00	23.147	5:56:00	21.911	5:56:00	22.781	5:56:00	23.106
91	6:00:00	21.902	6:00:00	22.797	6:00:00	23.155	6:00:00	21.902	6:00:00	22.797	6:00:00	23.116
92	6:04:00	21.903	6:04:00	22.803	6:04:00	23.159	6:04:00	21.903	6:04:00	22.803	6:04:00	23.117
93	6:08:00	21.908	6:08:00	22.81	6:08:00	23.165	6:08:00	21.908	6:08:00	22.81	6:08:00	23.131
94	6:12:00	21.907	6:12:00	22.814	6:12:00	23.172	6:12:00	21.907	6:12:00	22.814	6:12:00	23.134
95	6:16:00	21.913	6:16:00	22.814	6:16:00	23.175	6:16:00	21.913	6:16:00	22.814	6:16:00	23.134
96	6:20:00	21.911	6:20:00	22.817	6:20:00	23.182	6:20:00	21.911	6:20:00	22.817	6:20:00	23.146
97	6:24:00	21.904	6:24:00	22.812	6:24:00	23.182	6:24:00	21.904	6:24:00	22.812	6:24:00	23.156
98	6:28:00	21.903	6:28:00	22.832	6:28:00	23.183	6:28:00	21.903	6:28:00	22.832	6:28:00	23.162
99	6:32:00	21.907	6:32:00	22.824	6:32:00	23.192	6:32:00	21.907	6:32:00	22.824	6:32:00	23.157
100	6:36:00	21.917	6:36:00	22.83	6:36:00	23.206	6:36:00	21.917	6:36:00	22.83	6:36:00	23.158
101	6:40:00	21.913	6:40:00	22.835	6:40:00	23.206	6:40:00	21.913	6:40:00	22.835	6:40:00	23.174
102	6:44:00	21.914	6:44:00	22.839	6:44:00	23.21	6:44:00	21.914	6:44:00	22.839	6:44:00	23.181
103	6:48:00	21.91	6:48:00	22.838	6:48:00	23.211	6:48:00	21.91	6:48:00	22.838	6:48:00	23.182
104	6:52:00	21.9	6:52:00	22.844	6:52:00	23.221	6:52:00	21.9	6:52:00	22.844	6:52:00	23.182
105	6:56:00	21.892	6:56:00	22.842	6:56:00	23.232	6:56:00	21.892	6:56:00	22.842	6:56:00	23.188
106	7:00:00	21.891	7:00:00	22.851	7:00:00	23.229	7:00:00	21.891	7:00:00	22.851	7:00:00	23.197
107	7:04:00	21.886	7:04:00	22.842	7:04:00	23.229	7:04:00	21.886	7:04:00	22.842	7:04:00	23.203
108	7:08:00	21.887	7:08:00	22.839	7:08:00	23.236	7:08:00	21.876	7:08:00	22.839	7:08:00	23.209
109	7:12:00	21.888	7:12:00	22.835	7:12:00	23.25	7:12:00	21.88	7:12:00	22.835	7:12:00	23.215
110	7:16:00	21.889	7:16:00	22.841	7:16:00	23.251	7:16:00	21.886	7:16:00	22.841	7:16:00	23.224
111	7:20:00	21.89	7:20:00	22.836	7:20:00	23.262	7:20:00	21.888	7:20:00	22.836	7:20:00	23.227
112	7:24:00	21.891	7:24:00	22.852	7:24:00	23.261	7:24:00	21.882	7:24:00	22.852	7:24:00	23.23
113	7:28:00	21.892	7:28:00	22.856	7:28:00	23.26	7:28:00	21.882	7:28:00	22.856	7:28:00	23.235
114	7:32:00	21.893	7:32:00	22.852	7:32:00	23.257	7:32:00	21.876	7:32:00	22.852	7:32:00	23.238
115	7:36:00	21.894	7:36:00	22.851	7:36:00	23.256	7:36:00	21.874	7:36:00	22.851	7:36:00	23.243
116	7:40:00	21.895	7:40:00	22.85	7:40:00	23.268	7:40:00	21.868	7:40:00	22.85	7:40:00	23.251
117	7:44:00	21.896	7:44:00	22.848	7:44:00	23.262	7:44:00	21.869	7:44:00	22.848	7:44:00	23.252
118	7:48:00	21.897	7:48:00	22.84	7:48:00	23.255	7:48:00	21.86	7:48:00	22.84	7:48:00	23.249
119	7:52:00	21.898	7:52:00	22.829	7:52:00	23.259	7:52:00	21.856	7:52:00	22.829	7:52:00	23.249
120	7:56:00	21.899	7:56:00	22.839	7:56:00	23.27	7:56:00	21.849	7:56:00	22.839	7:56:00	23.246
121	8:00:00	21.9	8:00:00	22.835	8:00:00	23.269	8:00:00	21.835	8:00:00	22.835	8:00:00	23.246
122	8:04:00	21.91	8:04:00	22.833	8:04:00	23.273	8:04:00	21.828	8:04:00	22.833	8:04:00	23.25
123	8:08:00	21.911	8:08:00	22.836	8:08:00	23.267	8:08:00	21.814	8:08:00	22.836	8:08:00	23.252
124	8:12:00	21.912	8:12:00	22.84	8:12:00	23.264	8:12:00	21.814	8:12:00	22.84	8:12:00	23.259
125	8:16:00	21.914	8:16:00	22.839	8:16:00	23.261	8:16:00	21.81	8:16:00	22.839	8:16:00	23.263
126	8:20:00	21.915	8:20:00	22.827	8:20:00	23.257	8:20:00	21.812	8:20:00	22.827	8:20:00	23.264
127	8:24:00	21.918	8:24:00	22.83	8:24:00	23.265	8:24:00	21.804	8:24:00	22.83	8:24:00	23.263
128	8:28:00	21.92	8:28:00	22.826	8:28:00	23.263	8:28:00	21.792	8:28:00	22.826	8:28:00	23.273
129	8:32:00	21.924	8:32:00	22.821	8:32:00	23.26	8:32:00	21.79	8:32:00	22.821	8:32:00	23.272
130	8:36:00	21.925	8:36:00	22.822	8:36:00	23.254	8:36:00	21.778	8:36:00	22.822	8:36:00	23.264
131	8:40:00	21.927	8:40:00	22.825	8:40:00	23.254	8:40:00	21.784	8:40:00	22.825	8:40:00	23.266
132	8:44:00	21.928	8:44:00	22.811	8:44:00	23.25	8:44:00	21.778	8:44:00	22.811	8:44:00	23.267

NO	DTS1092		DTS1038		DTS901		DTS724		DTS1223		DTS1466	
	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer
133	8:48:00	21.931	8:48:00	22.814	8:48:00	23.249	8:48:00	21.778	8:48:00	22.814	8:48:00	23.277
134	8:52:00	21.932	8:52:00	22.802	8:52:00	23.255	8:52:00	21.778	8:52:00	22.802	8:52:00	23.279
135	8:56:00	21.934	8:56:00	22.804	8:56:00	23.244	8:56:00	21.764	8:56:00	22.804	8:56:00	23.275
136	9:00:00	21.935	9:00:00	22.796	9:00:00	23.238	9:00:00	21.774	9:00:00	22.796	9:00:00	23.264
137	9:04:00	21.937	9:04:00	22.793	9:04:00	23.236	9:04:00	21.772	9:04:00	22.793	9:04:00	23.27
138	9:08:00	21.939	9:08:00	22.796	9:08:00	23.24	9:08:00	21.761	9:08:00	22.796	9:08:00	23.268
139	9:12:00	21.942	9:12:00	22.806	9:12:00	23.232	9:12:00	21.745	9:12:00	22.806	9:12:00	23.269
140	9:16:00	21.945	9:16:00	22.797	9:16:00	23.238	9:16:00	21.744	9:16:00	22.797	9:16:00	23.269
141	9:20:00	21.946	9:20:00	22.803	9:20:00	23.228	9:20:00	21.744	9:20:00	22.803	9:20:00	23.269
142	9:24:00	21.947	9:24:00	22.797	9:24:00	23.231	9:24:00	21.73	9:24:00	22.797	9:24:00	23.275
143	9:28:00	21.949	9:28:00	22.79	9:28:00	23.228	9:28:00	21.735	9:28:00	22.79	9:28:00	23.279
144	9:32:00	21.951	9:32:00	22.784	9:32:00	23.214	9:32:00	21.719	9:32:00	22.784	9:32:00	23.27
145	9:36:00	21.952	9:36:00	22.788	9:36:00	23.208	9:36:00	21.716	9:36:00	22.788	9:36:00	23.278
146	9:40:00	21.954	9:40:00	22.787	9:40:00	23.205	9:40:00	21.703	9:40:00	22.787	9:40:00	23.278
147	9:44:00	21.957	9:44:00	22.788	9:44:00	23.205	9:44:00	21.703	9:44:00	22.788	9:44:00	23.277
148	9:48:00	21.958	9:48:00	22.783	9:48:00	23.204	9:48:00	21.697	9:48:00	22.783	9:48:00	23.281
149	9:52:00	21.96	9:52:00	22.771	9:52:00	23.197	9:52:00	21.681	9:52:00	22.771	9:52:00	23.269
150	9:56:00	21.962	9:56:00	22.76	9:56:00	23.195	9:56:00	21.676	9:56:00	22.76	9:56:00	23.27
151	10:00:00	21.963	10:00:00	22.768	10:00:00	23.186	10:00:00	21.665	10:00:00	22.768	10:00:00	23.264
152	10:04:00	21.964	10:04:00	22.756	10:04:00	23.176	10:04:00	21.649	10:04:00	22.756	10:04:00	23.257
153	10:08:00	21.966	10:08:00	22.747	10:08:00	23.182	10:08:00	21.649	10:08:00	22.747	10:08:00	23.25
154	10:12:00	21.968	10:12:00	22.75	10:12:00	23.171	10:12:00	21.651	10:12:00	22.75	10:12:00	23.246
155	10:16:00	21.971	10:16:00	22.742	10:16:00	23.172	10:16:00	21.641	10:16:00	22.742	10:16:00	23.239
156	10:20:00	21.973	10:20:00	22.743	10:20:00	23.168	10:20:00	21.638	10:20:00	22.743	10:20:00	23.248
157	10:24:00	21.974	10:24:00	22.746	10:24:00	23.164	10:24:00	21.621	10:24:00	22.746	10:24:00	23.241
158	10:28:00	21.975	10:28:00	22.733	10:28:00	23.153	10:28:00	21.626	10:28:00	22.733	10:28:00	23.23
159	10:32:00	21.976	10:32:00	22.723	10:32:00	23.148	10:32:00	21.605	10:32:00	22.723	10:32:00	23.227
160	10:36:00	21.979	10:36:00	22.725	10:36:00	23.137	10:36:00	21.591	10:36:00	22.725	10:36:00	23.22
161	10:40:00	21.981	10:40:00	22.717	10:40:00	23.122	10:40:00	21.583	10:40:00	22.717	10:40:00	23.228
162	10:44:00	21.983	10:44:00	22.707	10:44:00	23.102	10:44:00	21.574	10:44:00	22.707	10:44:00	23.225
163	10:48:00	21.985	10:48:00	22.708	10:48:00	23.104	10:48:00	21.565	10:48:00	22.708	10:48:00	23.226
164	10:52:00	21.987	10:52:00	22.705	10:52:00	23.105	10:52:00	21.569	10:52:00	22.705	10:52:00	23.232
165	10:56:00	21.988	10:56:00	22.697	10:56:00	23.095	10:56:00	21.568	10:56:00	22.697	10:56:00	23.235
166	11:00:00	21.989	11:00:00	22.697	11:00:00	23.088	11:00:00	21.551	11:00:00	22.697	11:00:00	23.227
167	11:04:00	21.99	11:04:00	22.696	11:04:00	23.075	11:04:00	21.55	11:04:00	22.696	11:04:00	23.224
168	11:08:00	21.991	11:08:00	22.692	11:08:00	23.078	11:08:00	21.548	11:08:00	22.692	11:08:00	23.236
169	11:12:00	21.992	11:12:00	22.696	11:12:00	23.074	11:12:00	21.531	11:12:00	22.696	11:12:00	23.231
170	11:16:00	21.994	11:16:00	22.683	11:16:00	23.074	11:16:00	21.526	11:16:00	22.683	11:16:00	23.231
171	11:20:00	21.995	11:20:00	22.671	11:20:00	23.07	11:20:00	21.523	11:20:00	22.671	11:20:00	23.219
172	11:24:00	21.997	11:24:00	22.659	11:24:00	23.062	11:24:00	21.526	11:24:00	22.659	11:24:00	23.226
173	11:28:00	21.998	11:28:00	22.658	11:28:00	23.057	11:28:00	21.512	11:28:00	22.658	11:28:00	23.217
174	11:32:00	21.999	11:32:00	22.657	11:32:00	23.053	11:32:00	21.499	11:32:00	22.657	11:32:00	23.208
175	11:36:00	22.01	11:36:00	22.654	11:36:00	23.049	11:36:00	21.486	11:36:00	22.654	11:36:00	23.199
176	11:40:00	22.014	11:40:00	22.649	11:40:00	23.042	11:40:00	21.485	11:40:00	22.649	11:40:00	23.202

NO	DTS1092		DTS1038		DTS901		DTS724		DTS1223		DTS1466	
	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer
177	11:44:00	22.015	11:44:00	22.64	11:44:00	23.042	11:44:00	21.481	11:44:00	22.64	11:44:00	23.196
178	11:48:00	22.017	11:48:00	22.631	11:48:00	23.045	11:48:00	21.473	11:48:00	22.631	11:48:00	23.186
179	11:52:00	22.021	11:52:00	22.627	11:52:00	23.037	11:52:00	21.465	11:52:00	22.627	11:52:00	23.188
180	11:56:00	22.023	11:56:00	22.627	11:56:00	23.037	11:56:00	21.464	11:56:00	22.627	11:56:00	23.18
181	12:00:00	22.025	12:00:00	22.62	12:00:00	23.028	12:00:00	21.446	12:00:00	22.62	12:00:00	23.176
182	12:04:00	22.027	12:04:00	22.617	12:04:00	23.015	12:04:00	21.441	12:04:00	22.617	12:04:00	23.172
183	12:08:00	22.029	12:08:00	22.608	12:08:00	23.009	12:08:00	21.423	12:08:00	22.608	12:08:00	23.18
184	12:12:00	22.032	12:12:00	22.607	12:12:00	23	12:12:00	21.404	12:12:00	22.607	12:12:00	23.178
185	12:16:00	22.034	12:16:00	22.597	12:16:00	22.997	12:16:00	21.407	12:16:00	22.597	12:16:00	23.167
186	12:20:00	22.036	12:20:00	22.591	12:20:00	22.996	12:20:00	21.404	12:20:00	22.591	12:20:00	23.167
187	12:24:00	22.038	12:24:00	22.586	12:24:00	22.982	12:24:00	21.401	12:24:00	22.586	12:24:00	23.161
188	12:28:00	22.041	12:28:00	22.566	12:28:00	22.986	12:28:00	21.398	12:28:00	22.566	12:28:00	23.156
189	12:32:00	22.043	12:32:00	22.566	12:32:00	22.982	12:32:00	21.394	12:32:00	22.566	12:32:00	23.158
190	12:36:00	22.046	12:36:00	22.559	12:36:00	22.965	12:36:00	21.385	12:36:00	22.559	12:36:00	23.161
191	12:40:00	22.049	12:40:00	22.558	12:40:00	22.957	12:40:00	21.383	12:40:00	22.558	12:40:00	23.158
192	12:44:00	22.051	12:44:00	22.549	12:44:00	22.947	12:44:00	21.375	12:44:00	22.549	12:44:00	23.152
193	12:48:00	22.055	12:48:00	22.541	12:48:00	22.941	12:48:00	21.363	12:48:00	22.541	12:48:00	23.147
194	12:52:00	22.057	12:52:00	22.545	12:52:00	22.936	12:52:00	21.358	12:52:00	22.545	12:52:00	23.14
195	12:56:00	22.059	12:56:00	22.52	12:56:00	22.93	12:56:00	21.354	12:56:00	22.52	12:56:00	23.134
196	13:00:00	22.061	13:00:00	22.519	13:00:00	22.92	13:00:00	21.343	13:00:00	22.519	13:00:00	23.132
197	13:04:00	22.063	13:04:00	22.514	13:04:00	22.907	13:04:00	21.341	13:04:00	22.514	13:04:00	23.123
198	13:08:00	22.068	13:08:00	22.507	13:08:00	22.911	13:08:00	21.332	13:08:00	22.507	13:08:00	23.118
199	13:12:00	22.069	13:12:00	22.503	13:12:00	22.905	13:12:00	21.323	13:12:00	22.503	13:12:00	23.108
200	13:16:00	22.072	13:16:00	22.501	13:16:00	22.9	13:16:00	21.319	13:16:00	22.501	13:16:00	23.103
201	13:20:00	22.074	13:20:00	22.497	13:20:00	22.895	13:20:00	21.312	13:20:00	22.497	13:20:00	23.1
202	13:24:00	22.078	13:24:00	22.488	13:24:00	22.89	13:24:00	21.31	13:24:00	22.488	13:24:00	23.093
203	13:28:00	22.08	13:28:00	22.481	13:28:00	22.888	13:28:00	21.307	13:28:00	22.481	13:28:00	23.082
204	13:32:00	22.083	13:32:00	22.477	13:32:00	22.889	13:32:00	21.295	13:32:00	22.477	13:32:00	23.064
205	13:36:00	22.089	13:36:00	22.459	13:36:00	22.874	13:36:00	21.288	13:36:00	22.459	13:36:00	23.075
206	13:40:00	22.091	13:40:00	22.451	13:40:00	22.872	13:40:00	21.283	13:40:00	22.451	13:40:00	23.077
207	13:44:00	22.093	13:44:00	22.443	13:44:00	22.865	13:44:00	21.276	13:44:00	22.443	13:44:00	23.064
208	13:48:00	22.095	13:48:00	22.44	13:48:00	22.857	13:48:00	21.271	13:48:00	22.44	13:48:00	23.059
209	13:52:00	22.097	13:52:00	22.427	13:52:00	22.839	13:52:00	21.264	13:52:00	22.427	13:52:00	23.047
210	13:56:00	22.099	13:56:00	22.427	13:56:00	22.841	13:56:00	21.255	13:56:00	22.427	13:56:00	23.04
211	14:00:00	22.102	14:00:00	22.427	14:00:00	22.834	14:00:00	21.248	14:00:00	22.427	14:00:00	23.039
212	14:04:00	22.104	14:04:00	22.43	14:04:00	22.827	14:04:00	21.236	14:04:00	22.43	14:04:00	23.038
213	14:08:00	22.106	14:08:00	22.431	14:08:00	22.82	14:08:00	21.229	14:08:00	22.431	14:08:00	23.035
214	14:12:00	22.108	14:12:00	22.426	14:12:00	22.825	14:12:00	21.229	14:12:00	22.426	14:12:00	23.028
215	14:16:00	22.11	14:16:00	22.417	14:16:00	22.814	14:16:00	21.223	14:16:00	22.417	14:16:00	23.022
216	14:20:00	22.114	14:20:00	22.416	14:20:00	22.815	14:20:00	21.217	14:20:00	22.416	14:20:00	23.026
217	14:24:00	22.115	14:24:00	22.408	14:24:00	22.816	14:24:00	21.215	14:24:00	22.408	14:24:00	23.023
218	14:28:00	22.118	14:28:00	22.393	14:28:00	22.805	14:28:00	21.213	14:28:00	22.393	14:28:00	23.017
219	14:32:00	22.122	14:32:00	22.393	14:32:00	22.787	14:32:00	21.217	14:32:00	22.393	14:32:00	23.004
220	14:36:00	22.124	14:36:00	22.381	14:36:00	22.781	14:36:00	21.193	14:36:00	22.381	14:36:00	22.997

NO	DTS1092		DTS1038		DTS901		DTS724		DTS1223		DTS1466	
	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer
221	14:40:00	22.126	14:40:00	22.373	14:40:00	22.785	14:40:00	21.185	14:40:00	22.373	14:40:00	22.997
222	14:44:00	22.128	14:44:00	22.385	14:44:00	22.785	14:44:00	21.181	14:44:00	22.385	14:44:00	22.993
223	14:48:00	22.132	14:48:00	22.383	14:48:00	22.768	14:48:00	21.179	14:48:00	22.383	14:48:00	22.985
224	14:52:00	22.134	14:52:00	22.379	14:52:00	22.774	14:52:00	21.187	14:52:00	22.379	14:52:00	22.982
225	14:56:00	22.136	14:56:00	22.372	14:56:00	22.755	14:56:00	21.177	14:56:00	22.372	14:56:00	22.975
226	15:00:00	22.139	15:00:00	22.362	15:00:00	22.755	15:00:00	21.17	15:00:00	22.362	15:00:00	22.976
227	15:04:00	22.14	15:04:00	22.356	15:04:00	22.746	15:04:00	21.161	15:04:00	22.356	15:04:00	22.962
228	15:08:00	22.144	15:08:00	22.349	15:08:00	22.751	15:08:00	21.167	15:08:00	22.349	15:08:00	22.962
229	15:12:00	22.147	15:12:00	22.347	15:12:00	22.734	15:12:00	21.157	15:12:00	22.347	15:12:00	22.953
230	15:16:00	22.149	15:16:00	22.354	15:16:00	22.727	15:16:00	21.152	15:16:00	22.354	15:16:00	22.953
231	15:20:00	22.153	15:20:00	22.356	15:20:00	22.724	15:20:00	21.151	15:20:00	22.356	15:20:00	22.953
232	15:24:00	22.155	15:24:00	22.344	15:24:00	22.727	15:24:00	21.148	15:24:00	22.344	15:24:00	22.947
233	15:28:00	22.157	15:28:00	22.348	15:28:00	22.727	15:28:00	21.144	15:28:00	22.348	15:28:00	22.953
234	15:32:00	22.159	15:32:00	22.334	15:32:00	22.728	15:32:00	21.143	15:32:00	22.334	15:32:00	22.947
235	15:36:00	22.163	15:36:00	22.335	15:36:00	22.72	15:36:00	21.134	15:36:00	22.335	15:36:00	22.95
236	15:40:00	22.164	15:40:00	22.339	15:40:00	22.71	15:40:00	21.14	15:40:00	22.339	15:40:00	22.954
237	15:44:00	22.166	15:44:00	22.338	15:44:00	22.7	15:44:00	21.141	15:44:00	22.338	15:44:00	22.944
238	15:48:00	22.169	15:48:00	22.342	15:48:00	22.685	15:48:00	21.142	15:48:00	22.342	15:48:00	22.927
239	15:52:00	22.172	15:52:00	22.343	15:52:00	22.685	15:52:00	21.141	15:52:00	22.343	15:52:00	22.924
240	15:56:00	22.174	15:56:00	22.335	15:56:00	22.684	15:56:00	21.142	15:56:00	22.335	15:56:00	22.932
241	16:00:00	22.176	16:00:00	22.339	16:00:00	22.682	16:00:00	21.143	16:00:00	22.339	16:00:00	22.935
242	16:04:00	22.179	16:04:00	22.336	16:04:00	22.672	16:04:00	21.144	16:04:00	22.336	16:04:00	22.935
243	16:08:00	22.183	16:08:00	22.327	16:08:00	22.664	16:08:00	21.143	16:08:00	22.327	16:08:00	22.942
244	16:12:00	22.185	16:12:00	22.313	16:12:00	22.668	16:12:00	21.145	16:12:00	22.313	16:12:00	22.939
245	16:16:00	22.186	16:16:00	22.326	16:16:00	22.665	16:16:00	21.144	16:16:00	22.326	16:16:00	22.944
246	16:20:00	22.189	16:20:00	22.325	16:20:00	22.662	16:20:00	21.145	16:20:00	22.325	16:20:00	22.943
247	16:24:00	22.191	16:24:00	22.326	16:24:00	22.661	16:24:00	21.143	16:24:00	22.326	16:24:00	22.934
248	16:28:00	22.193	16:28:00	22.333	16:28:00	22.655	16:28:00	21.144	16:28:00	22.333	16:28:00	22.925
249	16:32:00	22.195	16:32:00	22.326	16:32:00	22.66	16:32:00	21.145	16:32:00	22.326	16:32:00	22.929
250	16:36:00	22.197	16:36:00	22.319	16:36:00	22.647	16:36:00	21.144	16:36:00	22.319	16:36:00	22.926
251	16:40:00	22.199	16:40:00	22.33	16:40:00	22.642	16:40:00	21.143	16:40:00	22.33	16:40:00	22.924
252	16:44:00	22.21	16:44:00	22.332	16:44:00	22.65	16:44:00	21.144	16:44:00	22.332	16:44:00	22.921
253	16:48:00	22.213	16:48:00	22.336	16:48:00	22.637	16:48:00	21.146	16:48:00	22.336	16:48:00	22.91
254	16:52:00	22.214	16:52:00	22.326	16:52:00	22.64	16:52:00	21.145	16:52:00	22.326	16:52:00	22.91
255	16:56:00	22.217	16:56:00	22.317	16:56:00	22.641	16:56:00	21.147	16:56:00	22.317	16:56:00	22.914
256	17:00:00	22.219	17:00:00	22.324	17:00:00	22.639	17:00:00	21.148	17:00:00	22.324	17:00:00	22.915
257	17:04:00	22.223	17:04:00	22.333	17:04:00	22.642	17:04:00	21.149	17:04:00	22.333	17:04:00	22.917
258	17:08:00	22.224	17:08:00	22.327	17:08:00	22.633	17:08:00	21.153	17:08:00	22.327	17:08:00	22.92
259	17:12:00	22.226	17:12:00	22.33	17:12:00	22.637	17:12:00	21.154	17:12:00	22.33	17:12:00	22.916
260	17:16:00	22.229	17:16:00	22.342	17:16:00	22.642	17:16:00	21.151	17:16:00	22.342	17:16:00	22.921
261	17:20:00	22.234	17:20:00	22.341	17:20:00	22.637	17:20:00	21.152	17:20:00	22.341	17:20:00	22.911
262	17:24:00	22.236	17:24:00	22.339	17:24:00	22.631	17:24:00	21.151	17:24:00	22.339	17:24:00	22.913
263	17:28:00	22.238	17:28:00	22.331	17:28:00	22.626	17:28:00	21.152	17:28:00	22.331	17:28:00	22.919
264	17:32:00	22.239	17:32:00	22.339	17:32:00	22.619	17:32:00	21.153	17:32:00	22.339	17:32:00	22.925

NO	DTS1092		DTS1038		DTS901		DTS724		DTS1223		DTS1466	
	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer
265	17:36:00	22.242	17:36:00	22.331	17:36:00	22.613	17:36:00	21.154	17:36:00	22.331	17:36:00	22.927
266	17:40:00	22.245	17:40:00	22.339	17:40:00	22.623	17:40:00	21.153	17:40:00	22.339	17:40:00	22.925
267	17:44:00	22.247	17:44:00	22.353	17:44:00	22.622	17:44:00	21.152	17:44:00	22.353	17:44:00	22.926
268	17:48:00	22.249	17:48:00	22.349	17:48:00	22.613	17:48:00	21.153	17:48:00	22.349	17:48:00	22.936
269	17:52:00	22.253	17:52:00	22.355	17:52:00	22.621	17:52:00	21.154	17:52:00	22.355	17:52:00	22.941
270	17:56:00	22.255	17:56:00	22.353	17:56:00	22.621	17:56:00	21.155	17:56:00	22.353	17:56:00	22.932
271	18:00:00	22.257	18:00:00	22.365	18:00:00	22.624	18:00:00	21.154	18:00:00	22.365	18:00:00	22.931
272	18:04:00	22.259	18:04:00	22.367	18:04:00	22.635	18:04:00	21.155	18:04:00	22.367	18:04:00	22.936
273	18:08:00	22.263	18:08:00	22.362	18:08:00	22.628	18:08:00	21.156	18:08:00	22.362	18:08:00	22.922
274	18:12:00	22.266	18:12:00	22.363	18:12:00	22.635	18:12:00	21.157	18:12:00	22.363	18:12:00	22.937
275	18:16:00	22.268	18:16:00	22.374	18:16:00	22.638	18:16:00	21.158	18:16:00	22.374	18:16:00	22.943
276	18:20:00	22.272	18:20:00	22.374	18:20:00	22.639	18:20:00	21.157	18:20:00	22.374	18:20:00	22.939
277	18:24:00	22.275	18:24:00	22.376	18:24:00	22.642	18:24:00	21.158	18:24:00	22.376	18:24:00	22.941
278	18:28:00	22.277	18:28:00	22.39	18:28:00	22.639	18:28:00	21.159	18:28:00	22.39	18:28:00	22.946
279	18:32:00	22.279	18:32:00	22.395	18:32:00	22.643	18:32:00	21.16	18:32:00	22.395	18:32:00	22.959
280	18:36:00	22.283	18:36:00	22.395	18:36:00	22.646	18:36:00	21.161	18:36:00	22.395	18:36:00	22.963
281	18:40:00	22.285	18:40:00	22.401	18:40:00	22.652	18:40:00	21.162	18:40:00	22.401	18:40:00	22.967
282	18:44:00	22.287	18:44:00	22.409	18:44:00	22.656	18:44:00	21.164	18:44:00	22.409	18:44:00	22.964
283	18:48:00	22.289	18:48:00	22.412	18:48:00	22.661	18:48:00	21.165	18:48:00	22.412	18:48:00	22.956
284	18:52:00	22.292	18:52:00	22.41	18:52:00	22.664	18:52:00	21.167	18:52:00	22.41	18:52:00	22.972
285	18:56:00	22.294	18:56:00	22.421	18:56:00	22.67	18:56:00	21.168	18:56:00	22.421	18:56:00	22.954
286	19:00:00	22.296	19:00:00	22.424	19:00:00	22.667	19:00:00	21.169	19:00:00	22.424	19:00:00	22.964
287	19:04:00	22.299	19:04:00	22.43	19:04:00	22.677	19:04:00	21.17	19:04:00	22.43	19:04:00	22.97
288	19:08:00	22.304	19:08:00	22.432	19:08:00	22.687	19:08:00	21.171	19:08:00	22.432	19:08:00	22.966
289	19:12:00	22.305	19:12:00	22.443	19:12:00	22.689	19:12:00	21.173	19:12:00	22.443	19:12:00	22.968
290	19:16:00	22.307	19:16:00	22.44	19:16:00	22.682	19:16:00	21.174	19:16:00	22.44	19:16:00	22.973
291	19:20:00	22.309	19:20:00	22.458	19:20:00	22.691	19:20:00	21.175	19:20:00	22.458	19:20:00	22.986
292	19:24:00	22.32	19:24:00	22.468	19:24:00	22.699	19:24:00	21.176	19:24:00	22.468	19:24:00	22.986
293	19:28:00	22.322	19:28:00	22.484	19:28:00	22.702	19:28:00	21.177	19:28:00	22.484	19:28:00	22.995
294	19:32:00	22.325	19:32:00	22.491	19:32:00	22.706	19:32:00	21.176	19:32:00	22.491	19:32:00	23.002
295	19:36:00	22.328	19:36:00	22.494	19:36:00	22.707	19:36:00	21.177	19:36:00	22.494	19:36:00	23.008
296	19:40:00	22.334	19:40:00	22.498	19:40:00	22.717	19:40:00	21.178	19:40:00	22.498	19:40:00	23.006
297	19:44:00	22.336	19:44:00	22.503	19:44:00	22.727	19:44:00	21.179	19:44:00	22.503	19:44:00	23.01
298	19:48:00	22.339	19:48:00	22.51	19:48:00	22.742	19:48:00	21.181	19:48:00	22.51	19:48:00	23.018
299	19:52:00	22.344	19:52:00	22.52	19:52:00	22.747	19:52:00	21.18	19:52:00	22.52	19:52:00	23.013
300	19:56:00	22.346	19:56:00	22.52	19:56:00	22.763	19:56:00	21.182	19:56:00	22.52	19:56:00	23.007
301	20:00:00	22.348	20:00:00	22.52	20:00:00	22.765	20:00:00	21.183	20:00:00	22.52	20:00:00	23.003
302	20:04:00	22.352	20:04:00	22.53	20:04:00	22.769	20:04:00	21.184	20:04:00	22.53	20:04:00	23.001
303	20:08:00	22.354	20:08:00	22.546	20:08:00	22.786	20:08:00	21.185	20:08:00	22.546	20:08:00	23.013
304	20:12:00	22.356	20:12:00	22.559	20:12:00	22.794	20:12:00	21.184	20:12:00	22.559	20:12:00	23.017
305	20:16:00	22.359	20:16:00	22.566	20:16:00	22.8	20:16:00	21.185	20:16:00	22.566	20:16:00	23.017
306	20:20:00	22.361	20:20:00	22.575	20:20:00	22.805	20:20:00	21.186	20:20:00	22.575	20:20:00	23.024
307	20:24:00	22.363	20:24:00	22.593	20:24:00	22.817	20:24:00	21.184	20:24:00	22.593	20:24:00	23.028
308	20:28:00	22.365	20:28:00	22.608	20:28:00	22.829	20:28:00	21.185	20:28:00	22.608	20:28:00	23.034

NO	DTS1092		DTS1038		DTS901		DTS724		DTS1223		DTS1466	
	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer	Time	Temperatuer
309	20:32:00	22.369	20:32:00	22.619	20:32:00	22.837	20:32:00	21.186	20:32:00	22.619	20:32:00	23.038
310	20:36:00	22.373	20:36:00	22.634	20:36:00	22.846	20:36:00	21.187	20:36:00	22.634	20:36:00	23.045
311	20:40:00	22.375	20:40:00	22.635	20:40:00	22.87	20:40:00	21.188	20:40:00	22.635	20:40:00	23.053
312	20:44:00	22.378	20:44:00	22.639	20:44:00	22.866	20:44:00	21.189	20:44:00	22.639	20:44:00	23.055
313	20:48:00	22.379	20:48:00	22.647	20:48:00	22.874	20:48:00	21.19	20:48:00	22.647	20:48:00	23.067
314	20:52:00	22.382	20:52:00	22.664	20:52:00	22.892	20:52:00	21.191	20:52:00	22.664	20:52:00	23.077
315	20:56:00	22.385	20:56:00	22.678	20:56:00	22.902	20:56:00	21.192	20:56:00	22.678	20:56:00	23.09
316	21:00:00	22.387	21:00:00	22.688	21:00:00	22.918	21:00:00	21.19	21:00:00	22.688	21:00:00	23.091
317	21:04:00	22.389	21:04:00	22.696	21:04:00	22.934	21:04:00	21.191	21:04:00	22.696	21:04:00	23.099
318	21:08:00	22.391	21:08:00	22.699	21:08:00	22.945	21:08:00	21.192	21:08:00	22.699	21:08:00	23.113
319	21:12:00	22.394	21:12:00	22.723	21:12:00	22.964	21:12:00	21.193	21:12:00	22.723	21:12:00	23.12
320	21:16:00	22.396	21:16:00	22.74	21:16:00	22.989	21:16:00	21.194	21:16:00	22.74	21:16:00	23.12
321	21:20:00	22.399	21:20:00	22.758	21:20:00	23.018	21:20:00	21.195	21:20:00	22.758	21:20:00	23.114
322	21:24:00	22.413	21:24:00	22.766	21:24:00	23.028	21:24:00	21.196	21:24:00	22.766	21:24:00	23.118
323	21:28:00	22.416	21:28:00	22.785	21:28:00	23.035	21:28:00	21.197	21:28:00	22.785	21:28:00	23.127
324	21:32:00	22.419	21:32:00	22.796	21:32:00	23.038	21:32:00	21.198	21:32:00	22.796	21:32:00	23.148
325	21:36:00	22.423	21:36:00	22.81	21:36:00	23.055	21:36:00	21.199	21:36:00	22.81	21:36:00	23.169
326	21:40:00	22.425	21:40:00	22.813	21:40:00	23.067	21:40:00	21.201	21:40:00	22.813	21:40:00	23.172
327	21:44:00	22.427	21:44:00	22.833	21:44:00	23.088	21:44:00	21.202	21:44:00	22.833	21:44:00	23.186
328	21:48:00	22.429	21:48:00	22.849	21:48:00	23.096	21:48:00	21.203	21:48:00	22.849	21:48:00	23.206
329	21:52:00	22.434	21:52:00	22.865	21:52:00	23.126	21:52:00	21.205	21:52:00	22.865	21:52:00	23.209
330	21:56:00	22.436	21:56:00	22.871	21:56:00	23.145	21:56:00	21.204	21:56:00	22.871	21:56:00	23.226
331	22:00:00	22.437	22:00:00	23.875	22:00:00	23.154	22:00:00	21.206	22:00:00	23.702	22:00:00	23.237
332	22:04:00	22.439	22:04:00	24.771	22:04:00	23.172	22:04:00	21.207	22:04:00	24.683	22:04:00	23.244
333	22:08:00	22.443	22:08:00	25.811	22:08:00	23.182	22:08:00	21.208	22:08:00	25.911	22:08:00	23.245
334	22:12:00	22.446	22:12:00	27.102	22:12:00	23.19	22:12:00	21.209	22:12:00	28.473	22:12:00	23.246
335	22:16:00	22.449	22:16:00	29.805	22:16:00	23.215	22:16:00	21.21			22:16:00	23.246
336	22:20:00	22.452			22:20:00	23.231	22:20:00	21.211			22:20:00	23.247
337	22:24:00	22.455			22:24:00	23.328	22:24:00	21.212			22:24:00	23.248
338	22:28:00	22.461			22:28:00	24.452	22:28:00	21.211			22:28:00	23.247
339	22:32:00	22.465			22:32:00	25.621	22:32:00	21.212			22:32:00	23.248
340	22:36:00	22.472			22:36:00	26.957	22:36:00	21.211			22:36:00	23.247
341	22:40:00	23.475			22:40:00	29.832	22:40:00	23.347			22:40:00	23.247
342	22:44:00	24.445					22:44:00	24.3			22:44:00	23.249
343	22:48:00	25.425					22:48:00	25.401			22:48:00	23.248
344	22:52:00	26.651					22:52:00	28.347			22:52:00	23.251
345	22:56:00	29.362									22:56:00	24.031
346											23:00:00	24.838
347											23:04:00	25.87
348											23:08:00	28.028

RESUME

I am Ali Mohamed Handar. I graduated from primary and secondary education in local schools located in the cities of Souk Al-Khamis - Tripoli. I started my university studies at the Higher Institute of Science and Technology - Bani Walid in the Department of Civil Engineering in 1995, and I graduated in 1998 and worked as a teaching assistant at the Higher Institute of Science and Technology - Qasr Bin Ghashir and in 2010, then I was assigned as Director of the Technical Affairs management at the National Board for Technical Vocational Education - Ministry of Higher Education and also I was assigned as a Director of Projects Management at the Airports Authority - Ministry of Transportation and Transport. In 2019, I started my studies at the University of Karabuk, Department of Civil Engineering, to obtain a master's degree.