Theoretical Feasibility Study of Preferential Hyperthermia Using Silicon Carbide Inserts

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(Abstract)

Recently, hyperthermia has been investigated as an alternate therapy for the treatment of tumors. The present project explored the feasibility of preferential hyperthermia as a method of treating deep seated tumors. The overall goal of this research was to determine theoretically if preferential heating could be used to attain the desired thermal dose (DTD) for a two cm diameter tumor.

The simulations in this work show that, when using a single silicon carbide insert, the model cannot provide enough energy for an entire 2 cm diameter tumor to receive the DTD. However, when using an enhanced design model with multiple (4) silicon carbide inserts, the DTD could be attained in a tumor up to 3.5 cm in diameter.

This study involved using the commercially available software package ANSYS 7.0 program to model a spherical 2 cm tumor, assuming the tumor is located in deep tissue with a constant perfusion rate and no major blood vessels nearby. This tumor was placed in the center of a cube of healthy tissue. To achieve the preferential heating of the tumor, a silicon carbide insert was placed in the center of the tumor and microwave energy was applied to the insert (in the form of volumetric heating). The thermal modeling of this system was based on the Pennes Bioheat equation with a maximum temperature limitation of 80 ºC. The Thermal Dose Analyzer software program was used to evaluate the results of the thermal simulations (from ANSYS) to determine if the DTD had been attained.

Additional enhanced design models were also examined. These models include 2 cm and 4 cm tumors with four silicon carbide inserts symmetrically placed about the tumor and a 4 cm tumor model using a single silicon carbide insert with antennae attached to the insert to increase energy distribution to the tumor. The simulations show that only the enhanced design cases with four silicon carbide inserts can achieve the DTD for an entire 2 cm tumor.

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Nomenclature

C	Specific Heat, J/kg/K
D	Thermal Dose
E	Heat Generation Rate, W
k	Thermal Conductivity, W/m/K
Q	Heat Added to System, J
R	A Constant
t	Time, s
T	Temperature, ºC
ρ	Density, kg/m^3
ω	Perfusion Rate, ml/ml/min

Subscripts

a	Arterial
b	Blood
r	Reference
t	Tissue

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Chapter 1

Introduction

Recently, an alternative treatment for liver tumors, local hyperthermia, has been quickly gaining recognition (Dodd et al., 2000). Each year, this deadly disease affects more than 150,000 new patients in the United States (Wingo et al., 1995). In addition, over one-million new cases of hepatocellular carcinoma are found throughout the world each year (Curley et al., 1999). Currently, conventional medical therapy includes treatments such as surgery, chemotherapy, radiation therapy, and combinations of these three. These methods are invasive, have severe and unpleasant side effects, and are frequently unsuccessful.

In recent times, hyperthermia has been investigated as an alternate therapy. It has been used in conjunction with traditional treatments, and has been found to provide enhanced synergistic effects (Ishii, 1995). In general, these hyperthermia treatments are invasive (although they can be noninvasive) and are often administered through the usage of microwave energy, radiofrequency ablation, and lasers. Thus, it was desired to determine if a minimally invasive method of applying local hyperthermia treatments using microwave energy could be found. This project was initiated to investigate the feasibility of such a method, using an invasive probe in conjunction with a silicon carbide insert, for treating these deep seated tumors.

The work entailed in this project investigated the theoretical feasibility of using preferential hyperthermia for the treatment of deep seated tumors using silicon carbide inserts. A simple representation of the system investigated is shown in Figure 1.1. The silicon carbide inserts were developed by the Material Science and Engineering Department at Virginia Tech with silicon carbide being chosen for its ability to absorb microwave energy (details are described in Section 3.1). To determine the theoretical feasibility, a simplified computer thermal model of a deep seated tumor surrounded by healthy tissue with a silicon carbide insert placed in the center of the tumor was created (based on the Pennes Bioheat Equation). Then, various simulations were performed by adding heat to the silicon carbide insert and the cumulative thermal doses (based on the simulation results) were determined (as described in Section 3.2). Based on these results (discussed in Chapter 4), additional enhanced design simulations were performed to increase the amount of tumor achieving the desired thermal dose (DTD).

The main purpose of this research was to determine if a minimally invasive treatment system using one or more silicon carbide inserts could be used to preferentially heat (and attain the DTD) a 2 cm diameter (or larger) tumor. Achieving the DTD for a 2 cm or larger tumor was important because currently the maximum diameter tumor that can be treated via hyperthermia is approximately 2 cm (Erce and Parks, 2003 and Halac et al., 1983.

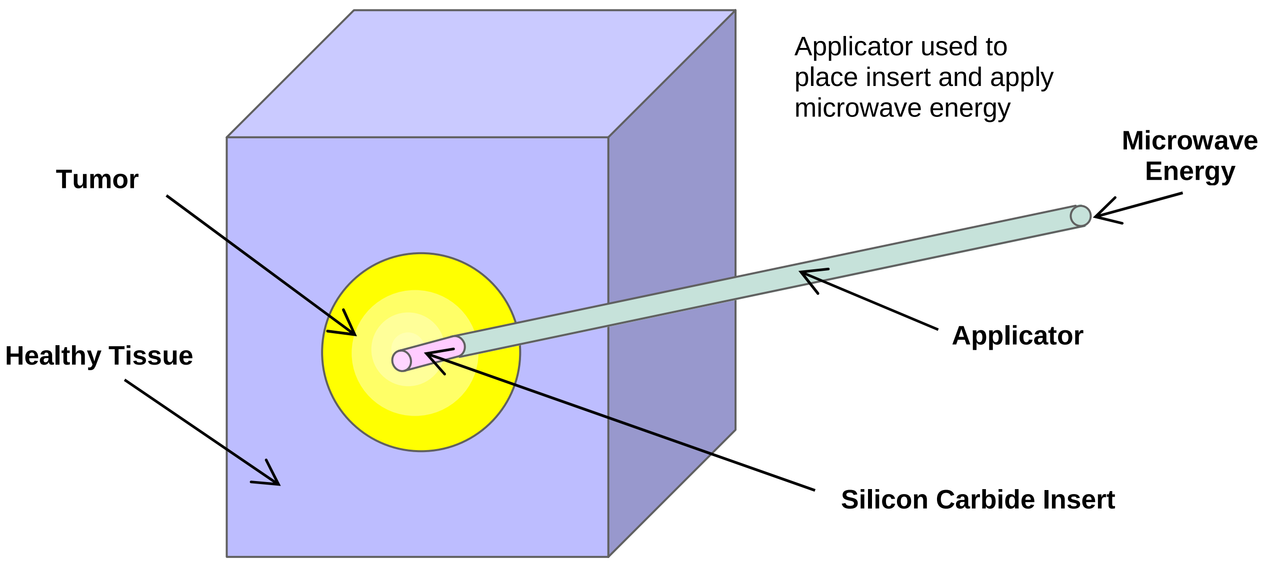


Figure 1.1. Schematic of the targeted microwave interstitial treatment.

In the remainder of this thesis I present the following: First, a background of prior research performed on various subject matters related to basic hyperthermia treatments, combination hyperthermia treatments, and computer modeling. After that, the development and verification of simplified thermal computer models of human tissue is described. Discussed next is the method of calculating the resulting thermal dose, the process of analyzing the results of the simulations of the thermal computer models.

Once these introductory topics have been considered, the results of the computer modeling (using the primary thermal model) are presented. First, the effects of varying the perfusion rates in the computer model are explained. Then, a comparison of the overall treatment times, where the optimal treatment time was chosen, is discussed. Presented next is the results of varying the heat input rate. Rates examined include a constant heat generation rate, a constant insert temperature, a pulsed heat generation rate, various ramp heat generation rates, as well as exponential decay heat generation rates.

At this point, the results of the computer modeling using the enhanced design models are presented and compared with the results from the primary thermal model (the single insert scenario). The enhanced design cases presented include the simulation results when using multiple (four) silicon carbide inserts as well as the results from the enhanced design case of a single silicon carbide insert with four conducting rods attached to the insert.

Next, the sensitivity of the thermal computer model to various parameters is discussed. This includes the model sensitivity to each individual parameter as well as the "worst case" results (where all parameters are varied at one time). Finally, the conclusions and recommendations of this work are presented.

Chapter 2

Literature Review

This chapter details some of the background of prior research that has been performed. First, the basic hyperthermia treatments and the various methods used to administer hyperthermia are examined. Next, the combinations of various different tumor treatments are discussed. Then, research involving the time-temperature relationship necessary for tissue necrosis is examined. Finally, the computer modeling of biological tissues, prospective hyperthermia treatments, and hyperthermia treatment planning is discussed.

2.1 Basic Hyperthermia Treatments

Hyperthermia has been described as an effective method to treat various types of malignant cells, both *in vitro* and *in vivo* (Kitamura et al., 1993 and Yanase et al., 1998). Traditional hyperthermia involves heating the tissue to at least 43°C for one hour, while high intensity thermal therapies involve higher temperature for shorter times. Traditional hyperthermia often involves two distinct phases. During the first phase (typically lasting 10 to 30 minutes), the blood flow to the area often doubles, with no significant cell destruction. However, during the second phase blood flow decreases, which is most likely due to localized microthrombosis in the hottest places in the tissue, and the amount of tissue necrosis increases significantly (Bolmsjo et al., 2000).

Reversible thermal effects have been shown to occur when tumors are briefly heated up to 44º C and then allowed to cool. However, in vivo studies have shown that when tissue is heated above 45º C irreversible tissue changes occur. Again, blood flow is affected when heating the tissue. The blood flow rate in hamsters was found to increase rapidly as the tissue temperature is raised from 32º C to 37º C, and then it was found to continue to increase at a slower rate as the tissue is heated to 44º C (Peller et al., 2003). Likewise, hemorrhagic coagulation necrosis was shown to occur when prostate tissue is heated above 45º C, and enhanced results were noted when the intraprostatic temperatures were raised above 50º C (Carter and Tubaro, 2000).

One of the problems with systemic hyperthermia is that areas of normal tissue are heated, as well as the desired tumor area. One approach to circumventing this problem is to cool the blood flow to the normal tissue. A study of this approach used “balanced heat transfer” involving systemic heat absorption and the dissipation rates (due to the extracorporeal blood cooling) (Oleson et al., 1984). The study involved comparing the results of a simplified model using five test dogs, with similar outcomes. These results indicated that systemic blood cooling could be used to limit systemic temperature rise thus allowing an increase in the intratumoral temperature.

Another approach is to use drugs to decrease the perfusion within the tumor. This has been shown to improve hyperthermia treatment efficacy. Various drugs have been investigated to reduce perfusion; however, these medications not only decreased the tissue perfusion in the tumor but in the normal tissue as well. New research has shown that an intravenous injection of the substance KB-R8498 causes a preferential reduction in the blood flow to the tumor. Using this preferential reduction could allow hyperthermia to be more effective (Shakil et al., 1999).

2.2 Methods of Applying Hyperthermia

There are several modalities that can be used to perform hyperthermia treatments (generally these treatments are invasive, but sometimes treatments can be performed nonivasively), with each method having advantages and limitations. Some of these modalities are noninvasive, such as high intensity focused ultrasound, and some are minimally invasive or invasive including microwave ablation, radiofrequency (RF) ablation, and laser ablation.

According to Ishii (1995) there are three crucial parameters in microwave hyperthermia. These parameters, applicable to both invasive and noninvasive treatments, are temperature, time, and focusing of heat. For these therapies, heat is produced by electromagnetic waves in the frequency range of 300 to 300,000 MHz while frequencies in the range of 300 kHz to 300 MHz are used to generate heat for radio frequency therapies (Lv et al., 2003 and Teague et al., 2003).

Benefits of microwave and radiofrequency treatments include the ability to apply the hyperthermia treatment directly to the tumor tissue through the invasive usage of probes (Tungjitkusolmun et al., 2002, Goldberg and Ahmeed, 2002, and Lencioni et al., 2000). In addition, these ablative therapies seem to have very effective results (Moroz et al., 2001, Yanase et al., 1998, and Kitamura et al., 1993). Furthermore, Hagness et al., (1998) showed there exists a high contrast in the dielectric properties between malignant tumors and healthy tissues. This contrast causes tumors to absorb more microwave energy than healthy tissue.

However, these treatment methods do have limitations. One of the significant limitations of these two modalities is the maximum tumor size which can be treated (Erce and Parks, 2003 and Lencioni et al., 2000). Generally, the current maximum tumor diameter which can be treated is approximately 2 cm (Erce and Parks, 2003 and Halac et al., 1983). Another limitation of both modalities includes the lack of accurate and ample methods of monitoring the treatments to ensure that the entire tumor is destroyed (Weidensteiner et al., 2003 and Hargreaves et al., 2000). Finally, when probes are used the tips often experience intense heating and focusing the energy in the proper location to ensure tumor destruction is very difficult (Callstrom et al., 2002 and Ahmed and Goldberg, 2002).

2.3 Combination Treatments

When used in combination with other therapies such as chemotherapy and radiation therapy, hyperthermia has been proven to have positive synergistic effects (e.g., in aiding the treatment of esophageal carcinoma, Kitamura et al., 2002, Sugimachi et al., 1992, Kitamura et al., 1995, and Sugimachi et al., 1992).

The effectiveness of combination hyperthermia treatments has also been shown in some clinical trials. A Phase III trial showed that when hyperthermia, monitored via invasive temperature probes, was added to radiation treatments for breast cancer recurrences there were significant improvements, including disease –free survival.

However, the depth of the tumor and whether the disease had become systemic also played significant roles. The response of tumors less than 2 cm deep was significantly better than the response of tumors greater than 2 cm deep. In addition, if the disease became systemic, the patients were less likely to have a favorable outcome (Sherar et al., 1997). For treating deeper tumors, radioactive microspheres have been successfully used apply *in situ* irradiation (Day, 1995)

A comparison study of treatments outcomes involving hyperthermia and irradiation, for two different rat yolk sac tumor cell lines was completed (Tamaki et al., 2002). This study looked at the results when the cell lines were treated solely by irradiation, solely by hyperthermia, and when they were treated with a combination therapy of both irradiation and hyperthermia. The results of this study show that when only using one method of treatment (either hyperthermia or irradiation), the results were mixed. One cell line had a better response for irradiation while the other had a better response to hyperthermia. However, both cell lines had significantly improved results with the combination therapy.

2.4 Time-Temperature Relationship for Thermal Therapies

A time-temperature relationship for tissue necrosis can be shown for a variety of different tissue and cell types, such as hamster kidney cells. This time-temperature relationship was determined to be that for each 1º C decrease in temperature, the time required to kill the cells increased by a factor of 1.8 (Borrelli et al., 1990). This relationship has been known for some time, and is often represented as a form of Arrhenius type relationship (Wright et al., 1998). For each degree increase in Celsius temperature, the time required to cause the same amount of cellular damage is reduced by half.

Monitoring temperatures during hyperthermia may be a way to improve hyperthermia treatments. However, manually monitoring temperatures is invasive, time consuming, and inefficient. Therefore, algorithms have been created (Engler et al., 1987) to be used as a method of automating temperature monitoring. This automation allows the obtaining of increased temperature measurements, greater efficiency, and greater versatility.

With the usage of hyperthermia in clinical settings, it is important to find a useful way to determine the relevant thermal dose received by the tissue. Therefore, the concept of equivalent or “degree-minutes” was created. This mathematical model is based on the thermal dose received after 1 hour at 43º C, which is sufficient to be lethal to tissue. When using adequately small time steps, the equivalent time, t_{43}, taken to reach a lethal thermal dose can be described by

$$t_{43} = \sum_{t=0}^{t=final} R^{(43-\bar{T})} \Delta t \tag{1}$$

where t is the current time, $\bar{T}$ is the average local temperature, and R is 0.5 above 43º C and 0.25 below 43º C (Sapareto and Dewey, 1984). Other researchers have used a similar Arrhenius-like relationship.

2.5 Computer Modeling

Proper understanding of and modeling of blood perfusion rates and their effects on heat transfer in perfused tissues is also imperative. Various thermal models, including the Pennes model, the Early models, the Chen and Holmes model, and the Weinbaum, Jiji, and Lemons model, for blood perfused tissues have been examined. The results of these examinations showed that the Pennes model, although not the most accurate, is the most practical model to use due to its simplicity and fast predictions of transient temperature profiles (Arkin et al., 1994). Furthermore, using inverse techniques to study the sensitivity of perfusion in hyperthermia indicated that when conduction is the dominating factor in hyperthermia, substantial errors in the perfusion rate produce only minor errors in the temperature distribution (Clegg et al., 1994).

A non-invasive study at Duke University Medical Center (Clegg et al, 1996) showed the importance of modeling prospective hyperthermia treatments (i.e., modeling the estimated power depositions). The modeling showed potential regions of high power deposition in the normal tissue. However, as this was detected by modeling before treatment began, adjustments were made to eliminate this potential problem.

Bolmsjo et al. (2000) compared the results of cell necrosis modeling with actual coagulated tissue volume observations (from invasive transurethral microwave thermotherapy treatments), finding results to be consistent. To develop the comparison, a digital model of the prostate was created. Then, as the treatment was administered, blood flow was measured. Using the measured blood flow and the known microwave power distribution, the temperature distribution was obtained and applied to a cell necrosis model to determine the necrosis volume. This volume was then compared with, and determined to be similar to, the actual volume of tissue necrosis seen in ultrasound.

Comparisons also have been made between clinical hyperthermia results and results of a radiofrequency hyperthermia treatment planning system (HyperPlan) which uses finite element and finite difference time domain numeric methods (Sreenivasa et al., 2003). Using HyperPlan, clinical multimodal microwave hyperthermia treatment plans can be created in about 1 to 2 days to be used on such tumors as cervical, prostate, and rectal carcinomas. Even with this treatment planning, there are areas of higher power deposition or hot spots. Nevertheless, the predicted temperature results using HyperPlan are relatively close to describing the clinical results (which were determined using invasive catheters). However, this system assumes that the antennas can all be steered in amplitude and phase exactly as they are theoretically intended to be. Nevertheless, computer modeling must have flexibility and be efficient as well as accurate for hyperthermia treatment planning (Indik et al., 1994).

2.6 Summary

Basic hyperthermia treatments and combination hyperthermia treatments have been successfully used to treat tumors. However, a lethal thermal dose must be achieved for a successful hyperthermia treatment, as described by the time-temperature relationship. Additionally, computer modeling has been used to determine the likely temperature distribution of a given treatment and to plan future hyperthermia treatments.

The purpose of this project was to consider the feasibility of a minimally invasive preferential hyperthermia microwave system (described in Section 3.1). Prior research combined computer modeling with temperature comparisons, however, this project combined computer modeling with thermal dose calculations (based on the time and temperature results of the modeling). The primary goals of this project included the following:

1. Determine if a single silicon carbide insert could cause an entire 2 cm tumor to receive the DTD;
2. Determine if enhanced design models (multiple inserts or modified single insert) could deliver enough energy to achieve the DTD for a 2 cm tumor;
3. Determine if enhanced design models could deliver enough energy for a larger tumor (4 cm) to attain the DTD.

Additional tasks required to achieve the key objectives included determining the optimal treatment time, ascertaining the best (with results closest to those of the constant insert temperature scenario) heat generation rate to input into the model, and determining the sensitivity of the thermal computer model to the various parameters of the model.

Chapter 3

Introduction and Methodology

3.1 Bioheat Model Development and Verification

The basic thermal model used in this work consisted of a single silicon carbide insert embedded in the tumor tissue surrounded by healthy tissue. For the healthy tissue, it was assumed that it was a deep tissue (such as the liver) having no major blood vessels flowing through the tissue (i.e., only perfusion flowing through it). The tumorous tissue was assumed to be spherical in shape, centered in the middle of the healthy tissue being modeled.

A simplified thermal computer model of the system, described above, was developed for use in this work. Heat transfer was assumed to follow the Pennes Bioheat Equation (Pennes, 1948),

$$\underset{(storage)}{\rho_t C_t \frac{\partial T}{\partial t}} = \underset{(conduction)}{k_c \nabla^2 T} - \underset{(perfusion)}{\rho_b C_b \omega (T - T_b)} + \underset{(deposition)}{Q(x, y, z, t)} \qquad (2)$$

where the properties ρ, C, and k are the density (kg/m^3), specific heat (J/kg/K), and thermal conductivity (W/m/K), respectively, and the subscripts b and t represent the blood and the tissue. The term ω represents the heat removal by blood called the coefficient of perfusion (ml/ml/s), T is the local temperature (K), and heat (W), is added to the system through Q(x,y,z,t). It was assumed that blood enters the tissue at the arterial temperature T_a, and the metabolic heating could be neglected. Since heat is deposited only in the insert, for the tissue and the tumor portions of the thermal model, Equation 2 is reduced to

$$\underset{(storage)}{\rho_t C_t \frac{\partial T}{\partial t}} = \underset{(conduction)}{k_c \nabla^2 T} - \underset{(perfusion)}{\rho_b C_b \omega (T - T_b)} \qquad (3)$$

Meanwhile, for the insert portion of the thermal model, Equation 2 becomes

$$\underset{(storage)}{\rho_t C_t \frac{\partial T}{\partial t}} = \underset{(conduction)}{k_c \nabla^2 T} + \underset{(deposition)}{Q(x, y, z, t)} \tag{4}$$

For the purpose of this modeling, the tissue, tumor, and insert were all assumed to have perfect contact at their interfaces.

In order to model this bioheat system, the computer software package ANSYS 7.0 was used to create a thermal model of a tissue tumor system. To ensure the accuracy of the thermal modeling of the ANSYS 7.0 program, 0.1 W of heat was applied to a 1 cm cube of tissue and the heat transfer computed using two different methods. The model result was found to be equivalent to that of the calculated solution to 4 significant figures. This verification was accomplished by examining the steady state temperature at the center of the 1 cm cube of tissue in the computer model and comparing it to the manually calculated temperature to ensure these temperatures matched (they were found to be the same to 4 significant figures).

The computer software package ANSYS 7.0 was used to create the thermal model geometries and components as well as to assign the parameter values to the components of the models. The various models that were created include the basic thermal model (with a 2 cm tumor and a single silicon carbide insert) and two different enhanced design models. The enhanced design models include models with four silicon carbide inserts (one model with a 2 cm tumor and another model with a 4 cm tumor) and a model with a single insert with four conducting rods attached to the insert (to enhance the distribution of energy to the tumor.

The parameter values used for these models are shown in Table 3.1 and the details of the model components and geometries are described in the rest of this section. These models were also given a constraint on the maximum temperature reached by any point in the system. The maximum temperature value chosen was 80 ºC and it ensured that neither the tissue in the system nor the blood in the system reach temperatures high enough to cause boiling or cavitation. This limit was comparable to the maximum temperature constraints described by Tungjitkusolmun (2002). In addition, for modeling, the heat (microwave energy) added to the system was assumed to be volumetric heating with all heat applied directly to the silicon carbide insert.

The primary thermal model was developed to represent a tissue system consisting of a 6 cm cube of tissue (each side 6 cm in length), having no major blood vessels flowing through the tissue, with a 2 cm diameter tumor in the center. The tumor was chosen to have a diameter of 2 cm because this represents the general size limitation currently experienced in hyperthermia treatments (Erce and Parks, 2003, Lencioni et al., 2000, and Halac et al., 1983). To this tissue system, a single silicon carbide insert was added to the center of the tumor. As a result of symmetry in the tissue system, the necessary thermal model analyzed was only one eighth of the tissue system, as shown in Figure 3.1.

Table 3.1. Parameter values used for thermal modeling

Input Parameters	Nominal Value
Tissue[1,2]	
Density (kg/m^3)	1000
Specific Heat (J/kg/K)	3500
Thermal Conductivity (W/m/K)	0.5
Perfusion Rate (ml/g/min)	2
Tumor [1,2,3]	
Density (kg/m^3)	1000
Specific Heat (J/kg/K)	3500
Thermal Conductivity (W/m/K)	0.55
Perfusion Rate (ml/g/min)	2
Silicon Carbide Insert[1]	
Density (kg/m^3)	3160
Specific Heat (J/kg/K)	675
Thermal Conductivity (W/m/K)	490
Conducting Rod[1,3]	
Density (kg/m^3)	21500
Specific Heat (J/kg/K)	132
Thermal Conductivity (W/m/K)	71

Sources:
1 Incropera,1996
2 Holmes, 1980
3 Tungjitkusolmun, 2002

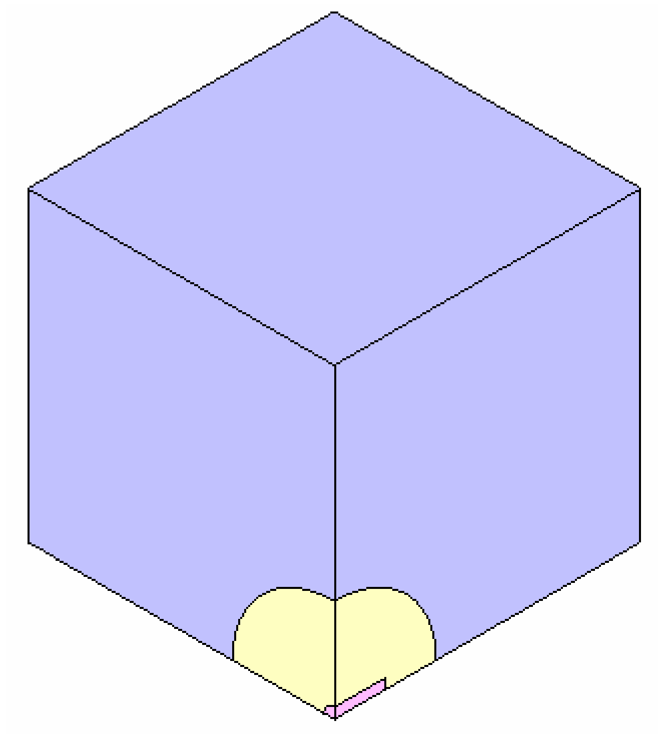


Figure 3.1. Model of the primary thermal model tissue system.

The inserts chosen, described below, were modeled after those made by the Material Science and Engineering (MSE) Department at Virginia Tech. The MSE department developed a system to position and apply energy to an insert, using a hypodermic needle, for preferential hyperthermia via microwave energy. The inserts were made of thin glass tubules filled with silicon carbide powder. Silicon carbide was chosen as the material for these inserts due to its excellent microwave energy absorption properties. For this feasibility study, the dielectric properties of the materials and the thin glass portion of the insert were neglected. Each thermal model consists of at least one cylindrical silicon carbide insert. These inserts have a length, L, of ten millimeters and a diameter, D, of two millimeters, as shown in Figure 3.2.

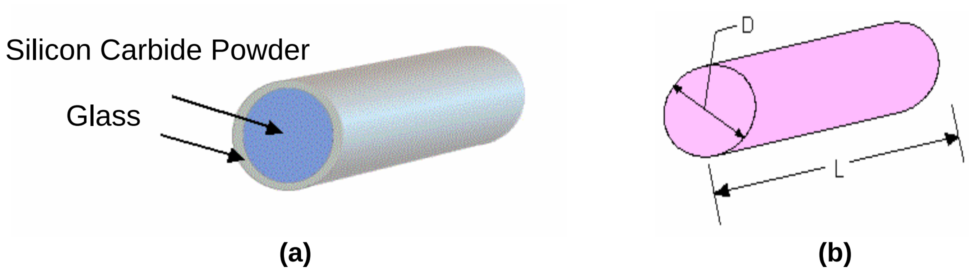
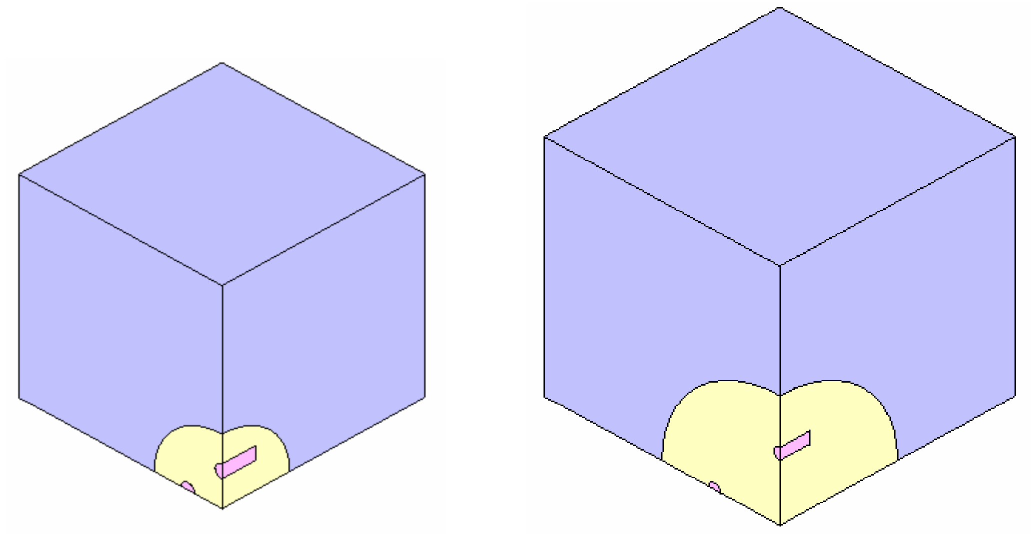


Figure 3.2. Fig. (a) silicon carbide insert; Fig. (b) model of the silicon carbide insert (neglecting glass coating).

The next thermal models created were made to simulate enhanced design cases of tissue systems being treated by using multiple silicon carbide inserts. For these models, four of the silicon carbide inserts were symmetrically placed in the tumor. Two different tissue systems were modeled in this manner. The first system modeled was the same size as the primary thermal model, with a 6 cm cube of tissue and a 2 cm diameter tumor. The second tissue system involved a larger cube of tissue (an 8 cm cube) with a larger tumor (4 cm in diameter). Again, as a result of symmetry in tissue systems, only one eighth of the tissue system was modeled. The resulting thermal models are shown in Figure 3.3.



(a) **(b)**

Figure 3.3. Model of the tissue systems used in the multiple insert thermal models with Fig. (a) the primary tissue system and Fig. (b) the larger 8 cm cube tissue system.

The final thermal model, another enhanced design case, was created to simulate a tissue system treated with a single silicon carbide insert with four conducting rods added to the insert (in an umbrella like arrangement) for additional heat transfer. These conducting rods were made of a medical grade stainless steel wire, 0.8 mm in diameter making an arc 18 mm in diameter. The parameters of the stainless steel were the same as those used by Tungjitkusolmun et al. (2002). The tissue system represented in this thermal model is an 8 cm cube of tissue with a 4 cm diameter tumor located in the center. Again, the symmetry of the tissue system was utilized. For this case, it was necessary to model one fourth of the tissue system, as shown in Figure 3.4.

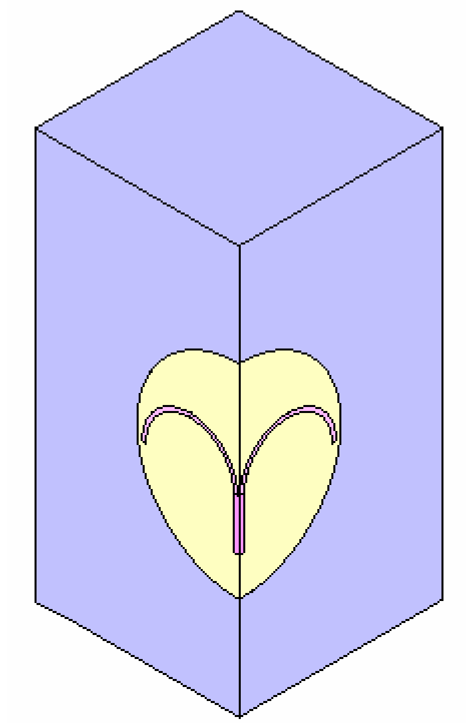


Figure 3.4. Model of the tissue system used in the conducting rods-insert thermal model

3.2 Thermal Dose Calculation

There exists a time-temperature relationship for cell death. The amount of energy needed for tissue necrosis is considered the required "thermal dose" for that tissue. In standard hyperthermia, the amount of energy required for tissue necrosis is equivalent to maintaining a temperature of 43º C for one hour. However, according to Borelli et al. (1990), for each increase in temperature by one degree C, the required amount of time necessary to cause tissue necrosis is almost cut in half.

The thermal dose time-temperature relationship, D(x,y), can be defined by the mathematical model presented by Sapareto and Dewey (1984),

$$D(x,y)=\int_0^{t_f} R^{T_r - T(x,y,t)}dt \qquad (5)$$

where R = $\begin{cases} .50, & T(x,y,t) \geq T_r; \\ .25, & T(x,y,t) < T_r \end{cases}$

and T_r is the reference temperature of 43º C. Next, the known relationship required for cell death (tissue maintained at 43º C for 1 hour) was applied to Equation 5 to determine the required thermal dose. This resulted in a thermal dose of 3600 s. This thermal dose was standardized by dividing by one hour (3600 s) to yield a unitless value of 1, which defines the threshold for cell death. All thermal doses reported in this work are based on this standardized thermal dose.

Several steps were required to determine the thermal dose at various locations for the thermal models. First, the ANSYS models were created (see Section 3.1); simulations (using finite element analysis) were then performed to determine the time-temperature distribution history due to the applied heat source. At this point, the computer software program "Thermal Dose Analyzer" (described below), was used to calculate the thermal dose from temperatures determined at each node in the finite element analysis.

Thermal Dose Analyzer was written using Visual Basic (code shown in the Appendix), to allow a user to input files containing the nodal (or local) temperatures for each time step. Then, the program analyzes the node temperatures at each time step and the time between the time steps. At this point, the thermal doses were calculated based on the present time step and previously calculated thermal dose using the equation

$$D(x,y)=\frac{\sum_{t=0}^{t=final} R^{T_r - T(x,y,t)}\Delta t}{3600} \qquad (6)$$

where R = $\begin{cases} .50, & T(x,y,t) \geq T_r; \\ .25, & T(x,y,t) < T_r \end{cases}$

These results were then entered into a database containing the node number, time step, current temperature, calculated thermal dose for the current time step, and the cumulative thermal dose (the sum of the thermal doses from all time steps up to and including the current step). This database was then used to correlate the node number with its cumulative thermal dose.

Once the thermal dose was calculated for each thermal model, the data for each node was plotted (cumulative thermal dose versus radial distance from the center of the tumor) to determine cumulative thermal dose as a function of the distance from the center of the tumor.

The absolute distance of each node from the center of the tumor was determined for each node number. This absolute distance was calculated using the Pythagorean Theorem. The calculation was performed for both the front plane and the side plane of each model, as shown in Figure 3.5. The "front plane" represents a slice of the model which crosses through the diameter of the insert; meanwhile, the "side plane" represents a slice of the model which runs along the length of the insert. This calculation method is used to display cumulative thermal dose in the remainder of this work (which will be referred to as thermal dose).

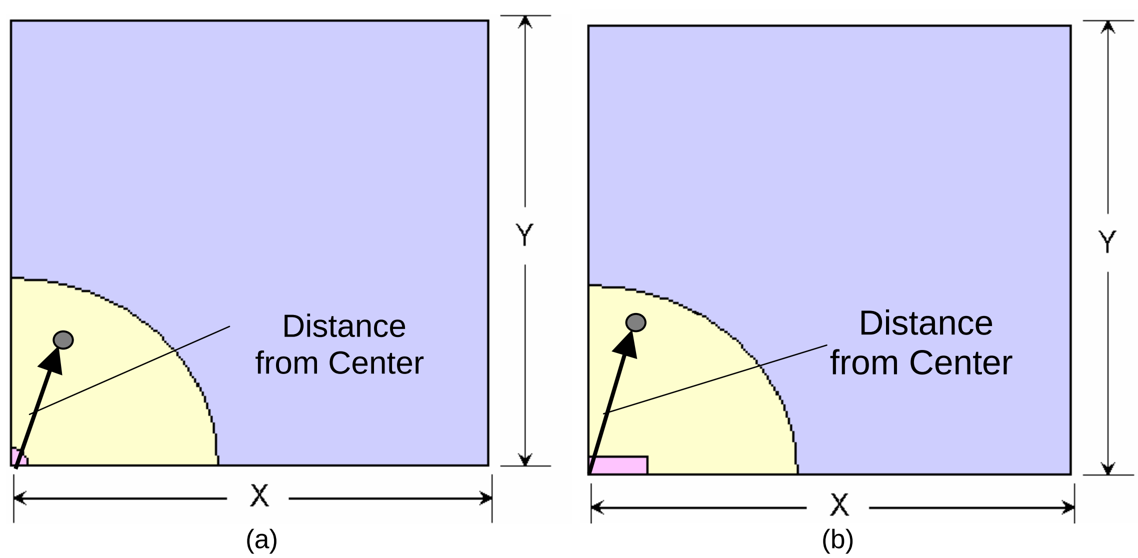


Figure 3.5. Graphical representation of the absolute distance from center for Fig. (a) the front plane and Fig. (b) the side plane.

Chapter 4

Results and Discussion

4.1 Comparison of Overall Treatment Times

A study was conducted to determine the minimum treatment time to achieve the maximum thermal dose under the constraint that the maximum temperature is limited to 80º C, which is similar to the constraint used by Tungjitkusolmun et al. (2002).

To compare the various treatment durations, a constant heat generation rate was applied to the silicon carbide insert for a set period of time (five, ten, or fifteen minutes). The rate of heat generation was determined in each case such that the maximum temperature limit of 80º C was not violated. Thus, as the treatment time increases, the heating rate decreases, however the total energy input increases as shown in Table 4.1. The cumulative thermal dose was calculated for each case (using the nodal temperatures) as described in Section 3.5. After each thermal simulation was performed, the thermal dose was calculated for the simulation. Figure 4.1 displays an example of the nodal temperatures for the 10 minute constant heat generation treatment, while Figure 4.2 shows the thermal dose as a function of the average radius from the insert for the three different treatment times.

Table 4.1. Relations between duration of treatment and amount of tissue achieving the desired thermal dose (DTD).

Duration of Treatment (min)	Energy Input Rate (W)	Total Energy Input (J)	Radial Distance Achieving DTD (cm)	Volume Achieving DTD (cm^3)
5	0.880	264	0.526	0.607
10	0.864	518.4	0.672	1.271
15	0.785	706.5	0.717	1.544

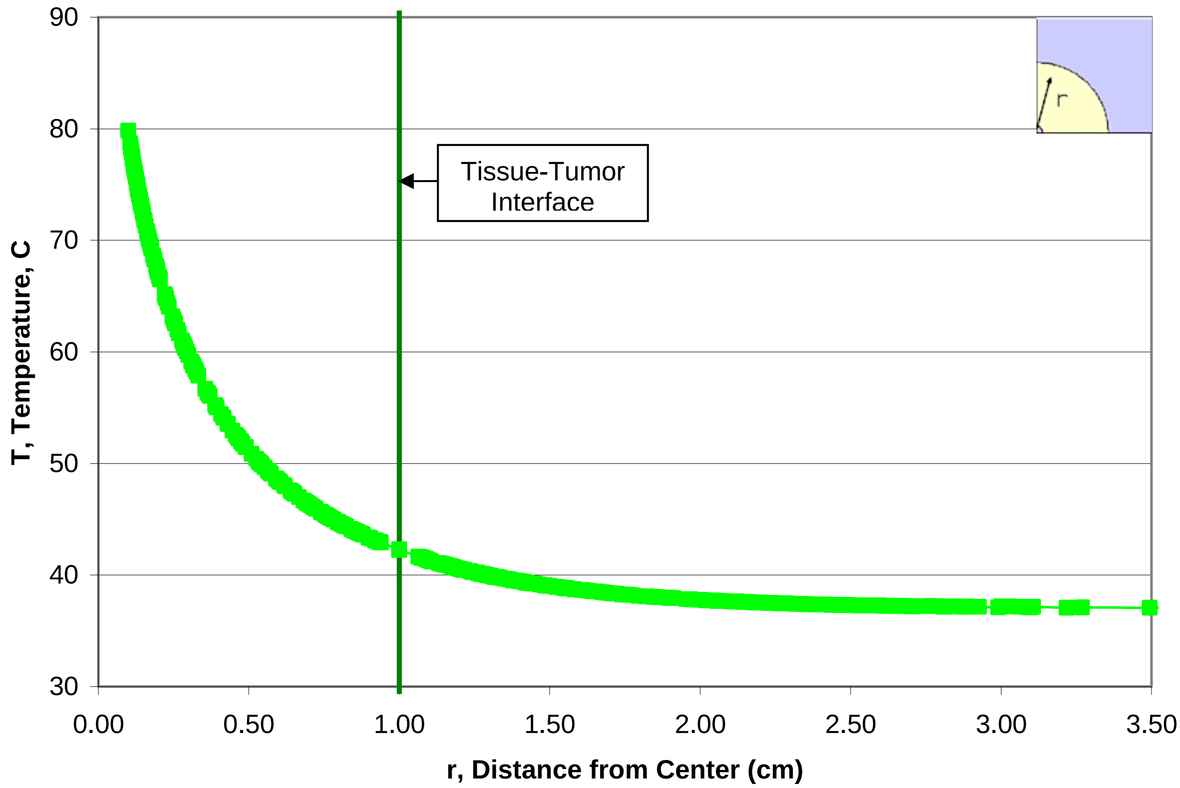
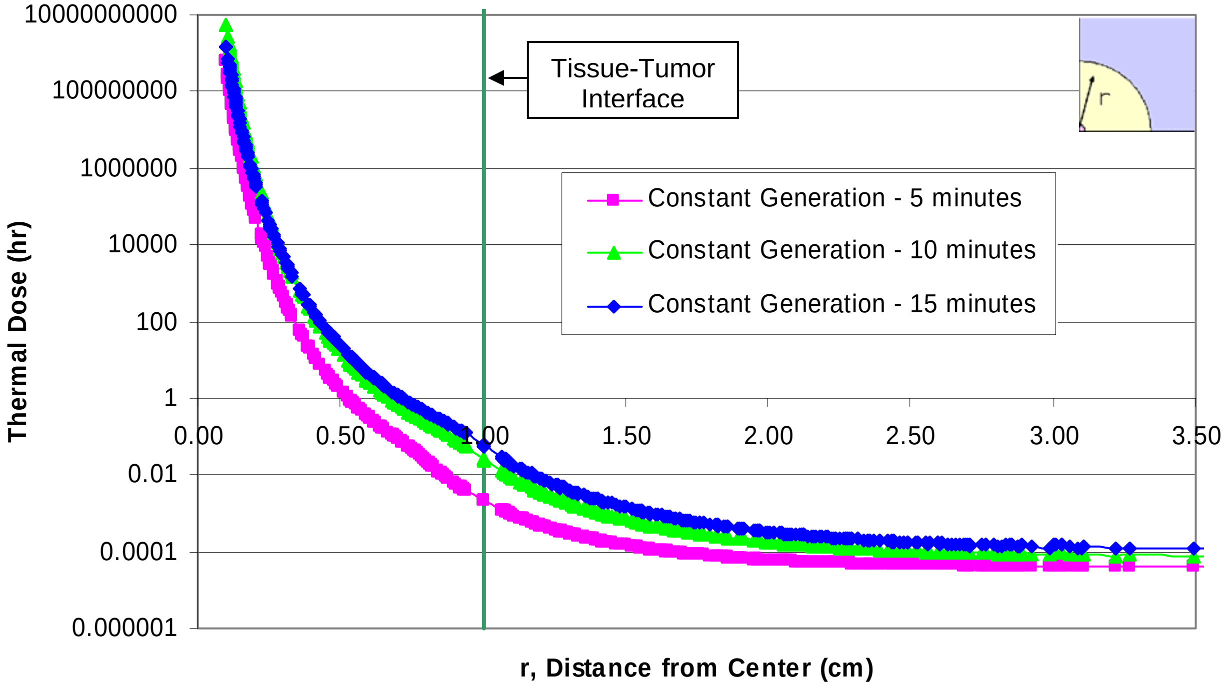
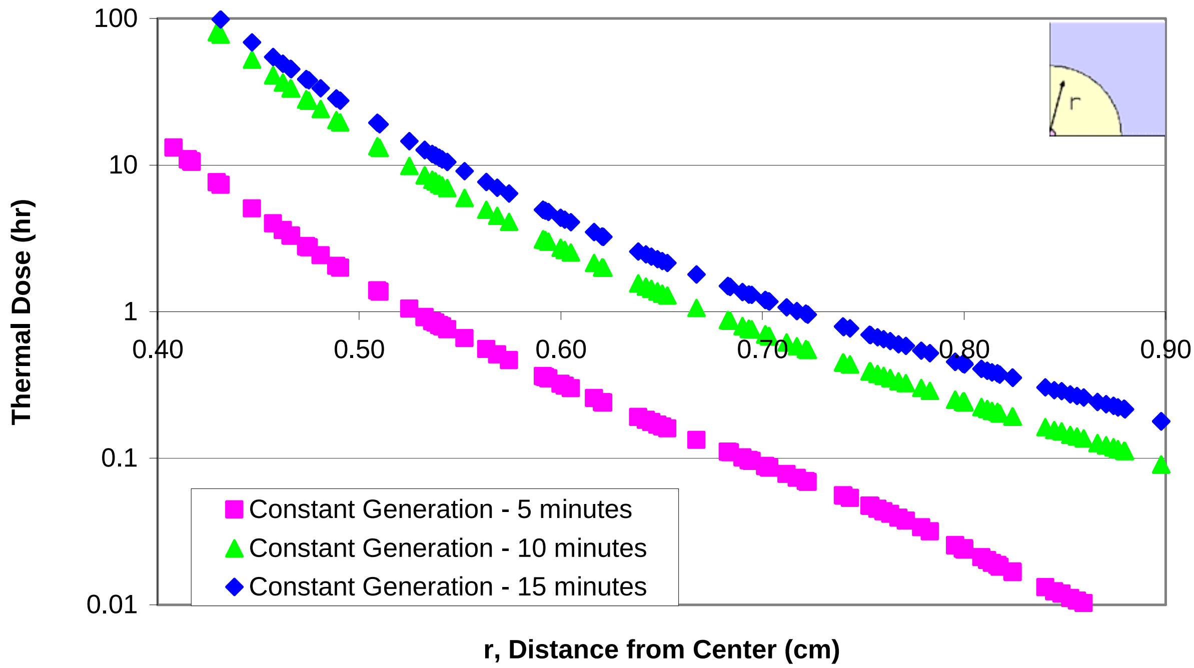


Figure 4.1. Example of the nodal temperatures for the 10 minute constant heat generation rate treatment



(a)



(b)

Figure 4.2. Thermal dose results for the time comparison simulations. Fig. (a) shows the thermal dose results of the entire front plane; Fig. (b) focuses on the location farthest from the center of the tumor where the desired thermal dose is estimated to occur (at a thermal dose of 1).

Figure 4.2 shows, as expected, that longer energy treatment times result in a greater volume of tissue receiving the desired thermal dose, DTD. Figure 4.3 shows the effects of increasing the treatment duration on the volume of tissue achieving the DTD. Examination of this figure also shows that the volume of tissue achieving the DTD does not increase linearly with time. Thus, after considering these results, it was determined that a ten minute treatment time was the most advantageous because it yielded the greatest volume of tissue attaining the DTD for a minimum treatment time. Therefore, for the simulations performed in the rest of this study, a 10 minute treatment duration was used.

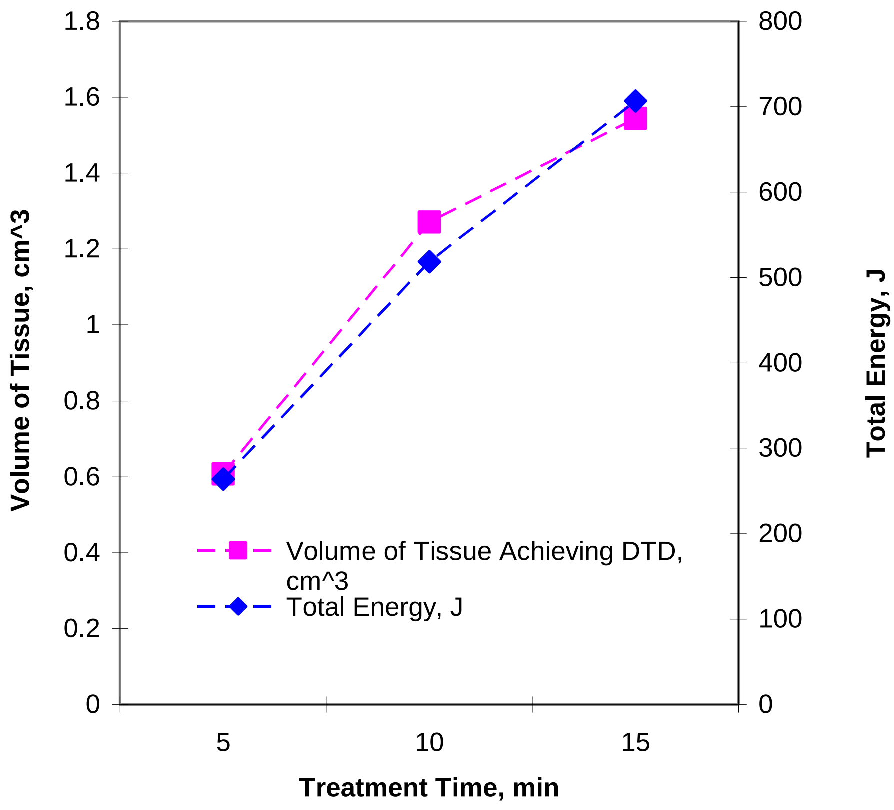


Figure 4.3. Comparison of treatment time and the resulting volume of tissue achieving the desired thermal dose (DTD).

4.2 Perfusion Comparison

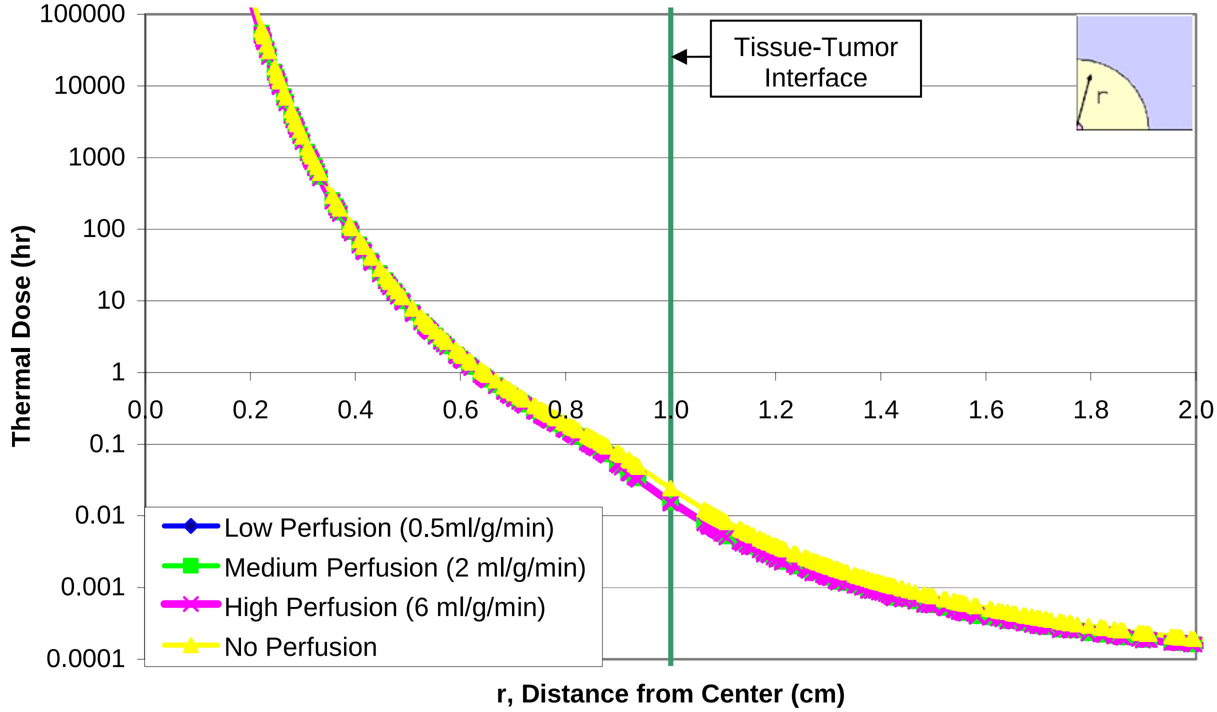
The effects of blood perfusion were determined using several different perfusion rates. This study was important for two reasons. First, tumor blood flow can vary greatly from tumor to tumor and is not completely understood. In addition, currently blood perfusion levels are estimated and exact values are not known. Therefore, a comparison of a range of values was important to understand the effects of variations in blood perfusion on the thermal dose.

To accomplish this study, all other properties and loads were maintained while the perfusion rate was varied for each thermal dose simulation. Various rates of perfusion (high, medium, low, and zero) were given to the tumor (Holmes and Chen, 1983), as shown in Table 4.2. The thermal dose for each perfusion rate was then calculated as described in Section 3.2.

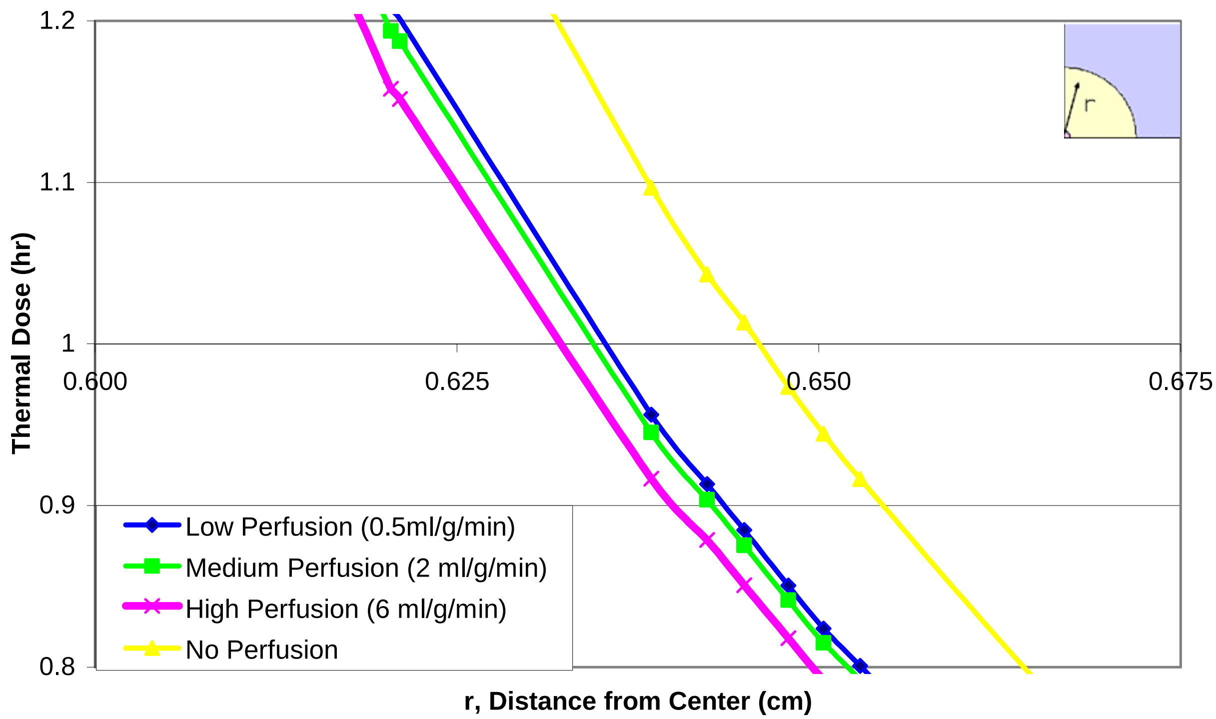
The results for the thermal dose are shown in Figure 4.4. Two important points are evident. First, the effect of perfusion magnitude is relatively small, as there is little difference between the low, medium, and high values. Secondly, the effect of the presence of perfusion is relatively small. Therefore, perfusion has a small effect on the calculation of thermal dose, as discussed further below.

Table 4.2. Perfusion rates used for perfusion comparison

Perfusion Rate	
Level	**Magnitude ml/g/min**
Zero	0
Low	0.5
Medium	2.0
High	6.0



(a)



(b)

Figure 4.4. Thermal dose results of perfusion study simulations. Fig. (a) shows the thermal dose results of the entire front plane; Fig. (b) focuses on the location farthest from the center of the tumor where the desired thermal dose (DTD) occurs (at a thermal dose of 1).

As Figure 4.4 shows, when there is no perfusion, the desired thermal dose (DTD) is achieved by all cells that are about 0.65 cm from the center of the tumor. Meanwhile, at the highest rate of perfusion, the DTD expected to occur for cells that are less than 0.63 cm away from the center of the tumor. The effects of perfusion on the volume of tissue achieving the DTD are summarized in Table 4.3.

As mentioned earlier, accounting for perfusion in the thermal model has some effect on the solution; however, the exact rate of perfusion is not as significant (i.e., ~ 5% of the affected volume as shown in Table 4.3). Therefore, for the simulations performed in the rest of this study, the medium rate of perfusion (2 ml/g/min) was used.

4.3 Effects of Heat Input Rate

The effects of the functional form of the heat rate applied to the silicon carbide insert were examined to determine the effects on the cumulative thermal dose. Both extreme cases of a constant heating rate and a constant temperature in the insert were examined along with other variable heating rates. These heating rates included pulse function generations, ramped heating generations (with both single and multiple slopes), and exponential decay heat generations as outlined in the following sections. These various heating scenarios were examined to determine the optimum heating protocol.

Table 4.3. Effects of perfusion on the volume of tissue achieving the required thermal dose

Perfusion Rate	Radial Distance (cm)	Volume (cm^3)	% of Tumor	% Volume Change From No Perfusion
Zero	0.65	1.13	27.0	0
Low	0.64	1.07	25.6	-4.9
Medium	0.63	1.07	25.5	-5.2
High	0.63	1.06	25.3	-6.3

4.3.1 Constant Generation Rate

To determine the maximum thermal dose possible with a constant heat generation rate, various thermal simulations were performed with different constant heat generation rates applied to a single silicon carbide insert in the primary thermal model (with a perfusion rate of 2 ml/g/min). For each simulation, the constant heat generation rate was applied for ten minutes.

Based on the results of Section 4.2, a constant heat generation rate of 0.86 W was used. At this point, the simulation was performed again, this time letting the system cool for ten minutes (until it the maximum temperature was less than 40º C) after applying the constant heat generation rate for ten minutes. After the thermal simulation was completed, the thermal dose was calculated for front and side planes, as described in Section 4.2. These results are shown in Figure 4.5.

Figure 4.5 shows that the maximum distance from the center that is expected to reach the desired thermal dose (DTD) is almost the same for the front and side planes. The radial distance from the center that achieves the DTD is 0.672 cm for the front plane and 0.676 cm for the side plane, a difference of less than 0.05 mm. Next, the estimated volume of tissue attaining the DTD was calculated. This volume was calculated using two different formulas: the spherical volume formula and the ellipsoid volume formula. The spherical volume formula indicated that 1.27 cm^3 of tissue reached the DTD while the ellipsoid volume formula indicated that 1.28 cm^3 of tissue reached the DTD. The difference in these two methods is less than one percent. Therefore, the rest of the primary thermal model simulations will only consider the spherical volume method (using the results from the front plane).

Although this model indicates that the tissue within a radial distance of over 0.67 cm from the center attains the DTD, this is not far enough for the entire tumor to achieve the DTD, for a 2 cm diameter tumor. Therefore, additional heat generation rates and patterns were examined.

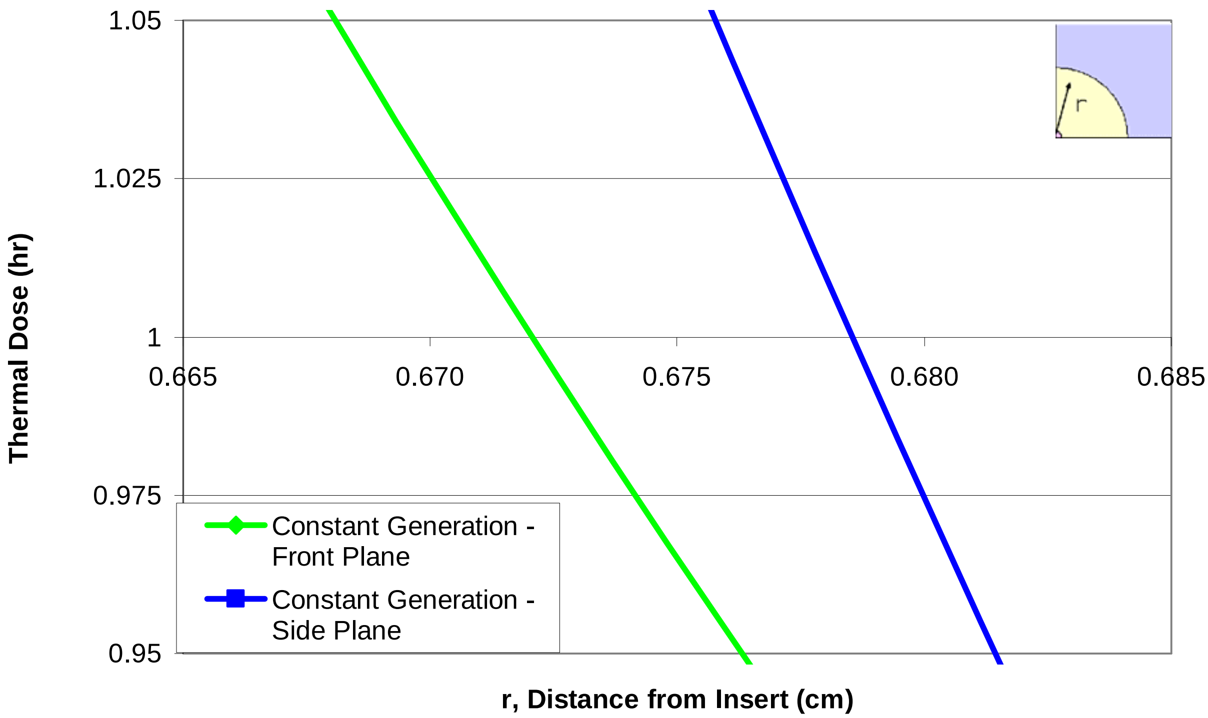


Figure 4.5. Front and side plane thermal dose results for the constant heat generation simulations focusing on the location farthest from the center of the tumor where the desired thermal dose (DTD) occurs (at a thermal dose of 1).

4.3.2 Constant Insert Temperature

Next, the case where the silicon carbide insert was held at a constant temperature of 80º C was examined. This thermal simulation represents the ideal case where the amount of energy applied to the insert constantly maintains the insert at the maximum temperature. Although maintaining a constant temperature of 80º C cannot be achieved practically, this case demonstrates the maximum attainable thermal dose for the primary thermal model with the current restraints of the system.

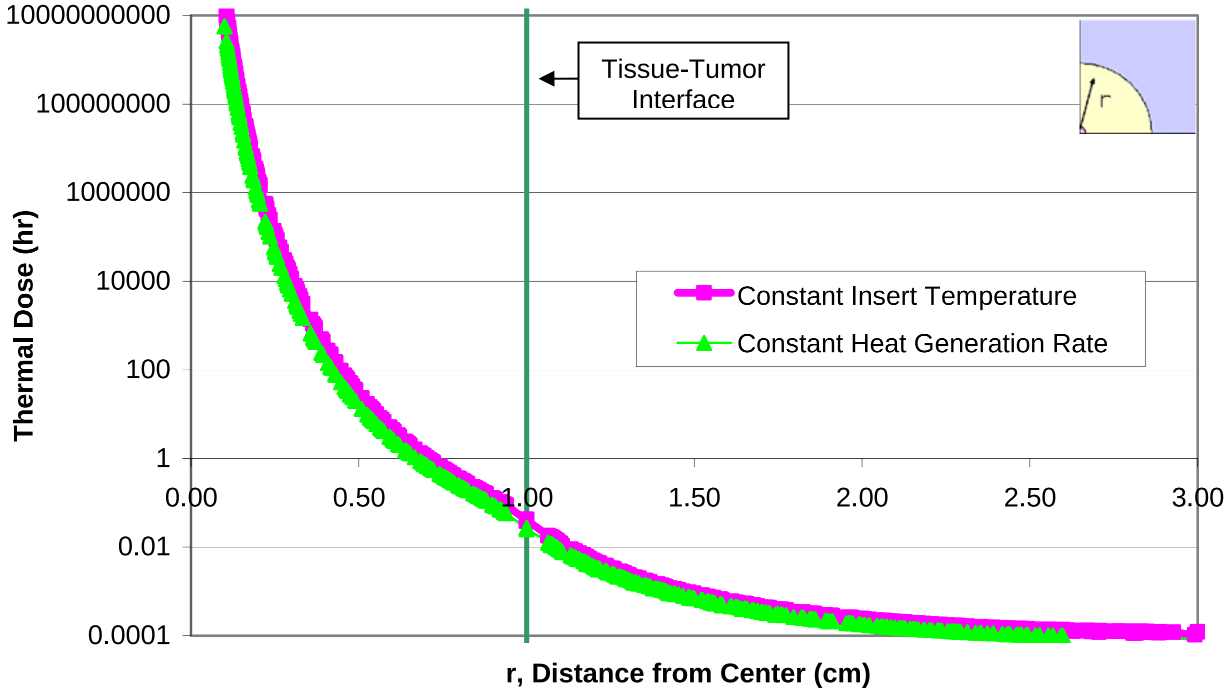
The constant temperature simulation was performed by maintaining the insert temperature at 80º C for ten minutes then allowing the system to cool another ten minutes (until the maximum temperature was less than 40º C). Once the constant temperature simulation was completed, the thermal dose results were evaluated and compared to the constant heat generation rate case. This comparison is shown in Figure 4.6. As expected (shown in the figure), the constant temperature simulation achieved the desired thermal dose (DTD) over a greater distance from the center than did the constant generation simulation.

In the constant temperature simulation, cells are expected to achieve the DTD up to about 0.70 cm from the center, as shown in Figure 4.6. This yields a volume of tumor attaining the DTD of approximately 1.46 cm^3. So, as expected, changing the heat input to the silicon carbide insert affects the cumulative thermal dose. Therefore, additional heat generation rates were examined to determine if they could improve upon the thermal dose achieved with a constant heat generation rate and approach the thermal dose with the insert set at a constant temperature of 80º C.

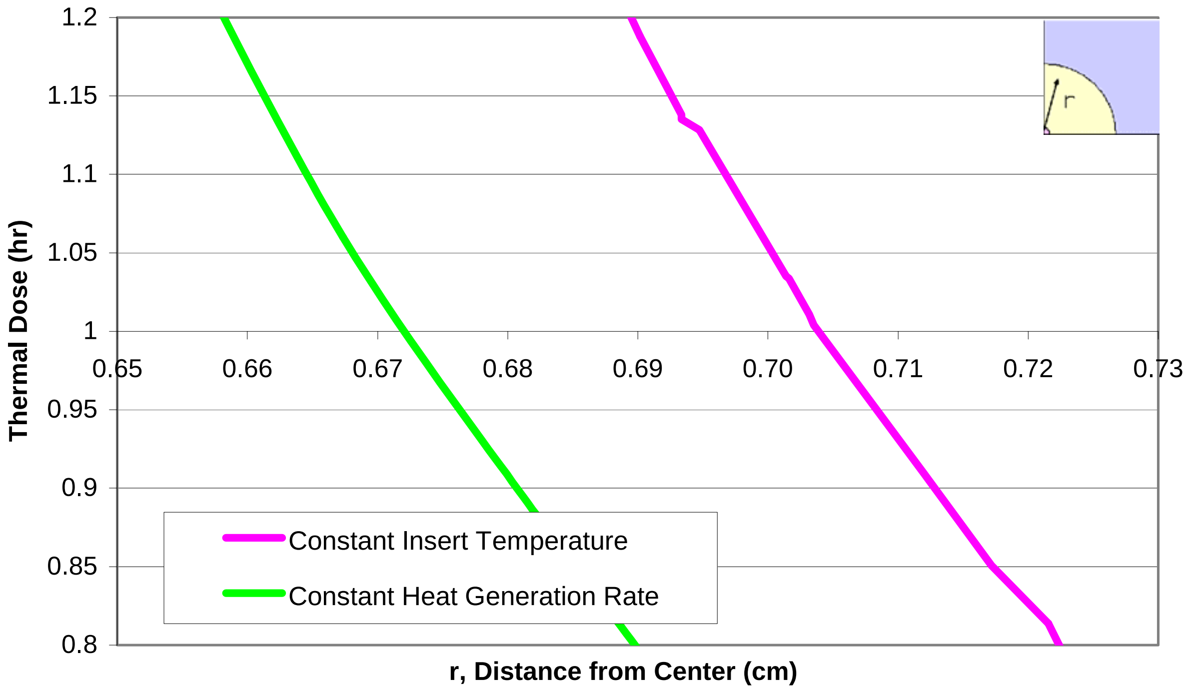
However, examination of the constant insert temperature thermal dose results reveals that even in this optimal case, where the insert is maintained at a constant temperature of 80º C, an entire 2 cm diameter tumor does not receive the DTD. Nevertheless, additional heat generation rates (including pulse function heat generation rates, ramp heat generation rates and exponential decay heat generation rates) were studied to determine an optimum form of heat generation (one that approaches the constant insert temperature results).

4.3.3 Pulse Function Generation Rate

The next form of heat generation applied to the silicon carbide insert was a pulse heat generation input. Many different pulses were evaluated to determine if they could be used to increase the cumulative thermal dose the primary thermal model experienced when undergoing a ten minute treatment. All of the pulse generation inputs had the same restraints on the simulation as the constant heat generation rate (the only change was the energy applied to the insert) including the maximum model temperature of 80º C.



(a)



(b)

Figure 4.6. Thermal dose results for the constant heat generation and constant insert temperature simulations. Fig. (a) shows the thermal dose results of the entire front and side planes; Fig. (b) focuses on the location farthest from the center of the tumor where the DTD occurs (at a thermal dose of 1).

The most promising pulse input is shown in Figure 4.7. This pulse input had 0.92 W applied to the insert for 28 seconds and then no energy (a cooling period) applied for two seconds, which was repeated during the entire 10 minute treatment time. The primary thermal model was run using this pulse heat generation rate with all other parameters the same as those defined for the constant heat generation simulation.

Once the pulse heat generation rate simulation was completed, the thermal dose results were evaluated and compared to the constant heat generation rate and the constant temperature cases. These comparisons are shown in Figure 4.8. As the figure shows, the cumulative thermal dose for pulsed heat generation input is almost as large as the cumulative thermal dose for the constant heat generation rate.

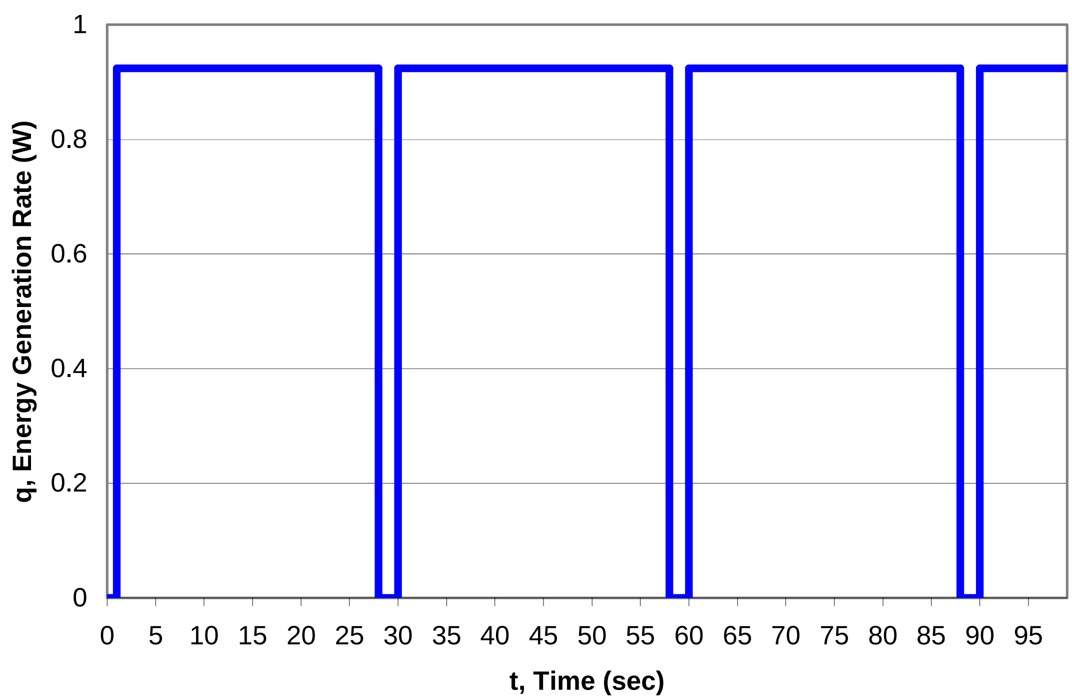
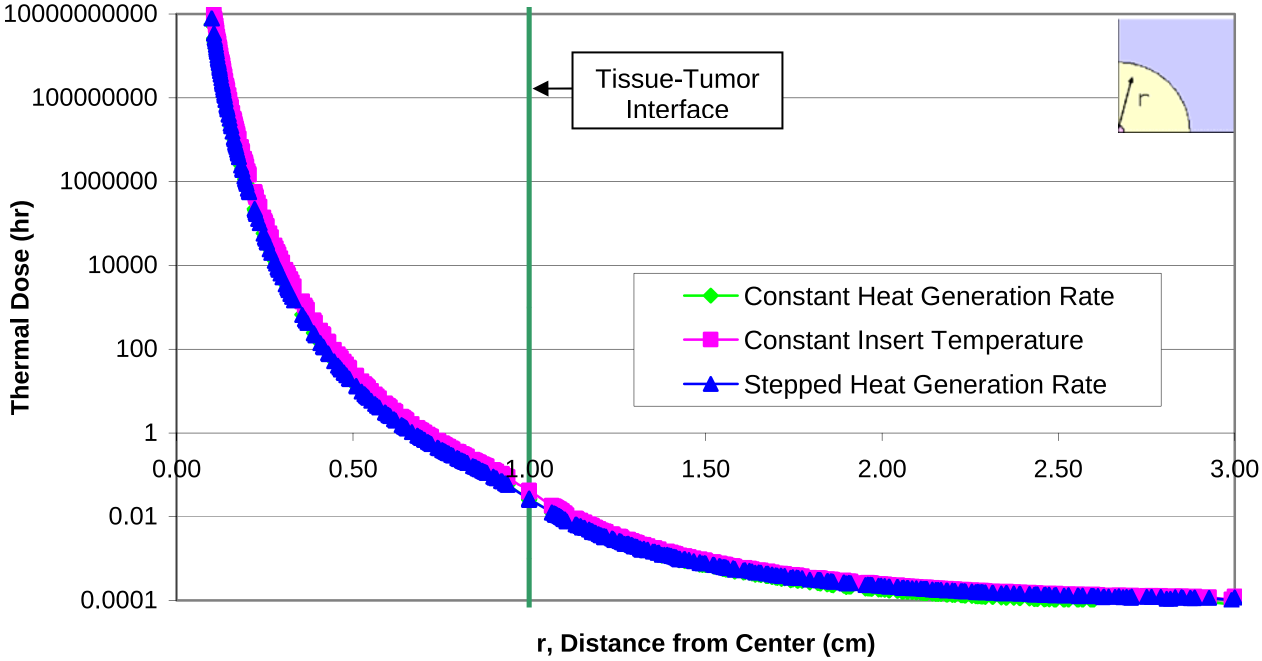
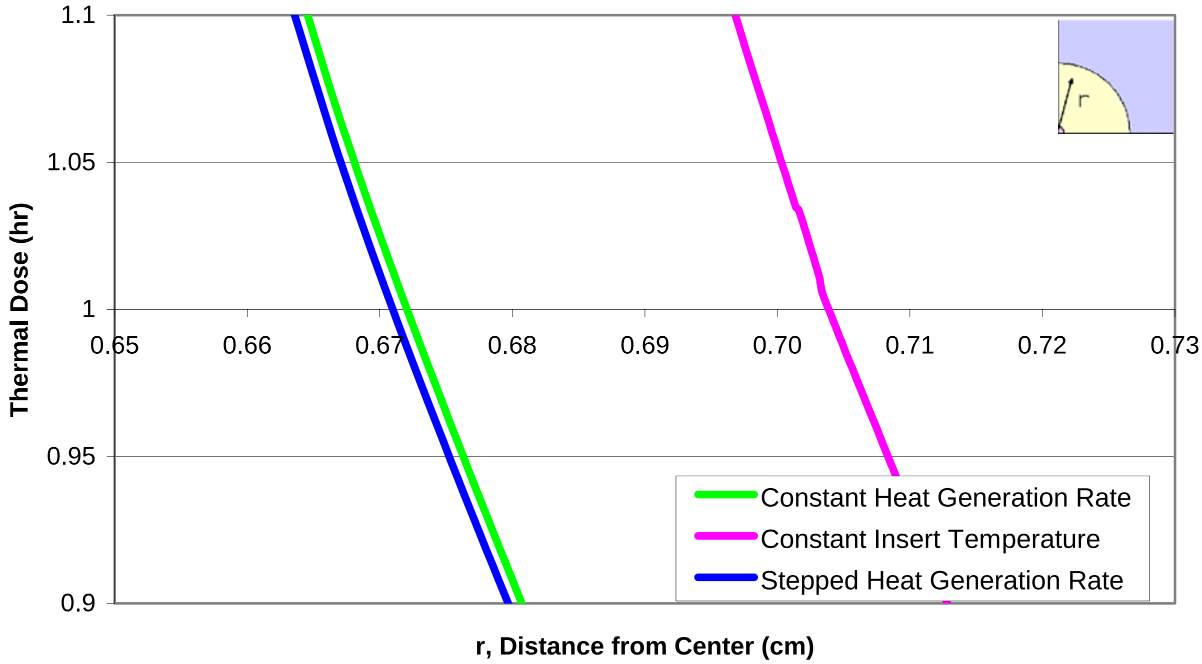


Figure 4.7. The pulse heat generation rate used for the primary thermal model pulse input simulation.



(a)



(b)

Figure 4.8. Comparison of the thermal dose results for the constant heat generation, pulse heat generation rate, and constant insert temperature simulations. Fig. (a) shows the thermal dose results of the entire front and side planes; Fig. (b) focuses on the location farthest from the center of the tumor where the DTD occurs (at a thermal dose of 1).

This was expected because considering the total energy applied to the model, the total amount of energy applied when using the pulse heat generation was almost identical to the total energy applied in the constant generation simulation. The resulting difference between the radial distances expected to achieve the DTD for the two cases is less than 0.45 percent.

Thus, the pulse heat generation rate is not better than the constant heat generation rate because no additional energy could be added to the simulation (due to the system constraint of a maximum temperature of 80º C) by using the pulse heat generation rate.

4.3.4 Ramped Generation Rate

The next heat generation rate forms investigated were ramped heat generation rate functions. These generation rates included single slope ramps and ramp generations with multiple slopes. As expected, the multiple slope ramp generations had better cumulative thermal dose results than the single slope ramp generations. In addition, these results led to the examination of exponential heat generation rates discussed later in this section.

Single Slope Inputs

As explained earlier, the single slope ramp heat generation rate was examined next. This heat generation form was chosen because it allows the tumor to experience a larger rate of energy input in the beginning and a decreasing amount throughout the rest of the simulation. The goal was to quickly heat the insert and maintain that high temperature without exceeding the maximum temperature limit of 80º C.

After examining several different single slope ramps, the most effective single slope ramp heat generation rate for the primary thermal simulation was determined. This single slope ramp started with an energy generation rate applied to the silicon carbide insert of 1.04 W and steadily decreased to 0.72 W over the ten minute treatment period, as shown in Figure 4.9. This heat generation rate was used to run the simulation along with all other parameters of the constant heat generation rate simulation. The resulting cumulative thermal dose was determined and is shown in Figure 4.10, where it is compared with the cumulative thermal doses of the constant heat generation rate and the constant insert temperature cases.

As expected, the single-slope ramp heat generation input produces a greater cumulative thermal dose than the constant heat generation but a smaller cumulative thermal dose than the constant insert temperature simulation. The single-slope ramp simulation did achieve the DTD slightly farther out than the constant generation simulation (about 0.05 mm). Thus, a 1.35 percent greater volume of tissue (1.29 cm^{3}) is expected to reach the DTD in the single-slope ramp generation case than in the constant heat generation rate case (1.27 cm^3).

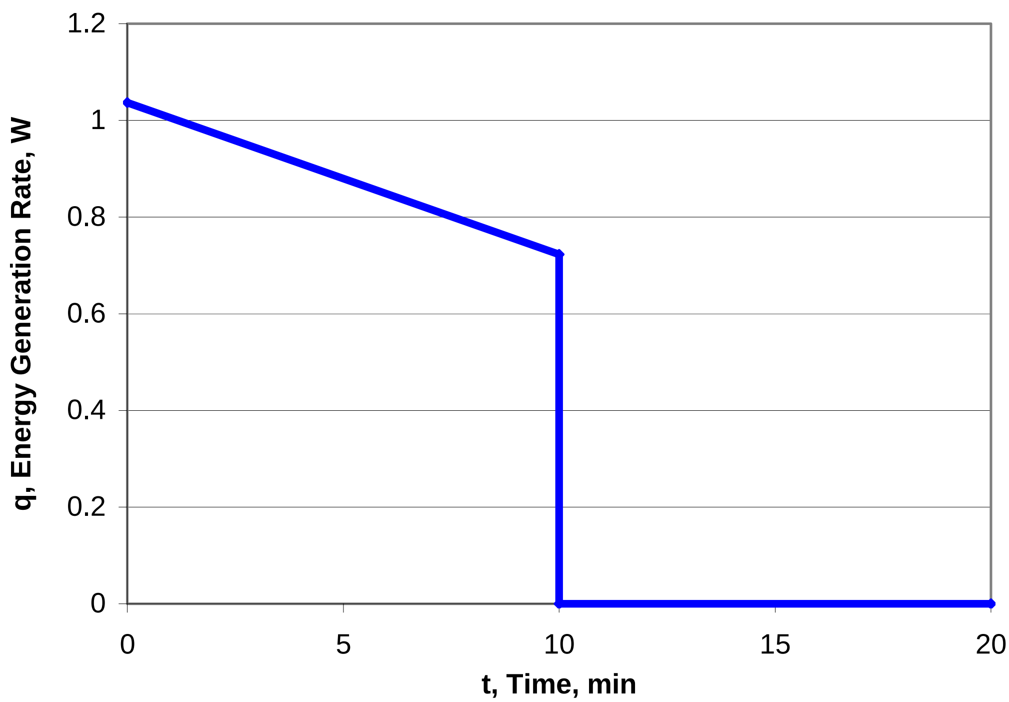
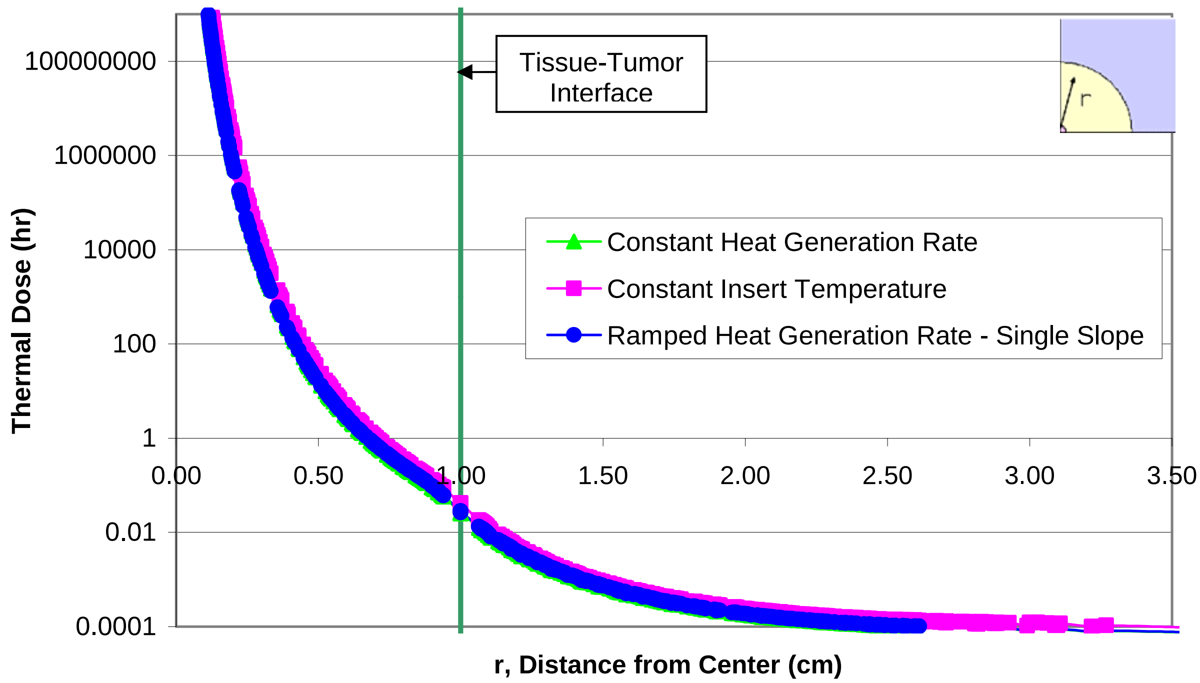
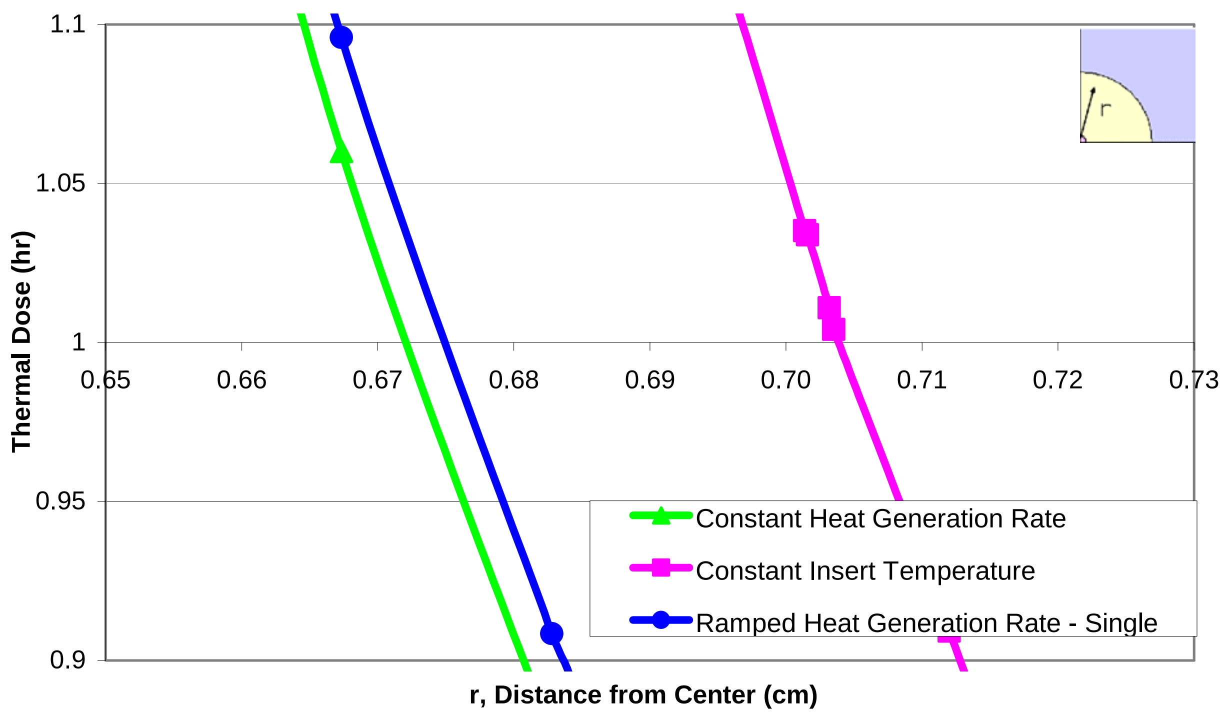


Figure 4.9. The single slope heat generation rate used for the primary thermal model single slope input simulation.



(a)



(b)

Figure 4.10. Comparison of the thermal dose results for the constant heat generation, ramped (single slope) generation rate, and constant insert temperature simulations. Fig. (a) shows the thermal dose results of the entire front and side planes; Fig. (b) focuses on the location farthest from the center of the tumor where the desired thermal dose (DTD) occurs (at a thermal dose of 1).

Thus, using a single-slope ramp heat generation rate allows for a slightly greater thermal dose to be delivered to the tumor while remaining within the system constraints. However, it was believed that more energy could be delivered to the system, and thereby a greater thermal dose, by applying a multi-sloped heat generation rate.

Multiple Slope Inputs

The multiple slope ramp heat generation rate allows the insert to obtain additional energy at the beginning of the simulation (when the need for a temperature increase – hence additional energy – is the greatest). Then, the amount of energy added decreases as the simulation continues. The best multiple-slope ramp heat generation rate, for the primary thermal simulation, was determined after examining the results of numerous different multi-slope ramp heat generation rates.

This multi-slope heat generation rate (used with all other parameters of the constant heat generation rate simulation) began with an initial energy generation rate applied to the silicon carbide insert of 1.07 W which was constantly decreased to an energy generation rate of 0.88 W over five minutes. Then, at five minutes, the slope of the energy generation was changed. This time, the energy generation began at 0.88 W – the ending energy generation rate of the first slope – and was constantly decreased to 0.86 W over the final five minute period. Then, the simulation was allowed to cool without adding any further energy (as with the constant heat generation rate simulation), as shown in Figure 4.11.

At this point, the resulting cumulative thermal dose was determined. Figure 4.12 shows the comparison of the multiple-slope ramp generation cumulative thermal dose with the cumulative thermal doses of the constant heat generation rate and the constant insert temperature cases.

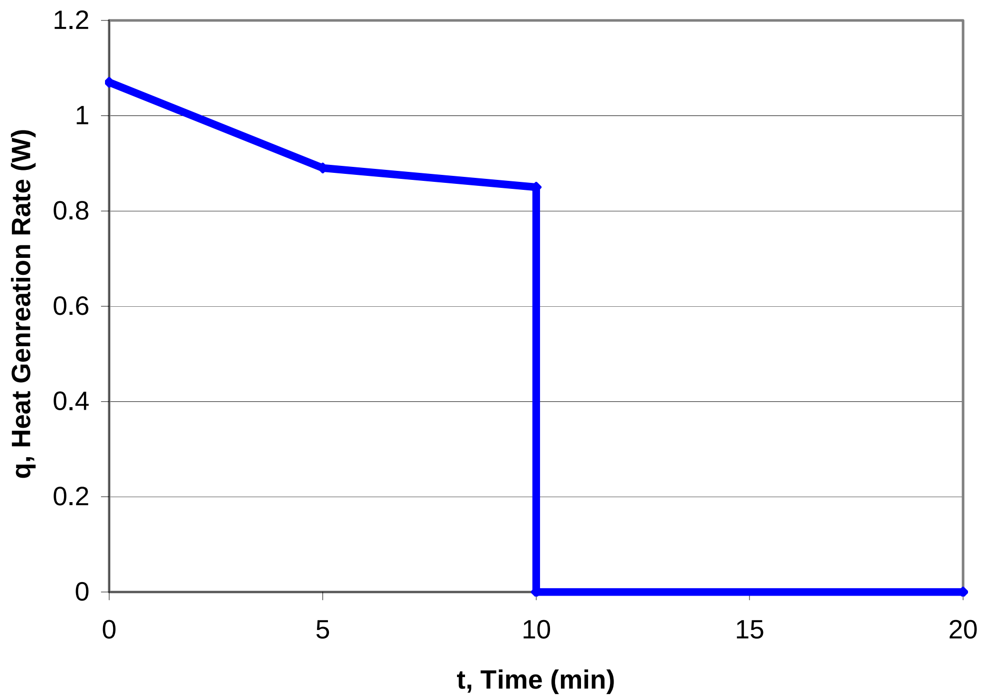


Figure 4.11. The multiple slope heat generation rate used for the primary thermal model multiple slope input simulation.

The figure shows, as expected, the multiple-slope ramp heat generation input produces a greater cumulative thermal dose than the constant heat generation but a smaller cumulative thermal dose than the constant insert temperature simulation. Closer examination of the simulation results reveals that the expected lethal cumulative thermal dose is achieved up to 0.69 cm from the center of the tumor for the multiple-slope ramp heat generation rate while the constant heat generation rate is only able to attain this cumulative desired thermal dose (DTD) up to 0.67 cm from the center.

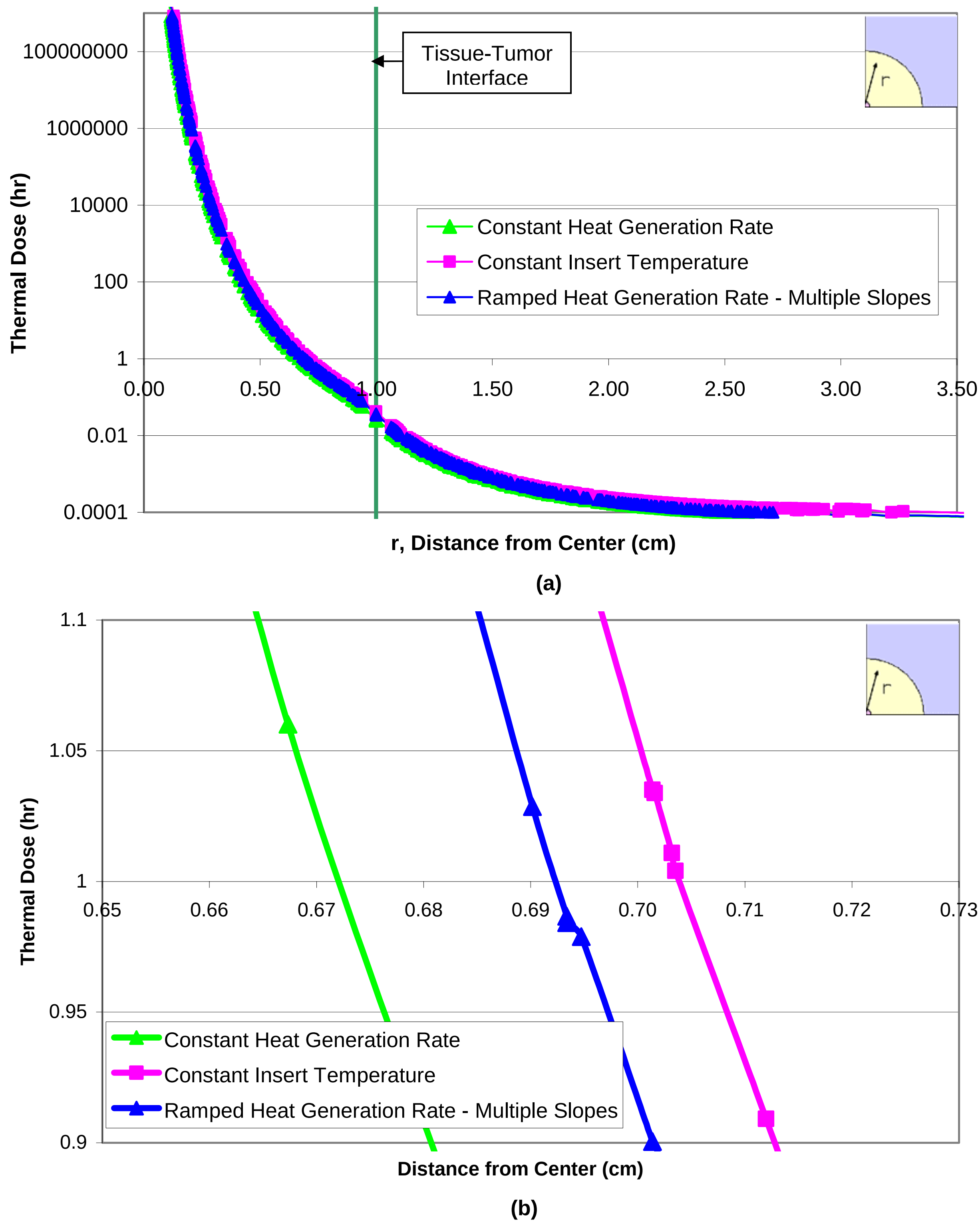


Figure 4.12. Comparison of the thermal dose results for the constant heat generation, ramped (multiple slope) generation rate, and constant insert temperature simulations. Fig. (a) shows the thermal dose results of the entire front and side planes; Fig. (b) focuses on the location farthest from the center of the tumor where the desired thermal dose occurs (at a thermal dose of 1).

The increase in the distance from the center where the cumulative thermal dose is achieved means that a greater volume of 1.39 cm^3, compared to 1.27 cm^3 in the constant heat generation rate case is. Thus, applying this multiple-slope ramp heat generation rate to the silicon carbide insert (instead of a constant heat generation rate) increases the volume of tissue that receives the DTD by 9.39 percent while remaining within the constraints of the system.

4.3.5 Exponential Decay Heat Generation Input

The exponential heat generation curve can almost be thought of as an infinite number of slopes for a ramp generation. As the number of slopes in the ramp heat generation rate increased so too did the cumulative thermal doses. The exponential heat generation rate allows for the maximum amount of energy (significantly more than in the constant heat generation rate case) to be added to the silicon carbide insert at the beginning of the simulation, to increase the temperature as close to 80º C as possible. Then, there is a rapid decrease in the amount of energy added which allows for the temperature to be maintained near 80º C without exceeding this limitation.

Many different exponential heat generation rates were examined to determine the optimum rate. The heat generation rate was determined by multiplying the value inserted into the ANSYS model (in W/m^3) by the volume of the silicon carbide insert. This heat generation rate, E (in watts), is described by

$$E = 0.8639 + 0.3927\, e^{-(t-1)/100} \tag{7}$$

where t is the current time. The first term of the heat generation rate is the minimum energy added to the simulation and was added at all heating times. Meanwhile, the second term of the equation represents the initial surge of energy and the decay of this energy. This equation was used to apply the exponential heat generation rate to the primary thermal model simulation and a graphical representation of Equation 7 is shown in Figure 4.13. As with the other simulations, energy was applied to the silicon carbide insert for ten minutes (at a rate described by Equation 7) with all other simulation parameters the same as with the constant heat generation simulation.

At this point, the resulting cumulative thermal dose was determined. Figure 4.14 shows the comparison of the exponential heat generation cumulative thermal dose with the cumulative thermal doses of the constant heat generation rate and the constant insert temperature cases.

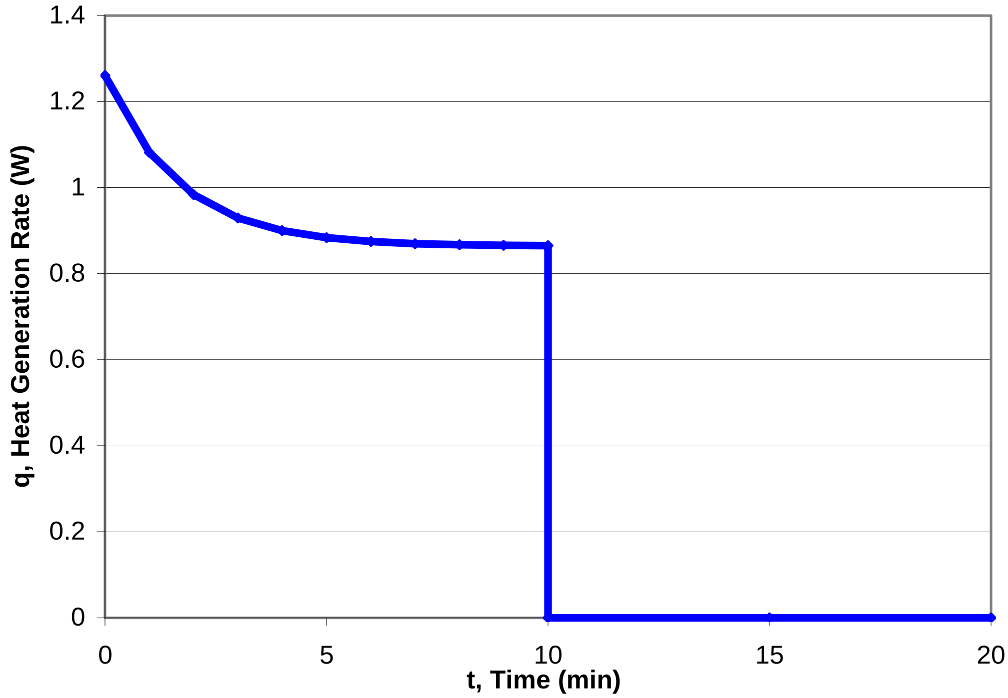


Figure 4.13. The exponential decay heat generation rate used for the primary thermal model exponential decay input simulation.

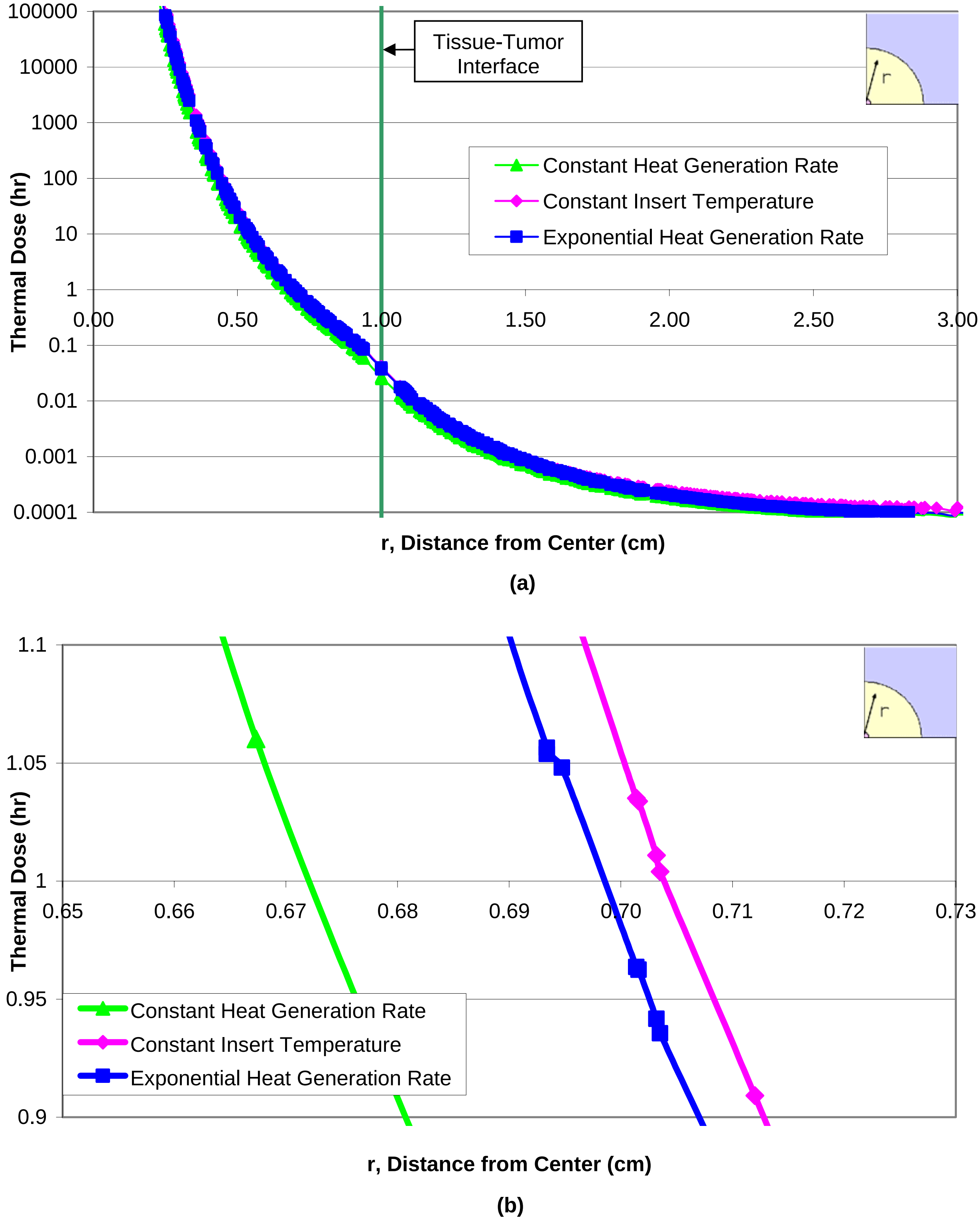


Figure 4.14. Comparison of the thermal dose results for the constant heat generation, exponential generation rate, and constant insert temperature simulations. Fig. (a) shows the thermal dose results of the entire front and side planes; Fig. (b) focuses on the location farthest from the center of the tumor where the desired thermal dose occurs (at a thermal dose of 1).

As expected, the exponential heat generation input produces a significantly greater cumulative thermal dose than the constant heat generation and a slightly smaller cumulative thermal dose than the constant insert temperature simulation. Closer examination of the cumulative thermal dose results indicates that when using an exponential heat generation rate, cells are expected to receive the desired thermal dose (DTD) at a radial distance of up to 0.70 cm from the center. This represents a slight increase (+ 0.03 cm) in the radial distance from the center where cells are expected to attain the DTD when compared with the constant heat generation rate.

This increase in the distance from the center where the DTD is received means that a greater volume of the tumor will attain the DTD. The volume expected to achieve the DTD in the exponential heat generation case is 1.43 cm^3 compared to 1.27 cm^3 in the constant heat generation case and 1.46 cm^3 in the constant insert temperature case. As a result, the volume of tissue achieving the DTD when using the exponential heat generation rate represents a 12.3 percent increase in volume when compared to the constant heat generation case and a decrease of only 2.31 percent when compared with the constant insert temperature case.

4.3.6 Summary of Primary Thermal Model Results

The results of the primary thermal model simulations are shown in Table 4.4. As the table shows, the best simulation is the constant insert temperature case. However, this is the theoretical best that can be achieved. The best that can be achieved in practice is the exponential heat generation simulation, which produces results closest to the constant insert simulation.

Table 4.4. Primary thermal model thermal dose results summary

Heat Generation Rate	Distance from Center achieving DTD (cm)	Volume of Tissue Achieving DTD (cm^3)	% Volume Change from Constant Heat Generation Case	% Volume Change From Ideal (Constant Insert Temperature) Case
Constant Heat Generation	0.67	1.27	---	- 14.95
Constant Insert	0.70	1.46	+ 14.95	---
Pulsed Heat Generation	0.67	1.27	- 0.45	- 15.40
Ramp Heat Generation				
Single Slope	0.67	1.29	+ 1.35	- 11.86
Mulitple Slope	0.69	1.39	+ 9.39	- 4.86
Exponential Heat	0.70	1.43	+ 12.30	- 2.31

As expected, even using the optimal heat generation rate there still was not enough energy applied to the insert to allow an entire two centimeter tumor to receive the DTD (can achieve the DTD in a tumor up to approximately 1.4 centimeters). Therefore, more than one insert will be needed to be able to destroy the tumor. As a result, an enhanced design system, with four silicon carbide inserts, was developed. In this system, the inserts are symmetrically placed around the center of the tumor. The details of this system and the simulations performed using a four silicon carbide insert system are discussed in the following section.

4.4 Enhanced Design Cases

Given that a single silicon carbide insert cannot deliver enough energy to the system to destroy an entire 2 cm tumor, as discussed in Section 4.3, it was determined that an enhanced design would be needed. Therefore, two different enhanced design models were created: a model with four silicon carbide inserts symmetrically placed about the center of the tumor and a model containing a single silicon carbide insert with four conducting steel rods used to distribute the energy throughout the tumor. The details of these enhanced design models were discussed in Section 3.1.

The simulations performed using these models had the same limitations as the primary thermal model did (same perfusion rate, tissue and tumor properties, as well as the same temperature restriction). The details of these simulations and their results are discussed in the following sections.

4.4.1 Multiple Inserts

When examining the enhanced design case of four silicon carbide inserts placed symmetrically around the tumor, it was determined that more than an entire 2 cm tumor could be destroyed. Therefore, similar simulations were performed, this time with a 4 cm tumor and the four inserts again placed symmetrically about the center of the tumor. The results of these simulations are shown and discussed below.

2 cm Tumor

Next, the enhanced design case of four symmetrically placed silicon carbide inserts in a 2 cm tumor was evaluated. These silicon carbide inserts were each symmetrically placed 0.5 cm away from the center of the tumor, received the same amount of energy, and was restricted to the same constraints as the primary thermal model (maintaining a maximum temperature less than 80º C with a constant perfusion rate of 2 g/ml/s).

Several different heat application rates were tested in this evaluation, including a constant heat generation rate of 0.58 W to each insert, for a total heat generation rate of 2.30 W. The constant insert temperature, showing the theoretical maximum energy applied, was maintained at 80º C. In addition, the exponential heat generation rate applied to each insert, E (in watts), is described by

$$E = 0.5498 + 0.7854\, e^{-(t-1)/90} \quad (8)$$

where t is the current time. Equation 8 follows the form of Equation 7, however, the exponent was changed slightly to achieve the best possible rate of decay without exceeding the maximum temperature limitation of 80º C. A pictorial representation of this heat generation rate is shown in Figure 4.15.

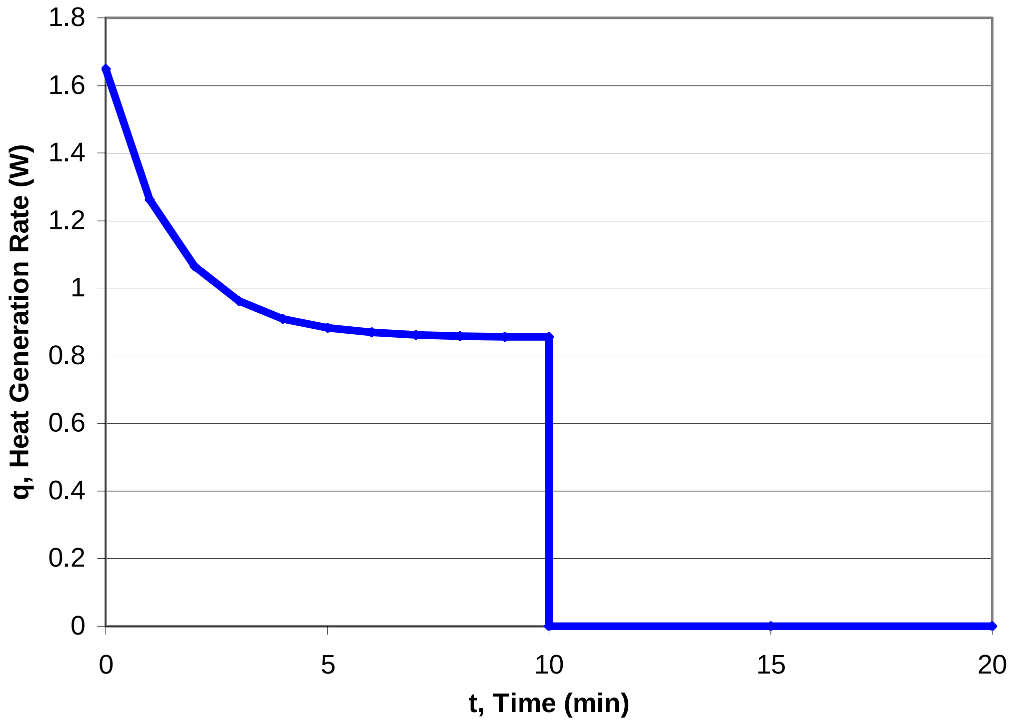


Figure 4.15. The exponential decay heat generation rate used for the 2 cm tumor multiple insert thermal model exponential decay input simulation.

Figure 4.16 shows the comparison of the cumulative thermal dose for the multiple insert constant heat generation rate, the exponential decay heat generation rate, constant insert temperature, with the cumulative thermal dose for the single insert constant heat generation rate. The figure shows (as expected) that the cumulative thermal dose increases with increased distance from the center until it peaks where the silicon carbide inserts are placed. However, with the multiple insert simulations, the data points do not follow a smooth curve (as they do in the primary thermal model). This is a result of plotting multiple points about the circumference for each radial distance and the placement of the inserts about the center of the tumor instead of in the center. Figure 4.17 presents a cross section of the tumor with 4 inserts. Examination of this figure shows how 2 points at equal distances from the center of the tumor are not at equal distances from the silicon carbide inserts. As a result, two points at the same distance from the center of the tumor receive dissimilar thermal doses.

The multiple silicon carbide insert simulation displays (as expected) the ability to achieve the desired thermal dose (DTD) at a greater distance from the center than the single silicon carbide insert case demonstrates. The volume of tissue attaining the DTD in each multiple insert simulation is discussed later; however, all cases using the four silicon carbide inserts demonstrate the ability to achieve the DTD for the entire 2 cm tumor.

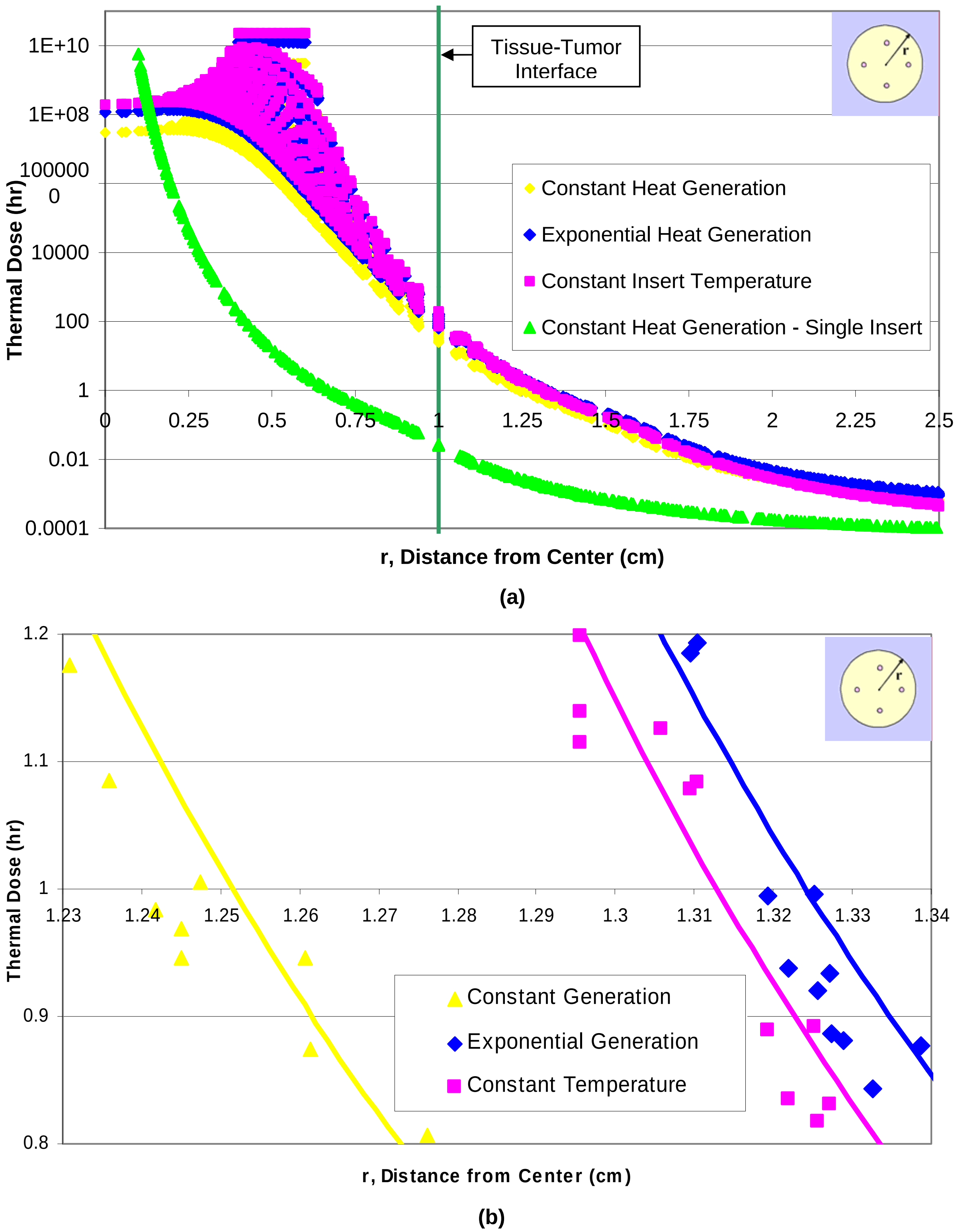


Figure 4.16. Comparison of the thermal dose results for the front plane for the simulations with four symmetrically placed inserts in a 2 cm tumor. Fig. (a) shows the thermal dose results of the entire front planes while Fig. (b) focuses on the location farthest from the center of the tumor where DTD occurs (at a thermal dose of 1) for the multiple insert simulation only.

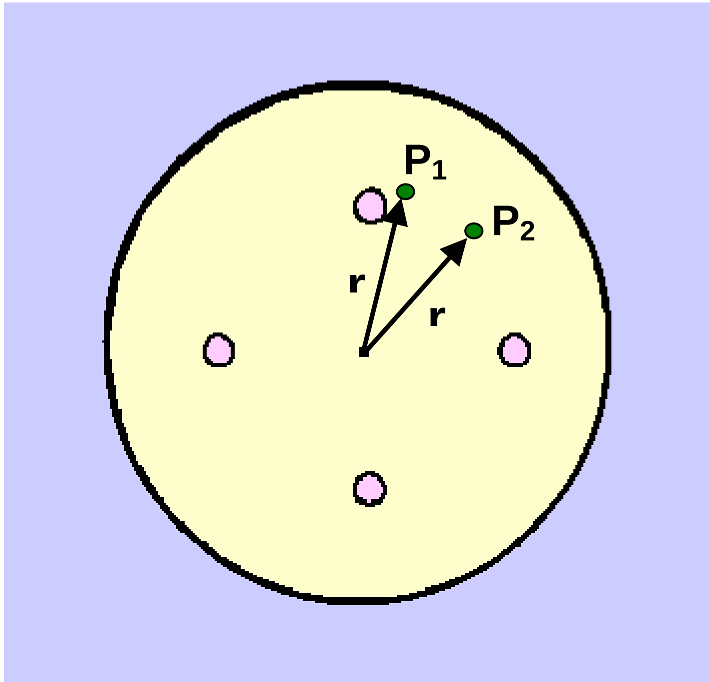


Figure 4.17. Pictorial representation of 2 points, P_1 and P_2, equal distance, r, from the center of the tumor but at different distances from the silicon carbide inserts.

An unexpected result was noticed when examining the multiple insert constant insert temperature simulation and the multiple insert exponential heat generation rate simulation. It was expected that the constant temperature simulation would have a cumulative thermal dose greater (at all points) than that of the exponential heat generation rate simulation. However, as the cumulative thermal dose approaches two and a half, the exponential heat generation rate simulation achieves the same thermal dose as the constant insert temperature simulation and then surpasses it. Although unexpected, this trend can be explained and understood. As the constant temperature was the ideal case, at the end of the period of heat application (in the simulation) the temperature of the insert was returned to body temperature so that no additional heat was added to the simulation. Meanwhile, for the exponential heat generation case, at the end of the period of heat application (in the simulation) no additional heat was applied to the insert, but the energy currently in the insert was allowed to dissipate to the tumor tissue, thus providing additional heating.

Next, the side plane cumulative thermal doses of the multiple insert simulations were examined. Figure 4.18 shows these comparisons. In addition, the volume of tissue receiving the DTD was also considered.

As expected, for the front and side planes, the multiple insert simulations produce significantly greater cumulative thermal doses than the single insert simulation. As a result, the maximum distance from the center where the DTD is received is greater for the multiple insert simulations. In addition, there is very little difference in the maximum distance from the center where the DTD is received when comparing the front and side planes.

Next, the volume of tissue attaining the DTD for each simulation was examined. The volume was calculated using two different calculations: a spherical calculation (using the conservative maximum distance from center where the DTD was achieved found on the front plane), and an ellipsoid volume calculation using the maximum distance from the center where the DTD was achieved found on both the front and side planes. As expected, there is very little difference (less than one percent) between the two different volume calculations. These results are summarized in Table 4.5.

In all of the multiple insert simulations the entire 2 cm tumor (a volume of 4.19 cm^3) received the DTD. In fact, for the exponential heat generation and the constant insert temperature simulations more than twice the volume of tissue in a 2 cm tumor achieved the DTD. Therefore, a 4 cm tumor was examined to determine if four silicon carbide inserts could cause an entire 4 cm tumor to attain the DTD.

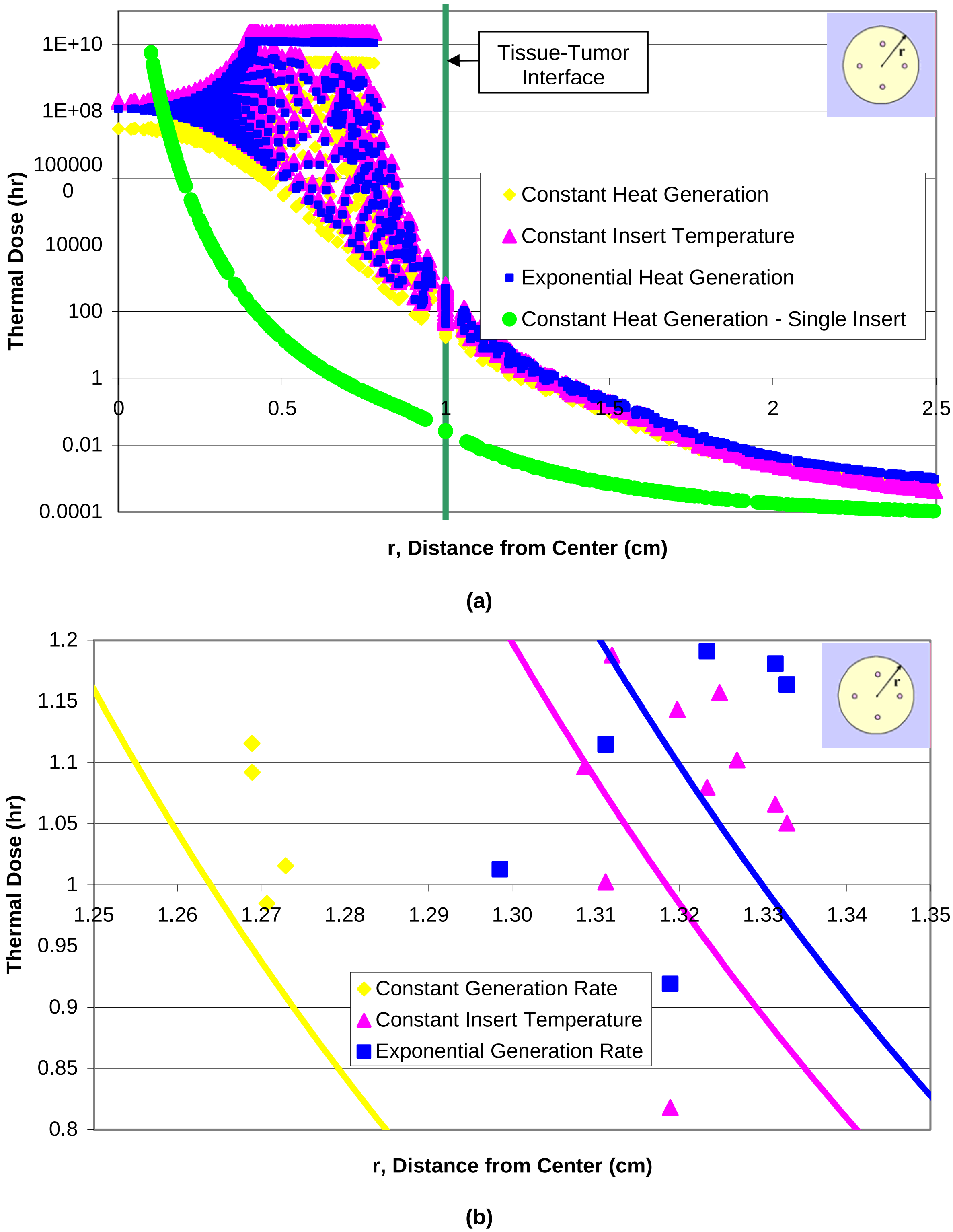


Figure 4.18. Comparison of the thermal dose results for the side plane for the simulations with four symmetrically placed inserts in a two centimeter tumor. Fig. (a) shows the thermal dose results of the entire side planes while Fig. (b) focuses on the location farthest from the center of the tumor where the DTD occurs (at a thermal dose of 1) for the multiple insert simulation only.

Table 4.5. Maximum distance from center and volume of tissue achieving the desired thermal dose (DTD)

Number of Inserts	Heat Generation	Maximum Distance From Center Reaching DTD (cm)		Volume of Tissue Reaching DTD (cm^3)	% Volume Change from Single Insert Constant Heat Generation Case
		Front Plane	Side Plane	Spherical Calculation	
Single Insert	Constant Heat Generation	0.67	0.68	1.27	---
Multiple Inserts	Constant Heat Generation	1.25	1.26	8.22	+ 547
	Exponential Heat Generation	1.32	1.33	9.74	+ 667
	Constant Insert Temperature	1.31	1.32	9.48	+ 646

4 cm Tumor

In the 4 cm simulations, the silicon carbide inserts were each symmetrically placed 1.0 cm away from the center of the tumor. As with the 2 cm tumor scenario, each insert received the same amount of energy and the system was maintained with the same constraints as all other simulations.

Again, various heat application rates were studied. These rates included a constant insert temperature where, again, all of the silicon carbide inserts were maintained at 80º C for the duration of the heating period. A constant heat generation rate of 0.770 W to each insert, which resulted in a total heat generation rate of 3.089 W for the entire model was also examined. In addition, an exponential heat generation rate was studied. This rate, was developed in a manner similar to the constant heat generation exponential decay equation and can be described by the equation

$$E = 0.5655 + 0.7697\ e^{-(t-1)/90} \qquad (9)$$

where t is the time (s). A graphical representation of Equation 9 is shown in Figure 4.19.

Next, the cumulative thermal dose was determined for each simulation. These thermal dose results are shown in Figure 4.20. Also shown in this figure, are the cumulative thermal dose results for the single insert simulation with a constant heat generation rate. As expected, the figure shows that the cumulative thermal dose increases with the increase in the distance from the center until it peaks where the silicon carbide inserts are placed.

As expected, when the four silicon carbide inserts are spaced farther out, a larger volume of tissue reaches the desired thermal dose. The trend lines in Figure 4.20 show the expected distance from center that reaches the DTD. Again, the constant insert temperature simulation had the greatest volume of tissue reaching the DTD, 22.3 cm^3, followed closely by the exponential heat generation simulation with 21.4 cm^3. The constant heat generation simulation had the smallest volume of tissue reaching the DTD, 19.67 cm^3, but still had considerably more tissue reaching the DTD than the single insert constant heat generation rate simulation. These results are summarized in Table 4.6.

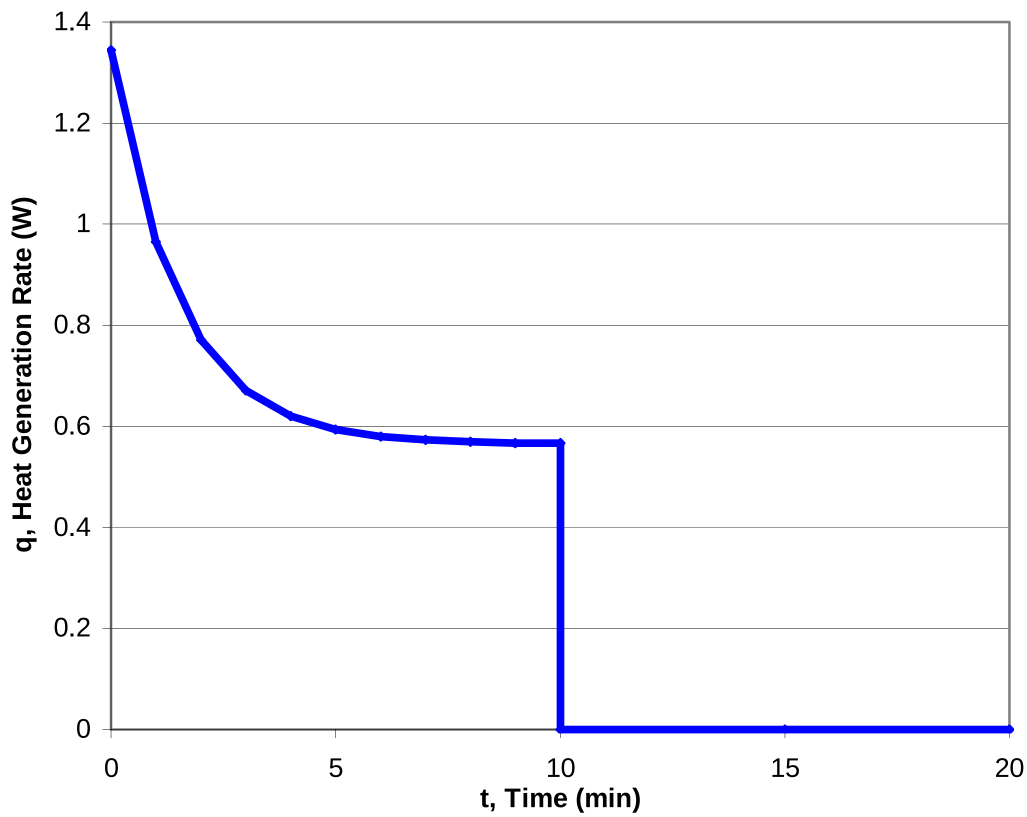


Figure 4.19. Graphical representation of the exponential decay heat generation rate used for the 4 cm tumor multiple insert thermal model exponential decay input simulation.

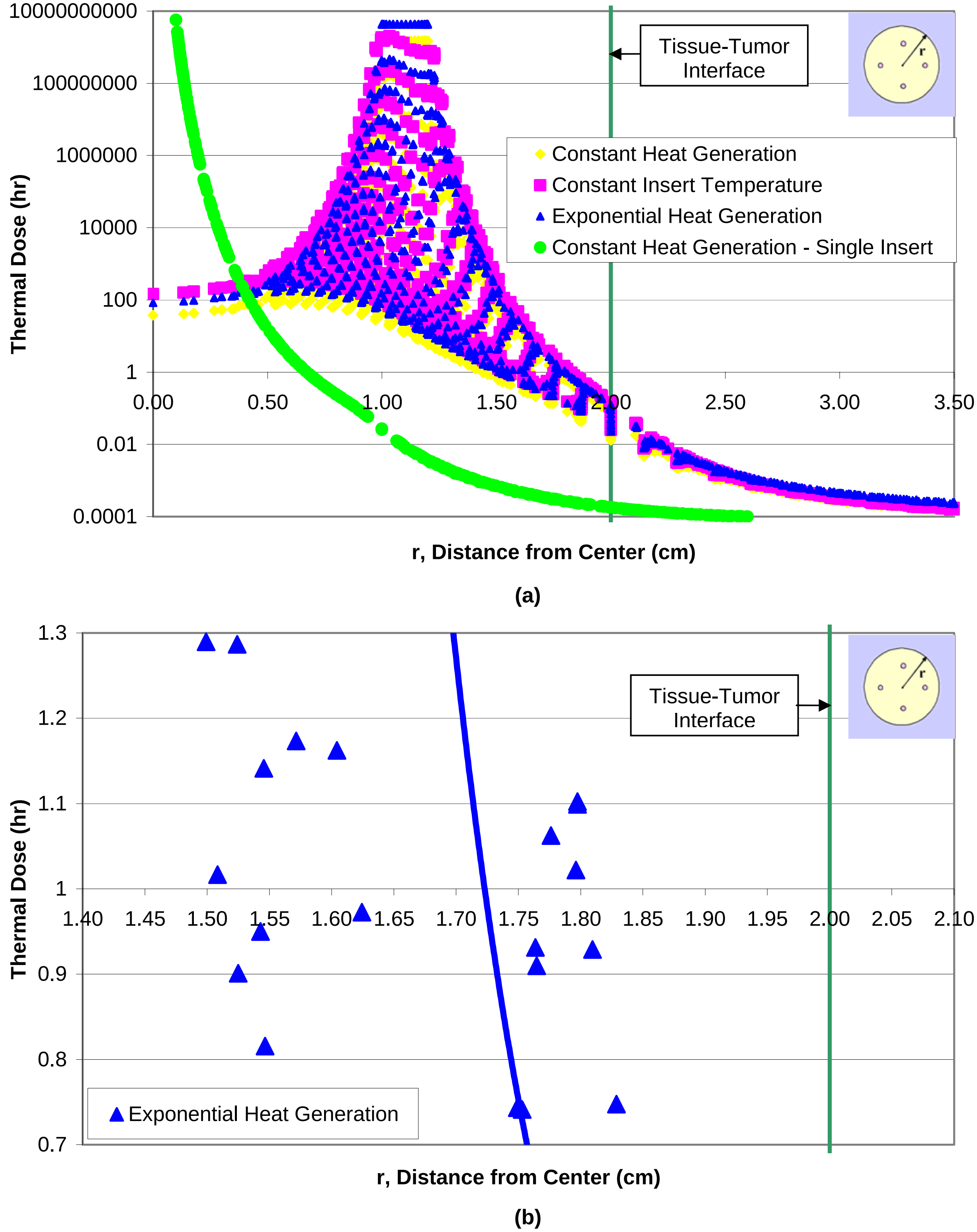


Figure 4.20. Comparison of the thermal dose results for the front plane for the simulations with four symmetrically placed inserts in a 4 cm tumor. Fig. (a) shows the thermal dose results of the entire front planes while Fig. (b) focuses on the location farthest from the center of the tumor where DTD is estimated to occur for the multiple insert exponential simulation only.

Table 4.6. Amount of tissue reaching the desired thermal dose (DTD) in simulation

Number of Inserts	Simulation	Distance From Center (cm)	Volume Receiving DTD (cm^3)	% Volume Change from Single Insert Constant Heat Generation Case
Single Insert	**Constant Heat Generation**	0.67	1.3	---
Multiple Inserts (4)	**Constant Heat Generation**	1.67	19.7	+ 1448.8
	Exponential Heat Generation	1.73	21.4	+ 1586.6
	Constant Insert Temperature	1.75	22.3	+ 1654.3

Note: The volume of a 3 cm tumor is 14.1 cm^3.
The volume of a 3.5 cm tumor is 22.4 cm^3.
The volume of a 4 cm tumor is 33.5 cm^3.

Thus, by examination of Table 4.6 it can be seen that an entire 3 cm tumor easily achieves the DTD. In addition, a 3.5 cm tumor almost entirely achieves the DTD. Although the simulations did not show that a 4 cm tumor achieves the DTD, it may be possible to achieve through a different arrangement of the four silicon carbide inserts or by adding additional silicon carbide inserts.

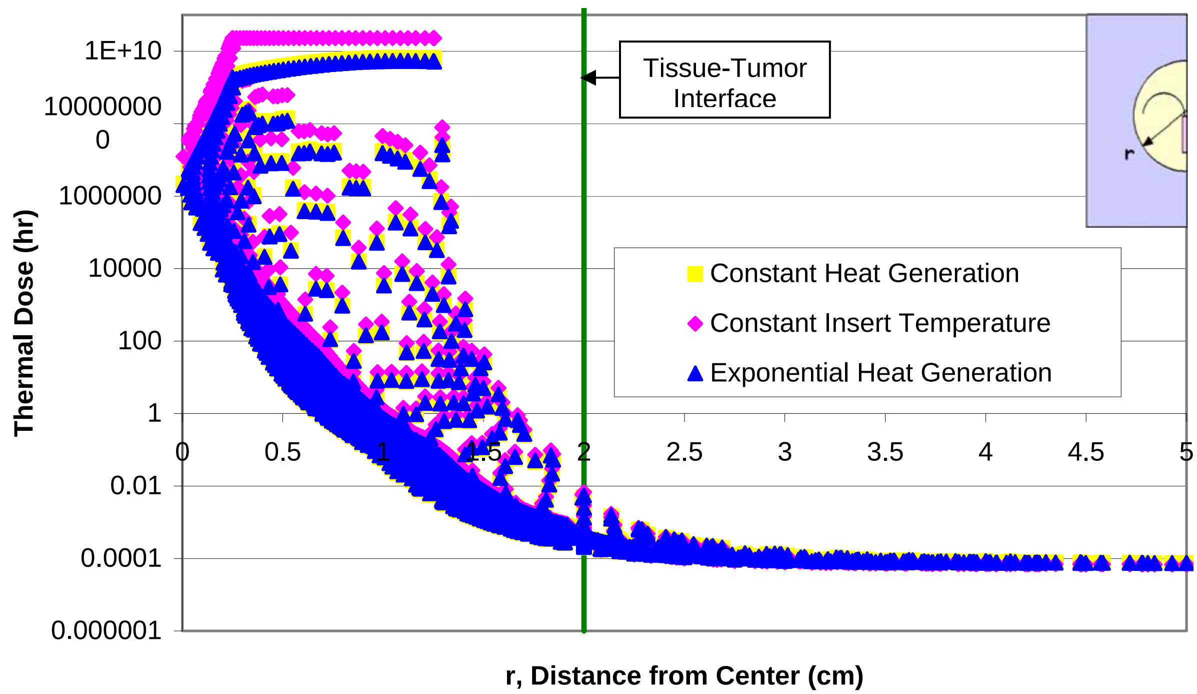
4.4.2 Conducting Rods Case

Another enhanced design case that was studied was the conducting rods case. This case used a single silicon carbide insert with four symmetrically placed conducting rods (which were used to transmit the energy farther into the tumorous tissue) geometrically similar to the probe used in the study by Tungjitkusolmun, 2002. The conducting rods and the geometry of this enhanced design case are described in further detail in Section 3.1.

As with the other simulations, this enhanced design case was submitted to simulations with the heat applied to the silicon carbide insert being in the forms constant heat generation, constant insert temperature (of 80º C), and exponential decay heat generation. As with the other simulations, all other parameters were the same as those in the Primary Thermal Model (single insert case) constant heat generation rate simulation. At this point, the resulting cumulative thermal dose was determined for each simulation. This section discusses the results of these enhanced conducting rods design simulations.

For these simulations, the front and side planes were identical, therefore, only the front plane is discussed. However, the results of horizontal planes (representing various vertical heights) were expected to be, and were, significantly different due to the location of the silicon carbide insert and the conducting rods.

When considering the entire front it is noticeable that the range of cumulative thermal dose values, for each radial distance from the center, is considerable, as shown in Figure 4.21. This range is due to the fact that the nodes of the tumor close to the conducting rods and the insert receive considerably more energy due to their proximity to these devices (similar to the multiple insert simulations). Therefore, a trend-line was used to show the approximate average distance from the center of the tumor achieving the DTD.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Thermal Dose (hr)
r, Distance from Center (cm)
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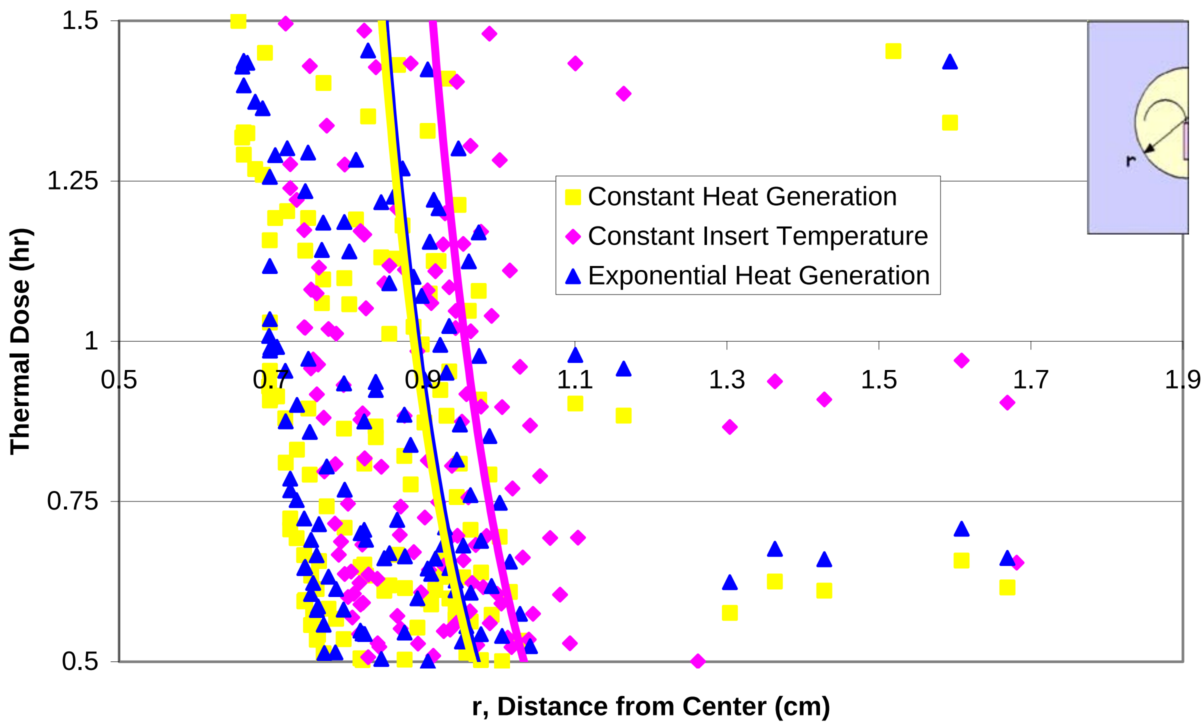
r

(a)


1.5
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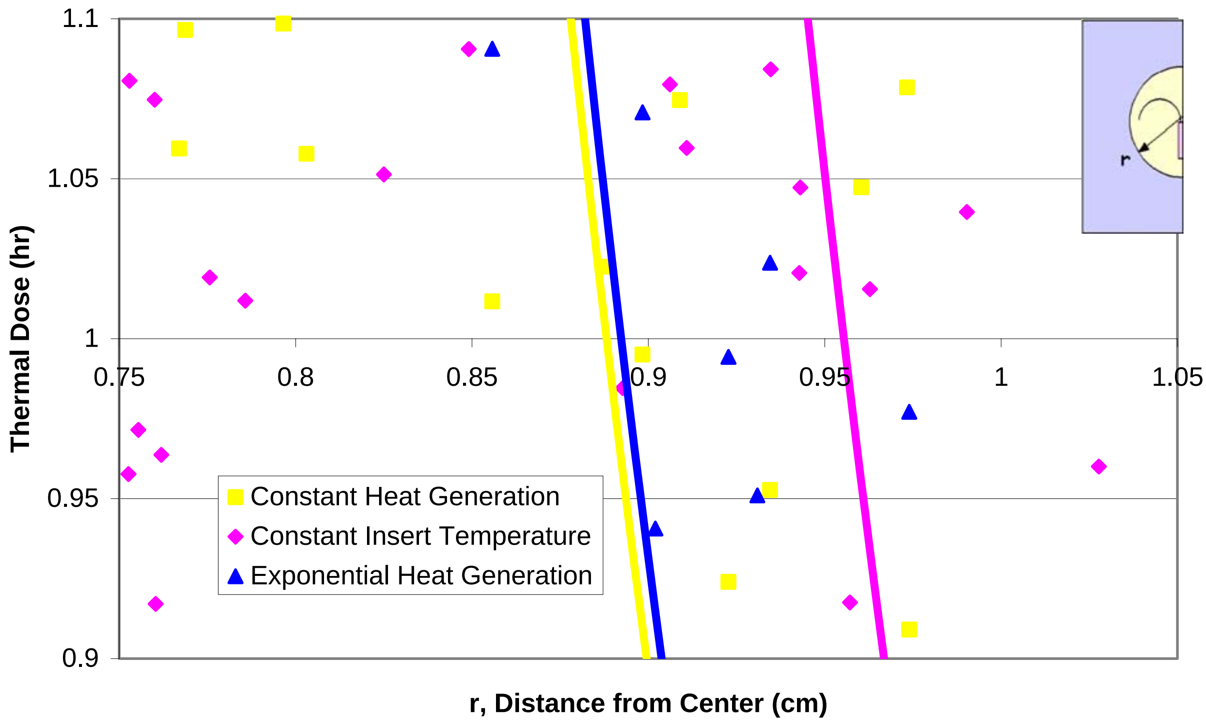
Thermal Dose (hr)
r, Distance from Center (cm)
Constant Heat Generation
Constant Insert Temperature
Exponential Heat Generation
r

(b)



(c)

Figure 4.21. Comparison of the thermal dose results for the front plane for the simulations with the conducting rods attached to the silicon carbide insert placed in a 4 cm tumor. Fig. (a) shows the thermal dose results of the entire front plane while Fig. (b) focuses on range of values where DTD occurs (at a thermal dose of 1) and Fig. (c) focuses on the location where the trend-line estimates the average distance from the center of the tumor achieving the DTD (at a thermal dose of 1).

Then, this estimated average distance from the center of the tumor was used to calculate the projected volume of tissue achieving the DTD. These calculations show that when using this estimated distance, the exponential heat generation rate had a slightly larger volume achieve the DTD, 3.01 cm^3, than the constant heat generation case, 2.94 cm^3. However, the amount of the tumor that received the DTD for the constant insert temperature case was significantly larger, 3.65 cm^3. These results are summarized in Table 4.7. Still, it is notable that (when using the projected average distance from center receiving the DTD) this design case cannot provide enough energy to cause an entire 2 cm tumor to reach the DTD.

Table 4.7. Comparison of the DTD results for the front plane of the conducting rods simulations with comparison to Primary Thermal Model constant heat generation case

Design Model	Heat Generation Rate	Distance from Center achieving DTD (cm)	Volume of Tissue Achieving DTD (cm^3)	% Volume Change From Single Insert Case	% Volume Change From Ideal (Constant Insert Temperature) Enhanced Design Case
Primary Thermal Model	**Constant Heat Generation**	0.67	1.27	---	NA
Enhanced Design Model Antennae Case	**Constant Heat Generation**	0.88	2.94	+ 133.86	- 19.45
	Constant Insert Temperature	0.96	3.65	+ 187.40	--
	Exponential Heat Generation	0.89	3.01	+ 137.01	- 17.53

Next, the cumulative thermal dose results were considered for various horizontal planes. Figure 4.22 shows the various different horizontal planes that are examined and their position relative to the enhanced design model used (conducting rods case). The horizontal plane at y = 4.65 cm corresponds to the plane that crosses at the apex of the conducting rods while the horizontal plane at y = 3.75 cm shows the plane that crosses at the silicon carbide insert and the conducting rod interface. In addition, the horizontal plane at y = 2.75 cm corresponds to the plane that crosses at the bottom of the silicon carbide insert.

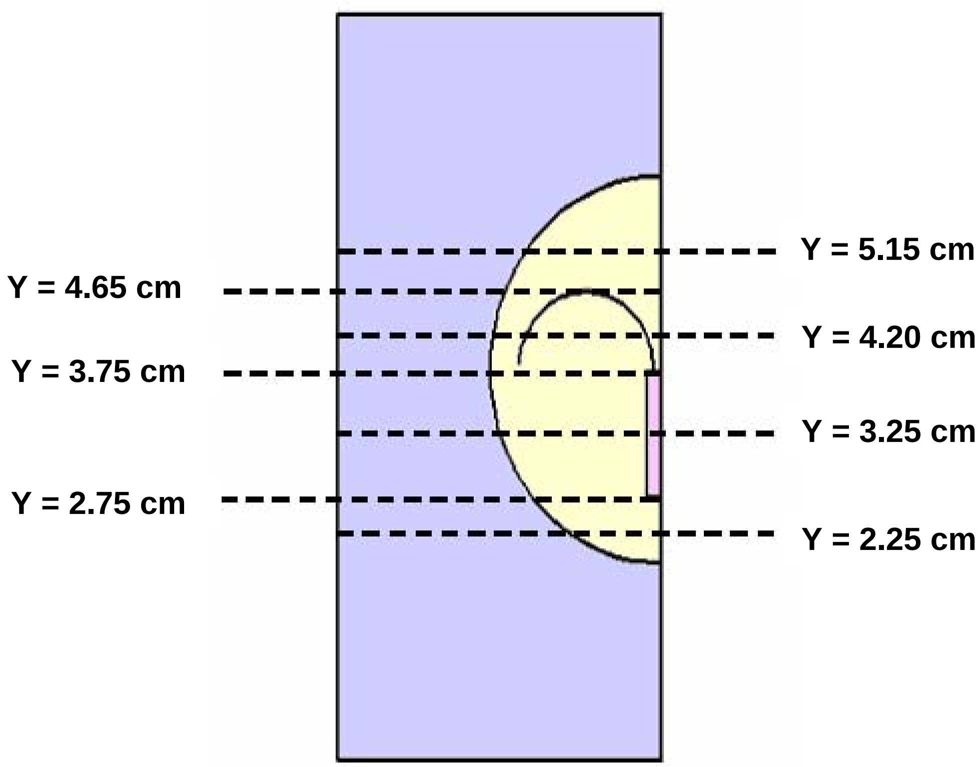
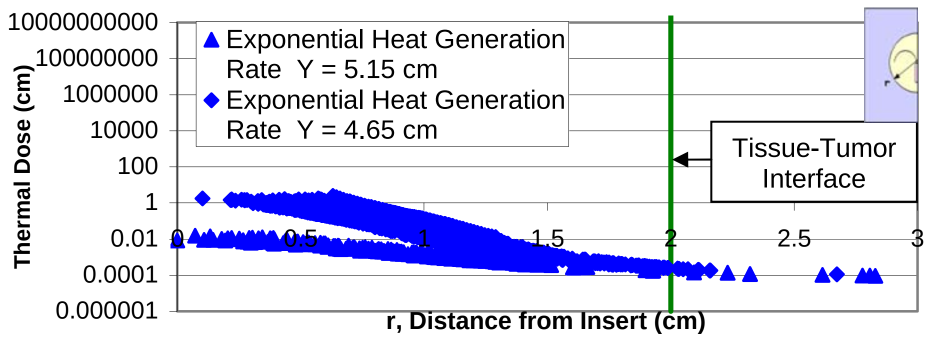


Figure 4.22. Horizontal planes of the enhanced design (conducting rods) case and their locations relative to the model in cm.

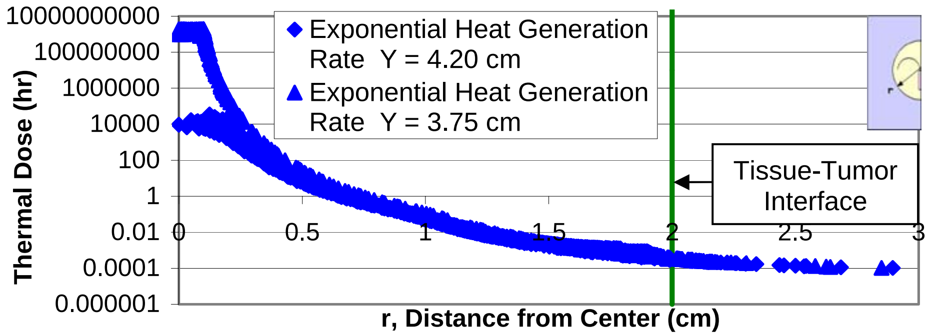
The cumulative thermal dose results for each of the horizontal planes are shown in Table 4.8 while the detailed horizontal plane results for the exponential heat generation rate are shown in Figure 4.23. As expected, the cumulative thermal dose results cover a wide range for the horizontal plane that goes through the apex of the conducting rods (at y = 4.65 cm). Meanwhile, in the horizontal planes that cut through the conducting rods (at y = 4.20 cm) and the silicon carbide conducting rods interface (at y = 3.75 cm) a slight drop in the cumulative thermal dose can be at the radial distance from center where the conducting rods ends (at approximately 1.8 cm).

Table 4.8. Comparison of select horizontal plane DTD results for the various heat generation rates of the enhanced design conducting rods simulations

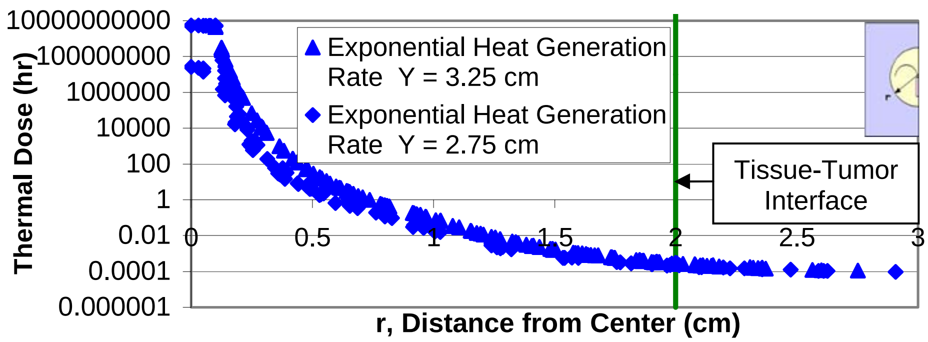
Horizontal Plane	Heat Generation Rate	Maximum Distance Achieving the DTD (cm)
Y = 5.15 cm	Constant Heat Generation Rate	---
	Constant Insert Temperature	---
	Exponential Heat Generation Rate	---
Y = 4.65 cm	Constant Heat Generation Rate	0.52
	Constant Insert Temperature	0.61
	Exponential Heat Generation Rate	0.54
Y = 4.20 cm	Constant Heat Generation Rate	0.65
	Constant Insert Temperature	0.70
	Exponential Heat Generation Rate	0.67
Y = 3.75 cm	Constant Heat Generation Rate	0.73
	Constant Insert Temperature	0.77
	Exponential Heat Generation Rate	0.74
Y = 3.25 cm	Constant Heat Generation Rate	0.73
	Constant Insert Temperature	0.77
	Exponential Heat Generation Rate	0.74
Y = 2.75 cm	Constant Heat Generation Rate	0.55
	Constant Insert Temperature	0.62
	Exponential Heat Generation Rate	0.56
Y = 2.25 cm	Constant Heat Generation Rate	---
	Constant Insert Temperature	---
	Exponential Heat Generation Rate	---



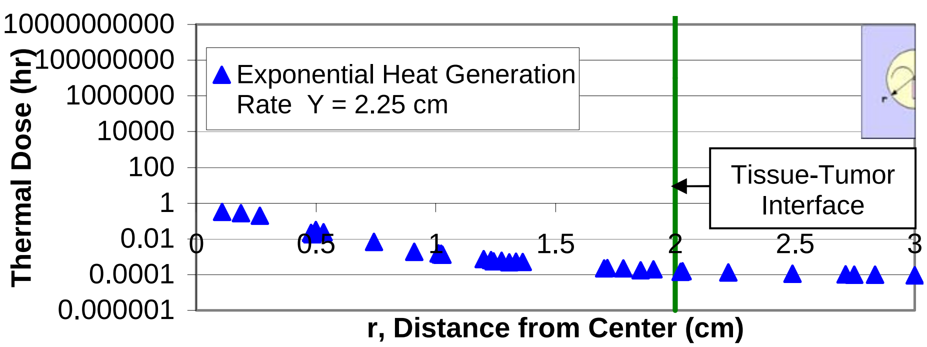
(a)



(b)



(c)



(d)

Figure 4.23. Comparison of the cumulative thermal dose results for various horizontal planes through the enhanced design conducting rods case. Fig. (a) shows the horizontal planes at y = 5.15 cm and y = 4.65 cm, Fig. (b) presents the horizontal planes at y = 4.20 cm and y = 3.75 cm, Fig. (c) displays the horizontal planes at y = 3.25 cm and y = 2.75 cm, and Fig. (d) shows the horizontal plane at y = 2.25 cm.

4.5 Sensitivity Analysis

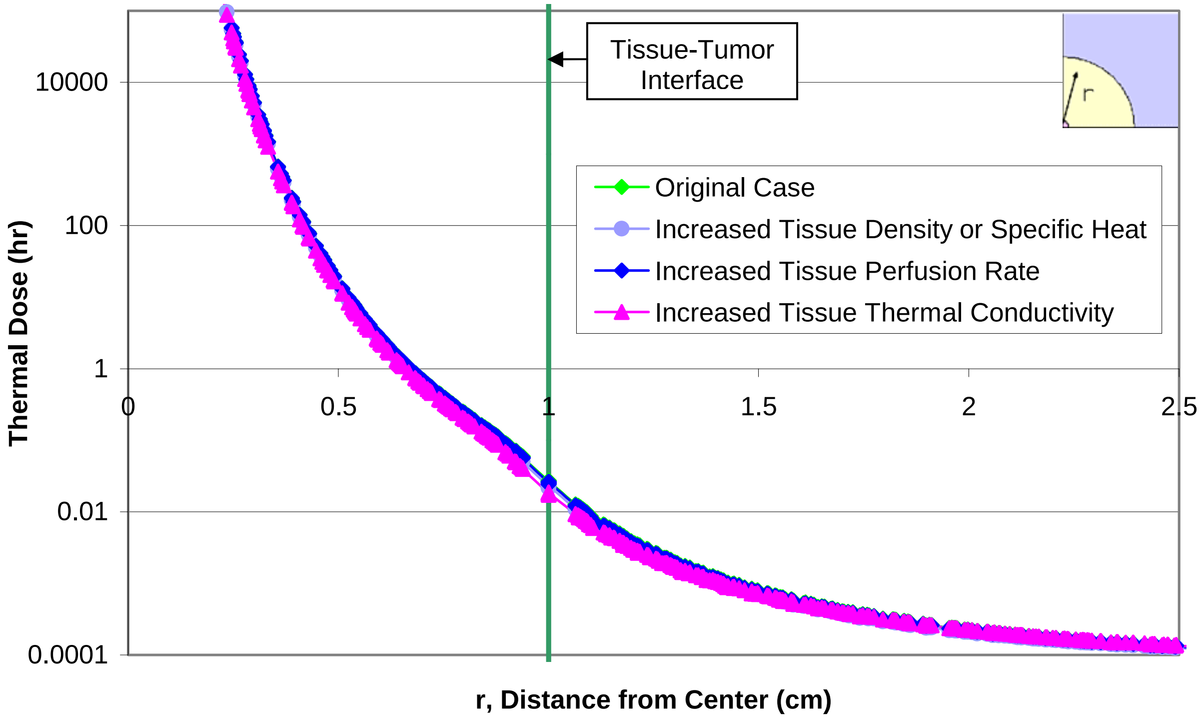
To determine the importance of individual parameters on the thermal model, as well as to understand the effects of parameters uncertainties, a sensitivity study was performed. For this study, the nominal individual input parameters of the tissue, tumor, and insert were each separately increased by ten percent while the remaining parameters were held at their original (nominal) value (nominal values are shown in Table 3.1). Then, the thermal simulation was performed and the resulting thermal doses calculated.

The effects of varying parameters, parameters that are intrinsic to the tissue, tumor, and insert, which cannot be externally controlled were examined first. Then, the effect of varying the heat generation rate applied to the insert was examined.

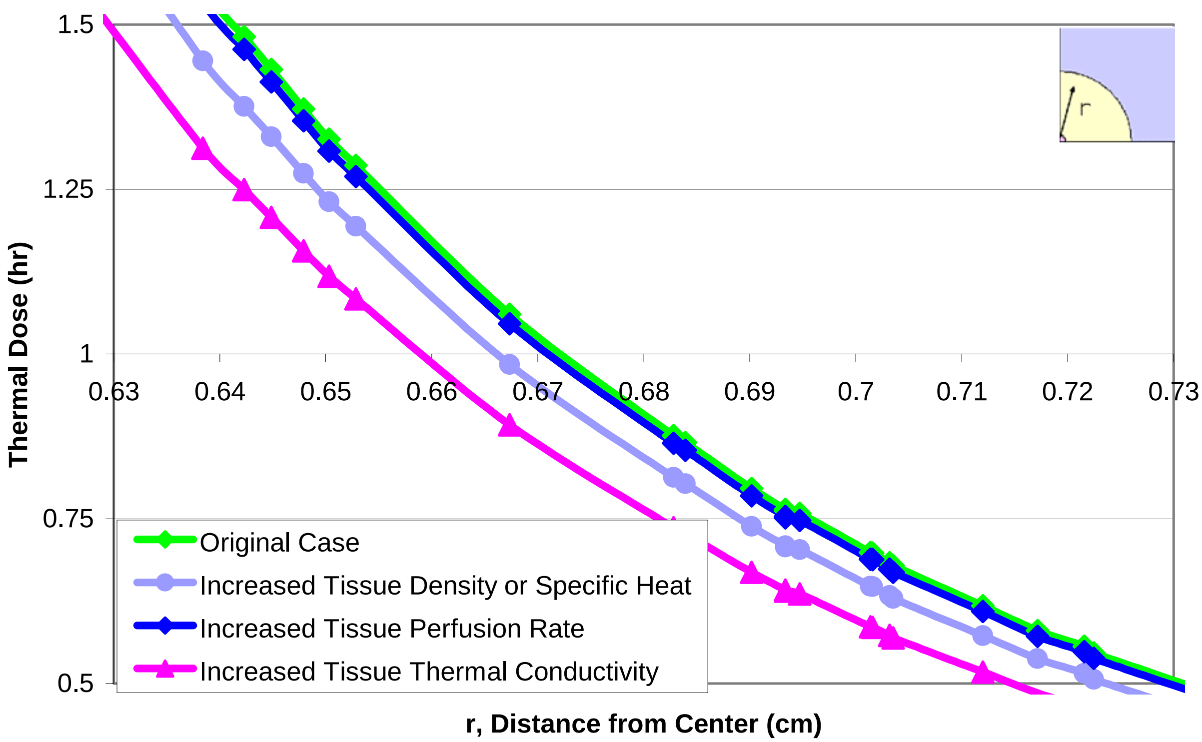
4.5.1 Sensitivity Study Results

Sensitivity analyses of the parameters intrinsic to the healthy tissue indicate the thermal dose increases when the tissue density, perfusion rate, specific heat, and thermal conductivity were each raised individually by ten percent. These results are shown in Figure 4.24. The results indicate that individually increasing these parameters does not cause substantial changes in the thermal dose results. Close examination reveals that increasing the tissue thermal conductivity has the greatest affect, decreasing the maximum distance from the center of the tumor where the desired thermal dose (DTD) is expected to occur by less than 0.15 millimeters.

Next, the intrinsic tumor parameters of density, perfusion rate, specific heat, and thermal conductivity were each raised individually by ten percent and sensitivity analyses were performed. The outcomes of these sensitivity studies are shown in Figure 4.25. These results indicate the thermal dose effects of individually increasing the tumor parameters are minimal. Close examination reveals that increasing the tumor thermal conductivity has the greatest affect, decreasing the maximum distance from the center of



(a)



(b)

Figure 4.24. Thermal dose results of healthy tissue sensitivity study simulations. Fig. (a) shows the thermal dose results for the entire front plane Fig. (b) focuses on the location farthest from the center of the tumor where the desired thermal dose (DTD) occurs (at a thermal dose of 1).

the tumor where the DTD is expected to occur by less than 0.2 mm. Meanwhile, increasing the tumor density or specific heat decreases the thermal dose. This decrease results in a decrease of the maximum distance from the center of the tumor where the DTD is expected to occur by about 0.1 mm. Additionally, increasing the tumor perfusion rate has almost no effect.

Next, the parameters intrinsic to the silicon carbide insert, density or specific heat, and thermal conductivity, were each raised individually by ten percent and sensitivity analyses were performed. The results of these sensitivity analyses indicate that changing the intrinsic insert parameters does not significantly affect the radial distance from the center where the DTD is expected to occur (at a thermal dose of one). Examination of Figure 4.26 shows the maximum decrease in this radial distance, occurring when either the density or the specific heat parameter is increased, is approximately 0.001 mm.

Finally, sensitivity analysis of the sole external parameter of the system, the heat generation rate applied to the silicon carbide insert, was performed by raising the heat generation rate by ten percent. The results, shown in Figure 4.27, indicate that increasing the heat generation rate parameter increases the radial distance from the center where the DTD is expected to occur (at a thermal dose of one) by approximately 0.5 mm.

Once the importance and the effects of individual parameters on the thermal model were determined, the maximum and minimum cumulative effect was studied to determine the worst possible deviation from the expected results. This portion of the sensitivity analysis included four thermal simulations: maximum and minimum thermal dose when varying only internal parameters and maximum and minimum thermal dose when varying internal and external parameters.

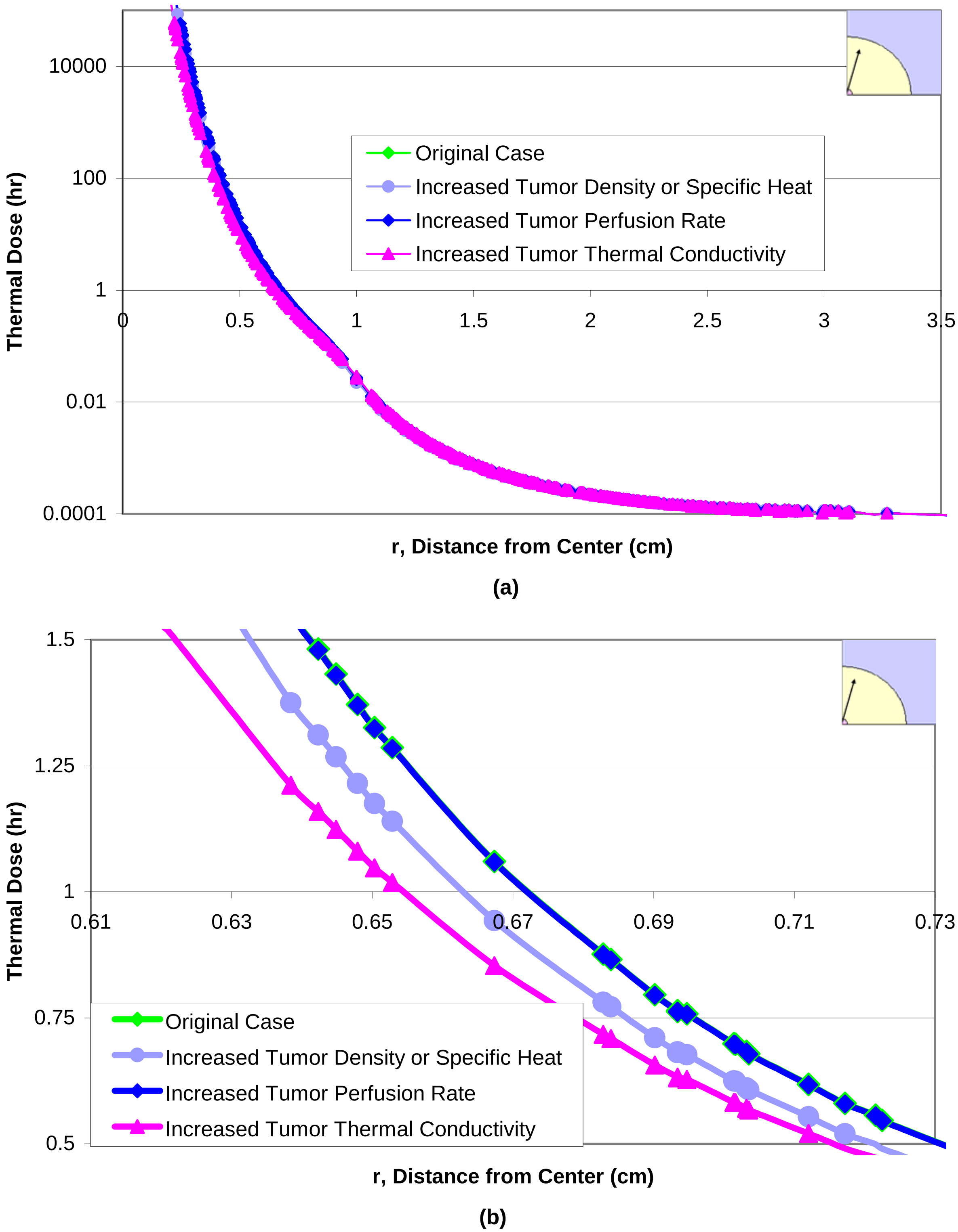


Figure 4.25. Thermal dose results of tumor sensitivity study simulations. Fig. (a) shows the thermal dose results of the entire front plane; Fig. (b) focuses on the location farthest from the center of the tumor where the DTD occurs (at a thermal dose of 1).

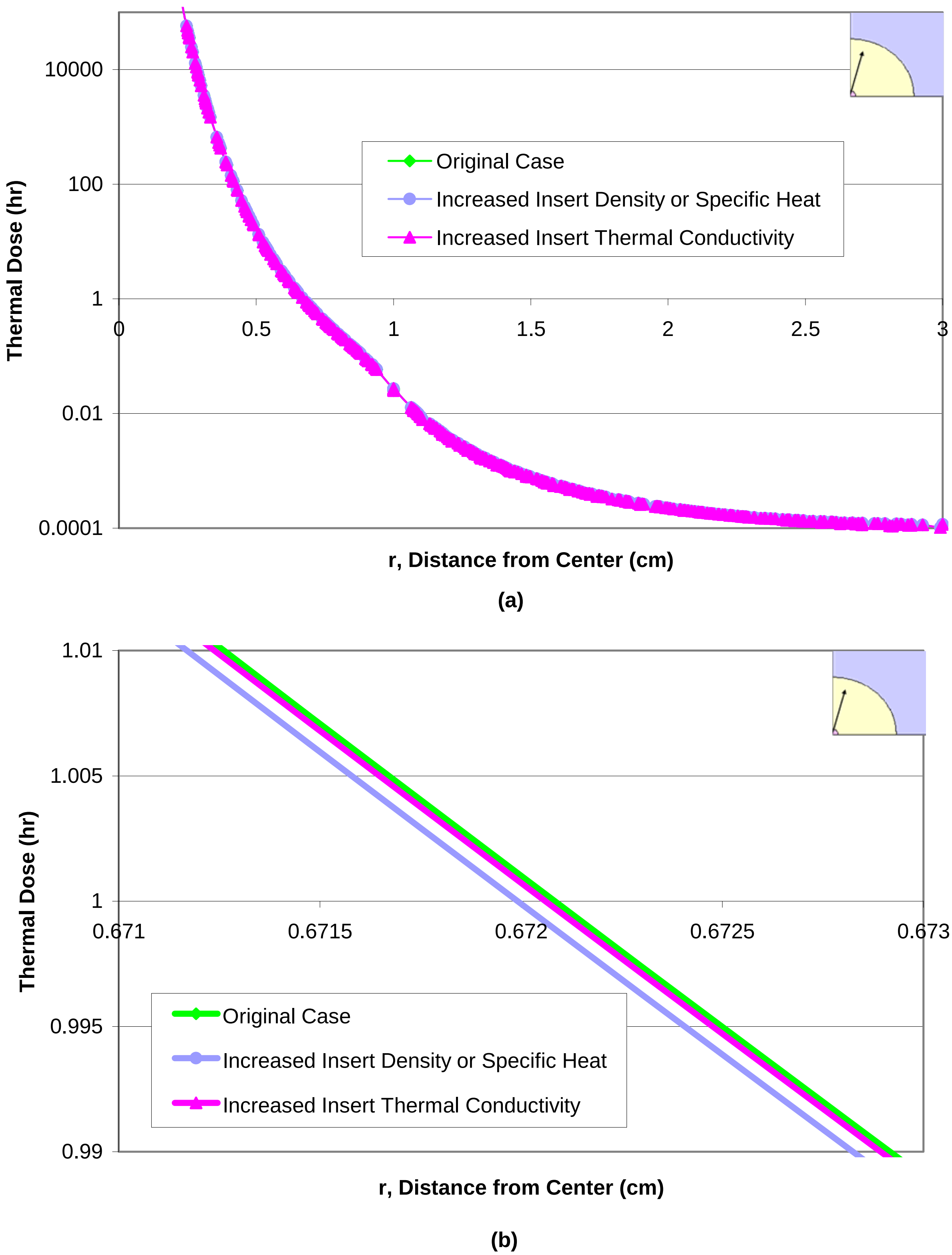


Figure 4.26. Thermal dose results of the intrinsic insert parameter sensitivity study simulations. Fig. (a) shows the thermal dose results of the entire front plane; Fig. (b) focuses on the location farthest from the center of the tumor where the DTD occurs (at a thermal dose of 1).

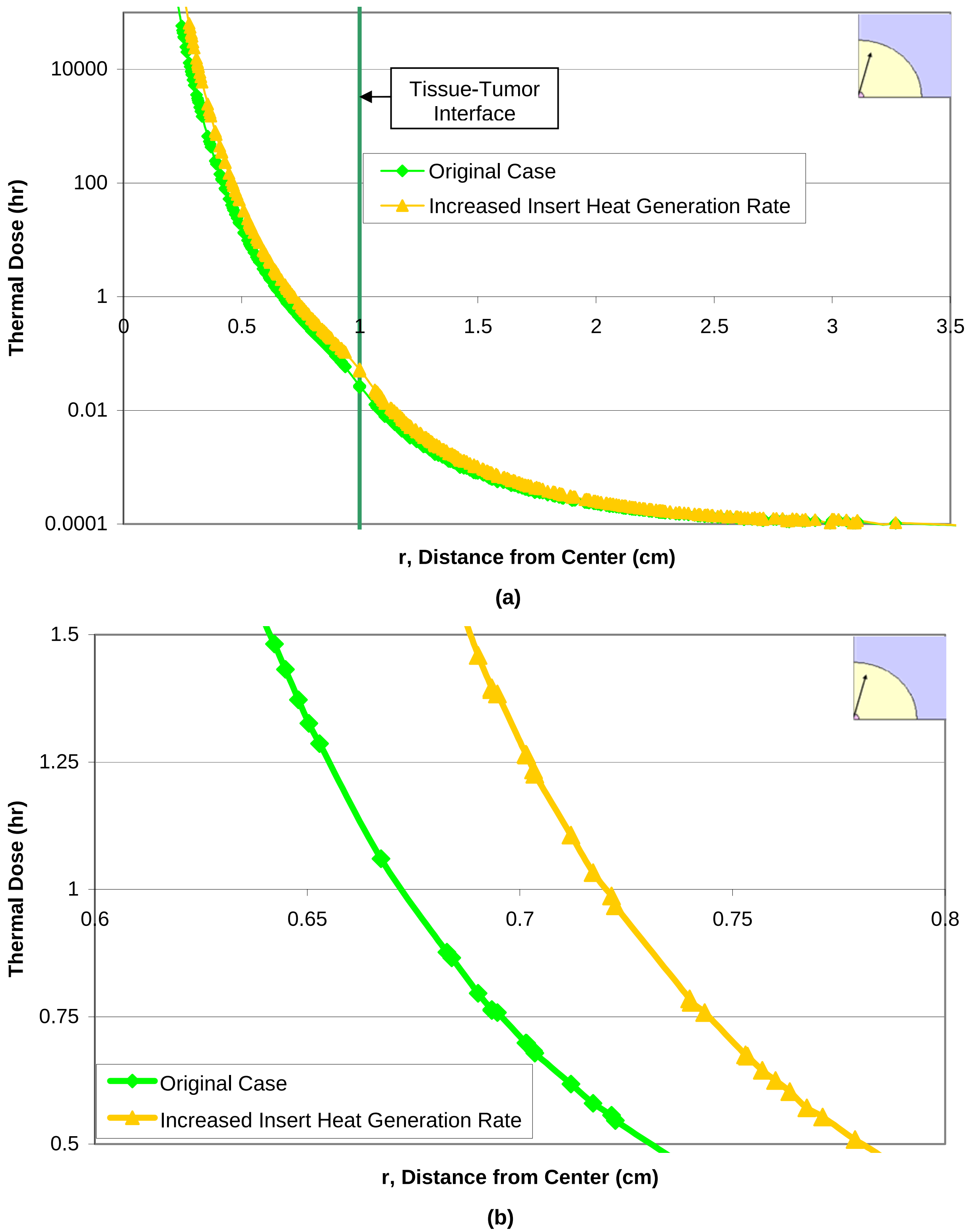


Figure 4.27. Thermal dose results of the external insert parameter sensitivity study simulations. Fig. (a) shows the thermal dose results of the entire front plane; Fig. (b) focuses on the location farthest from the center of the tumor where the DTD occurs (at a thermal dose of 1).

For example, to determine the minimum thermal dose (when considering the internal and external parameters), the nominal individual input parameters of the tissue, tumor, the insert density or specific heat, and thermal conductivity were all increased by ten percent while the heat generation rate applied to the insert was decreased by ten percent. Then, the thermal simulation was performed and the resulting thermal dose calculated. All of the worst case thermal simulations were performed in this manner. The thermal dose results of these simulations are shown in Figure 4.28.

4.5.2 Results of Sensitivity Study

The effect of increasing each individual parameter was examined for each parameter and the results of these studies are shown in Table 4.9. In addition, a summary of all the results of varying all parameters at one time (the worst case simulations) are shown in Table 4.10. As expected, the parameter which had the greatest effect on the model was the heat generation rate. It is interesting to note that the maximum from the expected results due to parameter variation is 62.4 percent which occurs when the amount of amount of heat added to the model is increased.

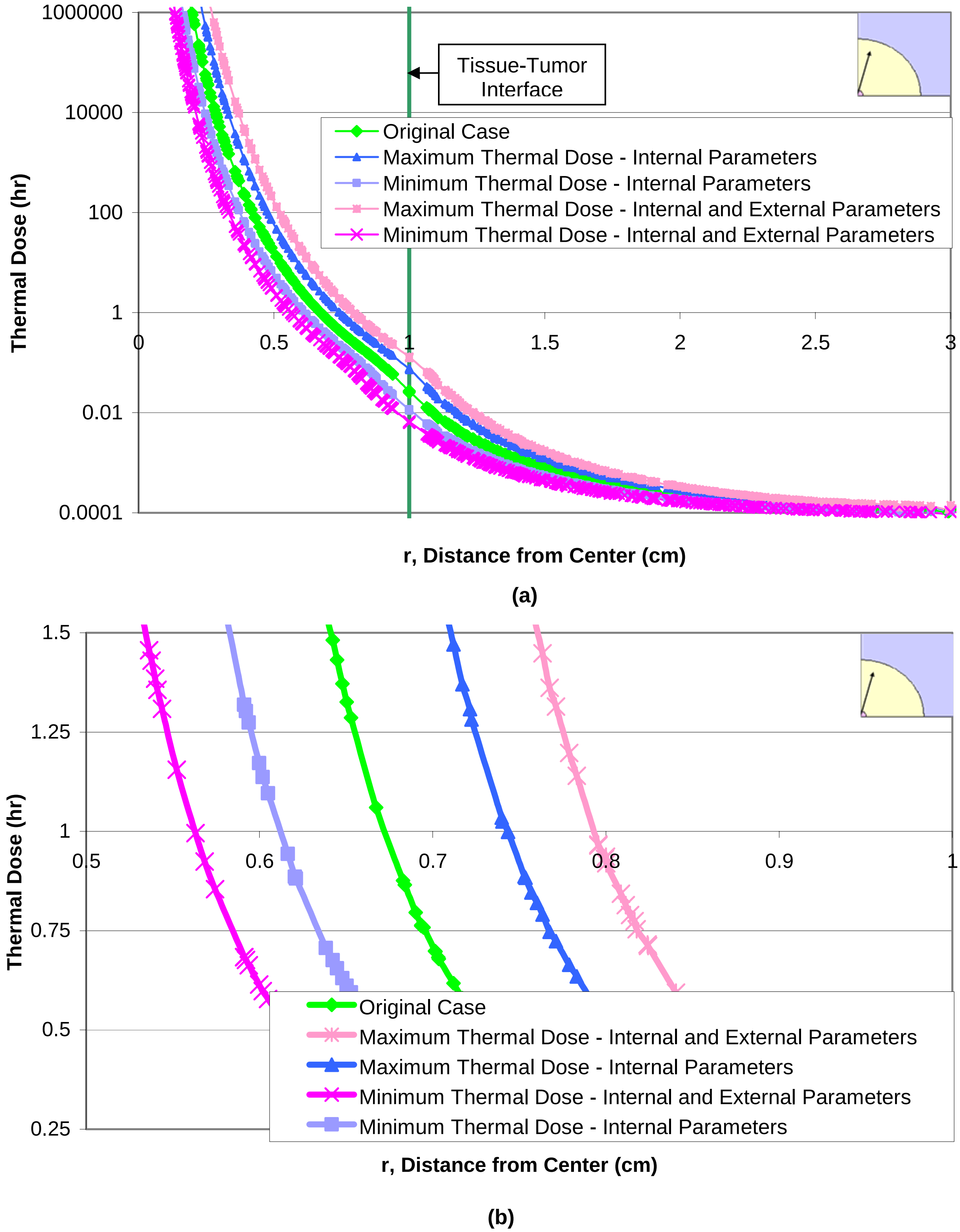


Figure 4.28. Maximum thermal dose changes by altering all parameters in the sensitivity study simulations. Fig. (a) shows the thermal dose results of the entire front plane; Fig. (b) focuses on the location farthest from the center of the tumor where the DTD (at a thermal dose of 1).

Table 4.9. Summary of sensitivity study thermal dose findings when increasing individual parameters.

Input Parameter Increased	Thermal Dose Result	Change in Estimated DTD Location (mm)	Volume Achieving DTD cm^3	% Volume Change
Tissue				
Density (kg/m^3) or Specific Heat (J/kg/K)	Decreased	- 0.06	1.24	- 2.65
Thermal Conductivity (W/m/K)	Decreased	- 0.13	1.20	- 5.69
Perfusion Rate (ml/g/min)	Decreased	- 0.012	1.26	- .053
Tumor				
Density (kg/m^3) or Specific Heat (J/kg/K)	Decreased	- 0.1	1.22	- 4.40
Thermal Conductivity (W/m/K)	Decreased	- 0.2	1.16	- 8.66
Perfusion Rate (ml/g/min)	Decreased	- 0.0015	1.27	- 0.06
Insert				
Density (kg/m^3) or Specific Heat (J/kg/K)	Decreased	- 0.001	1.27	- 0.04
Heat Generation Rate (W)	Increased	+ 0.5	1.68	- 24.02
Thermal Conductivity (W/m/K)	Decreased	- 0.0003	1.27	- 0.01

Table 4.10. Summary of sensitivity study findings when adjusting all parameters

Sensitivity Study	Change in Estimated DTD Location (mm)	Volume Achieving DTD cm^3	% Volume Change
Minimum Thermal Dose			
Internal Parameters	- 0.61	0.96	- 24.8
Internal and External Parameters	- 1.11	0.74	- 41.8
Maximum Thermal Dose			
Internal Parameters	+ 0.70	1.71	+ 34.6
Internal and External Parameters	+ 1.18	2.07	+ 62.4

Chapter 5

Conclusions and Recommendations

There are several important results that are seen in this study. First, the enhanced design cases were able to cause a greater volume (up to a 1587 % increase) of tissue to achieve the desired thermal dose, with the multiple silicon carbide inserts having the greatest effect. Next, the effects of perfusion were found to be relatively insignificant on the simulations (less than 0.2 %). Finally, changing the heat generation rate function only had small effects on the simulations, with the exponential decay heat generation input yielding the best results (a 12.3 % increase in the volume of tissue attaining the DTD in the primary thermal model) of the various heat input rates.

The results of this study indicated that increasing the number of inserts placed in the tumor has a significant effect on the results (producing up to a 1587 % increase in volume receiving the DTD). The results of the primary thermal model (using a single silicon carbide insert) showed that the largest diameter tumor that can all achieve the desired thermal dose is approximately 1.4 cm. However, increasing from a single silicon carbide insert to four inserts increases the largest entire tumor that can attain the desired thermal dose to approximately a 3.5 cm diameter.

Additionally, results indicated that the enhanced design conducting rods case cannot achieve the desired thermal dose for an entire 2 cm diameter tumor, although it can achieve the desired thermal dose for an entire tumor of approximately 1.8 cm in diameter. While this is an important increase in the amount of tissue receiving the desired thermal dose, the enhanced design conducting rods case does not have near as much effect as the multiple silicon carbide scenarios.

A parametric study was performed to examine the effects of varying the parameters of the primary thermal model (single silicon carbide insert case) including the perfusion rate, overall treatment time, and the heat generation input rate. Comparisons of the overall treatment time showed that the benefits of increasing the treatment time were non-linear. In other words, doubling the treatment time did not achieve a doubling of the volume of tissue achieving the desired thermal dose. From this comparison, it was determined that a ten minute treatment time was optimal for this model.

The effects of varying the rate (or level) of perfusion were insignificant (less than 1.1 % change in results) however, the presence of perfusion was significant (adding or removing perfusion caused a 6.3 % change in results). On the other hand, varying the heat generation input rate did have an effect on the results. It was determined that the difference in the volume of tissue achieving the desired thermal dose was insignificant (a slight decrease of 0.45 %) using pulsed heat generation rates as compared to that when using the constant heat generation rate. However, using single or multiple slope ramp heat generation rates or exponential decay heat generation rates did yield small increases (1.35 % for the single slope ramp, 9.39 % for the multiple slope ramp, and 12.30 % for the exponential decay generation) on the volume of tissue receiving the desired thermal dose when compared with the results of the constant heat generation case, with the exponential decay heat generation rates having the greatest effect of the various heat generation rates.

From these results, it is recommended that additional computer modeling be performed and that this research proceed on to *in vitro* testing. The additional computer modeling recommended includes investigating the effects of administering multiple treatments using a single silicon carbide insert. In addition, it is recommended that a new more detailed thermal model of the tissue and tumor be created and analyzed that includes inhomogeneities such as blood vessels (small and large) and unique tumor geometries to determine their effects. Furthermore, it is recommended that *in vitro* preferential hyperthermia tests, using the silicon carbide system modeled in this work with microwave heating, be performed on perfused donor animal organs with tumors. These results could then be used to verify the current thermal computer model and to make adjustments to the thermal model as necessary.

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Appendix

Thermal Dose Analyzer Code

Thermal Dose Module

```
Option Compare Database
Option Explicit

Private Const mcstrTableName = "TDoseData"
Private Const mcstrClassName = "TDoseData"

Private mstrStatus As String
Private mstrFolder As String
Private mstrSimulation As String

Private mlngFileCount As Long
Private mlngNodeCount As Long

Private marrValidNodes(130000) As Boolean

Private mdteStartTime As Date
Private mdteFinishTime As Date

Private mobjFS As FileSystemObject
Private mobjDB As Database

Public Event StatusUpdate()

Public Property Get Status() As String

    Status = mstrStatus

End Property

Public Property Let Folder(strFolder As String)

    ' Verify that Folder Exists
    If mobjFS.FolderExists(strFolder) = True Or strFolder = "" Then
        mstrFolder = strFolder
    Else
        Err.Raise vbObjectError + 76, mcstrClassName, "Folder Not Found!"
    End If

End Property

Public Property Get Folder() As String

    Folder = mstrFolder

End Property

Public Property Let Simulation(strSimulation As String)

    ' Verify Simulation Name Length
    If Len(strSimulation) <= 20 Then
        mstrSimulation = strSimulation
```

```
    Else
        Err.Raise vbObjectError + 77, mcstrClassName, "Simulation Name Too Long!"
    End If

End Property

Public Property Get Simulation() As String

    Simulation = mstrSimulation

End Property

Public Property Get FileCount() As Long

    FileCount = mlngFileCount

End Property

Public Property Get NodeCount() As Long

    NodeCount = mlngNodeCount

End Property

Public Property Get StartTime() As Date

    StartTime = mdteStartTime

End Property

Public Property Get FinishTime() As Date

    FinishTime = mdteFinishTime

End Property

Private Sub Class_Initialize()

    Set mobjFS = CreateObject("Scripting.FileSystemObject")
    Set mobjDB = Application.CurrentDb

    mlngFileCount = 0
    mlngNodeCount = 0

    mstrFolder = ""
    mstrSimulation = ""
    mstrStatus = ""

End Sub

Public Sub Process()

    Dim lngResult As Long

    ' Capture Start Time
    mdteStartTime = Now

    ' Reset Information
    mlngFileCount = 0
    mlngNodeCount = 0
    mstrStatus = "Initializing Environment ..."
```

```
    ' Raise StatusUpdate Event
    RaiseEvent StatusUpdate

    ' Verify that Folder Exists
    If mobjFS.FolderExists(mstrFolder) = False Then
        mdteFinishTime = Now
        Err.Raise vbObjectError + 76, mcstrClassName, "Folder Not Found!"
    End If

    ' Does Simulation Data already exist?
    If SimulationExists(mstrSimulation) = True Then
        lngResult = MsgBox("Data already exists for this Simulation Name!  Do you wish to overwrite existing
data?", _
                    vbYesNo, "Overwrite Simulation?")

        If lngResult = vbYes Then

            ' Update Status
            mstrStatus = "Deleting existing data ..."
            RaiseEvent StatusUpdate

            ' Delete Existing Simulation Data
            DeleteSimulation mstrSimulation

            ' Update Status
            mstrStatus = "Initializing Environment ..."
            RaiseEvent StatusUpdate

        Else

            ' Capture Finish Time
            mdteFinishTime = Now

            ' Update Status
            mstrStatus = "Process Aborted ... Data Already Exists!"

            Exit Sub

        End If
    End If

    ' Load Valid Nodes
    LoadValidNodes

    ' Load Raw Data
    LoadRawData

    ' Calc Thermal Dose Data
    CalcThermalDose

    ' Capture Finish Time
    mdteFinishTime = Now

    ' Update Status
    mstrStatus = "Completed in " & _
                DateDiff("s", mdteStartTime, mdteFinishTime) & _
                " seconds"

End Sub

Private Sub LoadRawData()
```

```
    Dim objFolder As Folder
    Dim objFile As File

    Set objFolder = mobjFS.GetFolder(mstrFolder)

    For Each objFile In objFolder.Files

        ' Update Status
        mstrStatus = "Processing '" & objFile.Name & "' ..."
        RaiseEvent StatusUpdate

        ' Load File
        LoadFile objFile.Path

        ' Update File Count
        mlngFileCount = mlngFileCount + 1

    Next

    ' Update Status
    mstrStatus = "Data Loaded ... Starting Calculations"
    RaiseEvent StatusUpdate

    ' Releae Objects
    Set objFolder = Nothing
    Set objFile = Nothing

End Sub

Private Sub CalcThermalDose()

   Dim objRS As DAO.Recordset
   Dim strSQL As String

   ' Build Query String
   strSQL = "SELECT DISTINCT NODE FROM " & mcstrTableName & _
           " WHERE Simulation = '" & mstrSimulation & "' ORDER BY NODE"

   ' Open Recordset
   Set objRS = mobjDB.OpenRecordset(strSQL)

   ' Process Recordset
   Do Until objRS.EOF

      ' Update Status
      mstrStatus = "Calculating Node " & objRS!Node & " ..."
      RaiseEvent StatusUpdate

      ' Calculate Node Info
      CalcNode objRS!Node

      ' Increment Node Count
      mlngNodeCount = mlngNodeCount + 1

      ' Move to next record
      objRS.MoveNext

   Loop

   ' Close and Release Recordset
   objRS.Close
   Set objRS = Nothing
```

```
End Sub

Private Sub Class_Terminate()

    ' Close Database
    mobjDB.Close

    ' Release Objects
    Set mobjDB = Nothing
    Set mobjFS = Nothing

End Sub

Private Sub LoadFile(ByVal strFileName As String)

    Dim objFile As Scripting.TextStream
    Dim objRS As DAO.Recordset

    Dim strLine As String
    Dim strTime As String
    Dim strNode As String
    Dim strTemp As String
    Dim strSQL As String

    Dim intPos As Integer

    ' Open File
    Set objFile = mobjFS.OpenTextFile(strFileName, ForReading, False)

    ' Find Time Info
    Do Until objFile.AtEndOfStream

        ' Read Line
        strLine = objFile.ReadLine

        ' Look for Time Info (Exit loop if found)
        intPos = InStr(1, strLine, "TIME=", vbTextCompare)
        If intPos > 0 Then
            strTime = CInt(Mid(strLine, intPos + 5, 10))
            Exit Do
        End If

    Loop

    ' Open Recordset
    strSQL = "SELECT * FROM " & mcstrTableName & _
             " WHERE Simulation = '" & mstrSimulation & "' AND Time = " & strTime
    Set objRS = mobjDB.OpenRecordset(strSQL)

    ' Process File Data
    Do Until objFile.AtEndOfStream

        ' Read Line
        strLine = objFile.ReadLine

        ' Process Data
        strNode = Mid(strLine, 1, 8)
        strTemp = Mid(strLine, 9, 10)
        If IsNumeric(strNode) And IsNumeric(strTemp) Then

            ' Valid Node to Load?
```

```
            If marrValidNodes(CLng(strNode)) = True Then

               ' Write Data to Table
               objRS.AddNew
               objRS!Simulation = mstrSimulation
               objRS!Time = CInt(strTime)
               objRS!Node = CLng(strNode)
               objRS!Temp = CSng(strTemp)
               objRS.Update

            End If

         End If

      Loop

      ' Close and Release RecordSet
      objRS.Close
      Set objRS = Nothing

      ' Close and Relase File
      objFile.Close
      Set objFile = Nothing

   End Sub

   Private Sub CalcNode(ByVal lngNode As Long)

     Dim objRS As DAO.Recordset
     Dim strSQL As String
     Dim sngTempDiff As Single
     Dim dblTDose As Double
     Dim dblCumTDose As Double
     Dim intLastTime As Integer

     ' Initialize Variables
     intLastTime = 0
     dblTDose = 0
     dblCumTDose = 0

     ' Build Query String
     strSQL = "SELECT * FROM " & mcstrTableName & _
            " WHERE Simulation = '" & mstrSimulation & "' AND Node = " & lngNode & _
            " ORDER BY Node, Time"

     ' Open Recordset
     Set objRS = mobjDB.OpenRecordset(strSQL)

     ' Process Recordset
     Do Until objRS.EOF

       ' Calc Temp Difference
       sngTempDiff = 43 - objRS!Temp

       ' Calc Thermal Dose
       If sngTempDiff > 0 Then
         dblTDose = (0.25 ^ sngTempDiff) * (objRS!Time - intLastTime)
       Else
         dblTDose = (0.5 ^ sngTempDiff) * (objRS!Time - intLastTime)
       End If

       ' Update Cummulative Thermal Dose
```

```
      dblCumTDose = dblCumTDose + dblTDose

      ' Update Record
      objRS.Edit
      objRS!TDose = dblTDose
      objRS!CumTDose = dblCumTDose
      objRS.Update

      ' Move to next record
      intLastTime = objRS!Time
      objRS.MoveNext

   Loop

   ' Close and Release Recordset
   objRS.Close
   Set objRS = Nothing

End Sub

Private Function SimulationExists(ByVal strSimulation) As Boolean

    Dim objRS As DAO.Recordset
    Dim strSQL As String

    ' Build SQL Statement
    strSQL = "SELECT COUNT(*) AS REC_COUNT FROM " & mcstrTableName & _
            " WHERE Simulation = '" & strSimulation & "'"

    ' Open Recordset
    Set objRS = mobjDB.OpenRecordset(strSQL)

    ' Set Return Value
    If objRS!REC_COUNT > 0 Then
        SimulationExists = True
    Else
        SimulationExists = False
    End If

    ' Close and Release Recordset
    objRS.Close
    Set objRS = Nothing

End Function

Private Sub DeleteSimulation(ByVal strSimulation)

    Dim strSQL As String

    ' Build SQL Statement
    strSQL = "DELETE FROM " & mcstrTableName & " WHERE Simulation = '" & strSimulation & "'"

    ' Execute SQL Statement
    mobjDB.Execute strSQL, dbFailOnError

End Sub

Private Sub LoadValidNodes()

    Dim objRS As DAO.Recordset
    Dim strSQL As String
    Dim lngPos As Long
```

```
    ' Initialize Array
    For lngPos = 0 To UBound(marrValidNodes, 1) - 1
        marrValidNodes(lngPos) = False
    Next

    ' Build Query String
    strSQL = "SELECT Node FROM ValidNodes"

    ' Open Recordset
    Set objRS = mobjDB.OpenRecordset(strSQL)

    ' Process Recordset
    Do Until objRS.EOF

        ' Update Array
        marrValidNodes(objRS!Node) = True

        ' Move to next record
        objRS.MoveNext

    Loop

    ' Close and Release Recordset
    objRS.Close
    Set objRS = Nothing

End Sub
```

Main Menu Form

```
Option Compare Database
Option Explicit

Private Sub cmdCompact_Click()

    DoCmd.RunCommand acCmdCompactDatabase

End Sub

Private Sub cmdSimList_Click()
On Error GoTo Err_cmdSimList_Click

    Dim stDocName As String

    stDocName = "SimulationList"
    DoCmd.OpenQuery stDocName, acNormal, acReadOnly

Exit_cmdSimList_Click:
    Exit Sub

Err_cmdSimList_Click:
    MsgBox Err.Description
    Resume Exit_cmdSimList_Click

End Sub

Private Sub cmdSimData_Click()
On Error GoTo Err_cmdSimData_Click
```

```
    Dim stDocName As String

    stDocName = "TDoseData_Simulation"
    DoCmd.OpenQuery stDocName, acNormal, acReadOnly

Exit_cmdSimData_Click:
    Exit Sub

Err_cmdSimData_Click:
    MsgBox Err.Description
    Resume Exit_cmdSimData_Click

End Sub

Private Sub cmdSimDataNode_Click()
On Error GoTo Err_cmdSimDataNode_Click

    Dim stDocName As String

    stDocName = "TDoseData_Node"
    DoCmd.OpenQuery stDocName, acNormal, acReadOnly

Exit_cmdSimDataNode_Click:
    Exit Sub

Err_cmdSimDataNode_Click:
    MsgBox Err.Description
    Resume Exit_cmdSimDataNode_Click

End Sub

Private Sub cmdSimDataTime_Click()
On Error GoTo Err_cmdSimDataTime_Click

    Dim stDocName As String

    stDocName = "TDoseData_Time"
    DoCmd.OpenQuery stDocName, acNormal, acReadOnly

Exit_cmdSimDataTime_Click:
    Exit Sub

Err_cmdSimDataTime_Click:
    MsgBox Err.Description
    Resume Exit_cmdSimDataTime_Click

End Sub
Private Sub cmdSimDataDelete_Click()
On Error GoTo Err_cmdSimDataDelete_Click

    Dim stDocName As String

    stDocName = "SimulationDelete"
    DoCmd.SetWarnings False
    DoCmd.OpenQuery stDocName, acNormal, acEdit
    DoCmd.SetWarnings True

Exit_cmdSimDataDelete_Click:
    Exit Sub

Err_cmdSimDataDelete_Click:
    MsgBox Err.Description
```

```
    Resume Exit_cmdSimDataDelete_Click

End Sub
Private Sub cmdDelete_Click()
On Error GoTo Err_cmdDelete_Click

    Dim stDocName As String
    Dim stLinkCriteria As String

    stDocName = "DeleteData"
    DoCmd.OpenForm stDocName, , , stLinkCriteria

Exit_cmdDelete_Click:
    Exit Sub

Err_cmdDelete_Click:
    MsgBox Err.Description
    Resume Exit_cmdDelete_Click

End Sub
Private Sub cmdLoad_Click()
On Error GoTo Err_cmdLoad_Click

    Dim stDocName As String
    Dim stLinkCriteria As String

    stDocName = "LoadData"
    DoCmd.OpenForm stDocName, , , stLinkCriteria

Exit_cmdLoad_Click:
    Exit Sub

Err_cmdLoad_Click:
    MsgBox Err.Description
    Resume Exit_cmdLoad_Click

End Sub
Private Sub cmdExit_Click()
On Error GoTo Err_cmdExit_Click


    DoCmd.Quit

Exit_cmdExit_Click:
    Exit Sub

Err_cmdExit_Click:
    MsgBox Err.Description
    Resume Exit_cmdExit_Click

End Sub
Private Sub cmdEditNodes_Click()
On Error GoTo Err_cmdEditNodes_Click

    Dim stDocName As String
    Dim stLinkCriteria As String

    stDocName = "ValidNodes"
    DoCmd.OpenForm stDocName, acFormDS, , stLinkCriteria

Exit_cmdEditNodes_Click:
    Exit Sub
```

```
Err_cmdEditNodes_Click:
    MsgBox Err.Description
    Resume Exit_cmdEditNodes_Click

End Sub
```

Load Data Form

```
Option Compare Database
Option Explicit

Private WithEvents objTDoseData As TDoseData

Private Sub cmdFolder_Click()

    Dim objFD As FileDialog
    Dim varFolder As Variant

    ' Create FileDialog Object
    Set objFD = Application.FileDialog(msoFileDialogFolderPicker)

    ' Set Initial Folder Name
    If Not IsNull(txtFolder.Value) And txtFolder.Value <> "" Then
        objFD.InitialFileName = txtFolder.Value
    End If

    ' Show Dialog and Update txtFolder
    If objFD.Show = -1 Then
        For Each varFolder In objFD.SelectedItems

            ' Update TDoseData Folder
            objTDoseData.Folder = varFolder

            ' Handle Error Condition
            If Err.Number <> 0 Then
                MsgBox Err.Description, vbExclamation, "Invalid Folder!"
            End If

            ' Set txtFolder Value
            txtFolder.Value = objTDoseData.Folder
            txtFolder_AfterUpdate

        Next varFolder
    End If

    ' Release Object
    Set objFD = Nothing

End Sub

Private Sub cmdProcess_Click()

    ' Turn Hourglass On
    DoCmd.Hourglass True

    ' Move Focus
    txtFolder.SetFocus

    ' Disable Button
```

```
    cmdProcess.Enabled = False

    ' Clear Status Info
    txtFileCount.Value = ""
    txtNodeCount.Value = ""
    txtStartTime.Value = ""
    txtFinishTime.Value = ""
    txtStatus.Value = ""

    ' Load and Calculate Data
    objTDoseData.Process

    ' Update Status Info
    txtFileCount.Value = CStr(objTDoseData.FileCount)
    txtNodeCount.Value = CStr(objTDoseData.NodeCount)
    txtStartTime.Value = CStr(objTDoseData.StartTime)
    txtFinishTime.Value = CStr(objTDoseData.FinishTime)
    txtStatus.Value = objTDoseData.Status

    ' Turn Hourglass Off
    DoCmd.Hourglass False

End Sub

Private Sub Form_Load()

    Set objTDoseData = New TDoseData

End Sub

Private Sub Form_Unload(Cancel As Integer)

    Set objTDoseData = Nothing

    DoCmd.Hourglass False

End Sub

Private Sub objTDoseData_StatusUpdate()

    ' Update Status Info
    txtFileCount.Value = CStr(objTDoseData.FileCount)
    txtNodeCount.Value = CStr(objTDoseData.NodeCount)
    txtStartTime.Value = CStr(objTDoseData.StartTime)
    txtStatus.Value = objTDoseData.Status

    ' Repaint Form
    Me.Repaint

End Sub

Private Sub txtFolder_AfterUpdate()

    ' Enable Process Button?
    If Not IsNull(txtFolder.Value) And Not IsNull(txtSimulation.Value) Then
        If txtFolder.Value <> "" And txtSimulation.Value <> "" Then
            cmdProcess.Enabled = True
        Else
            cmdProcess.Enabled = False
        End If
    Else
        cmdProcess.Enabled = False
```

```
    End If

End Sub

Private Sub txtFolder_BeforeUpdate(Cancel As Integer)

    On Error Resume Next

    ' Update Folder
    If Not IsNull(txtFolder.Value) Then
        objTDoseData.Folder = txtFolder.Value
    Else
        objTDoseData.Folder = ""
    End If

    ' Handle Error Condition
    If Err.Number <> 0 Then
        MsgBox Err.Description, vbExclamation, "Invalid Folder"
        txtFolder.Value = objTDoseData.Folder
        Cancel = True
    End If

End Sub

Private Sub txtSimulation_AfterUpdate()

    ' Enable Process Button?
    If Not IsNull(txtFolder.Value) And Not IsNull(txtSimulation.Value) Then
        If txtFolder.Value <> "" And txtSimulation.Value <> "" Then
            cmdProcess.Enabled = True
        Else
            cmdProcess.Enabled = False
        End If
    Else
        cmdProcess.Enabled = False
    End If

End Sub

Private Sub txtSimulation_BeforeUpdate(Cancel As Integer)

    On Error Resume Next

    ' Update Simulation Name
    If Not IsNull(txtSimulation.Value) Then
        objTDoseData.Simulation = txtSimulation.Value
    Else
        objTDoseData.Simulation = ""
    End If

    ' Handle Error Condition
    If Err.Number <> 0 Then
        MsgBox Err.Description, vbExclamation, "Invalid Simulation Name"
        txtSimulation.Value = objTDoseData.Simulation
        Cancel = True
    End If

End Sub
```

Delete Data Form

```
Option Compare Database
Option Explicit

Private Sub cboSimulation_AfterUpdate()

End Sub

Private Sub cboSimulation_BeforeUpdate(Cancel As Integer)

    ' Enable/Disable Button
    If cboSimulation.Value = "" Or IsNull(cboSimulation.Value) Then
        cmdDelete.Enabled = False
    Else
        cmdDelete.Enabled = True
    End If

End Sub

Private Sub cmdDelete_Click()

    Dim lngResult As Long
    Dim strSQL As String

    ' Verify Delete
    lngResult = MsgBox("This will delete ALL data for simulation [" & cboSimulation.Value & _
                    "]!  Are you sure you want to delete?", vbYesNo, "Verify Simulation Delete")

    ' Delete simulation if user responded YES
    If lngResult = vbYes Then

        ' Build SQL Statement
        strSQL = "DELETE FROM TDoseData WHERE Simulation = '" & cboSimulation.Value & "'"

        ' Execute SQL Statement
        DoCmd.SetWarnings False
        DoCmd.RunSQL strSQL
        DoCmd.SetWarnings True

        ' ReQuery Combo Box
        cboSimulation.Requery
        cboSimulation.SetFocus
        cboSimulation.Value = ""

        ' Disable Command Button
        cmdDelete.Enabled = False

    End If

End Sub
```

Supplemental Notes

Table: TDoseData

Properties

DateCreated:	5/27/2003 7:13:13 PM	DefaultView:	Datasheet
GUID:	{guid {798BCC50-7B4F-4F5A-BE14-1C1ABA3E80EB}}	LastUpdated:	8/28/2003 12:58:21 PM
NameMap:	Long binary data	OrderByOn:	False
Orientation:	Left-to-Right	RecordCount:	0
Updatable:	True		

Columns

Name		Type	Size
Simulation		Text	20
AllowZeroLength:	False		
Attributes:	Variable Length		
CollatingOrder:	General		
ColumnHidden:	False		
ColumnOrder:	Default		
ColumnWidth:	Default		
DataUpdatable:	False		
Description:	Simulation Name		
DisplayControl:	Text Box		
GUID:	{guid {C50ABDDD-0F10-4823-BAFF-8DE5ABF923C3}}		
IMEMode:	0		
IMESentenceMode:	3		
OrdinalPosition:	0		
Required:	True		
SourceField:	Simulation		
SourceTable:	TDoseData		
UnicodeCompression:	True		
Time		Integer	2
AllowZeroLength:	False		
Attributes:	Fixed Size		
CollatingOrder:	General		
ColumnHidden:	False		
ColumnOrder:	Default		
ColumnWidth:	Default		
DataUpdatable:	False		
DecimalPlaces:	Auto		
Description:	Time		
DisplayControl:	Text Box		
GUID:	{guid {454D86BE-B80C-4457-8EFA-8D644916CCE1}}		
OrdinalPosition:	1		
Required:	True		
SourceField:	Time		
SourceTable:	TDoseData		
Node		Long Integer	4
AllowZeroLength:	False		
Attributes:	Fixed Size		
CollatingOrder:	General		
ColumnHidden:	False		
ColumnOrder:	Default		
ColumnWidth:	Default		
DataUpdatable:	False		
DecimalPlaces:	Auto		

	Description:	Node	
	DisplayControl:	Text Box	
	GUID:	{guid {C20C871B-55E0-452A-8C71-3ED2284D7CB4}}	
	OrdinalPosition:	2	
	Required:	True	
	SourceField:	Node	
	SourceTable:	TDoseData	
Temp		Single	4
	AllowZeroLength:	False	
	Attributes:	Fixed Size	
	CollatingOrder:	General	
	ColumnHidden:	False	
	ColumnOrder:	Default	
	ColumnWidth:	Default	
	DataUpdatable:	False	
	DecimalPlaces:	Auto	
	Description:	Node Temp	
	DisplayControl:	Text Box	
	GUID:	{guid {F28C7DA8-FB97-4B66-A65A-ADFFB92C053B}}	
	OrdinalPosition:	3	
	Required:	True	
	SourceField:	Temp	
	SourceTable:	TDoseData	
TDose		Double	8
	AllowZeroLength:	False	
	Attributes:	Fixed Size	
	CollatingOrder:	General	
	ColumnHidden:	False	
	ColumnOrder:	Default	
	ColumnWidth:	Default	
	DataUpdatable:	False	
	DecimalPlaces:	Auto	
	Description:	Thermal Dose - This Time Entry Only	
	DisplayControl:	Text Box	
	GUID:	{guid {9A916298-FC40-458D-AEE4-B646D9B0A618}}	
	OrdinalPosition:	4	
	Required:	False	
	SourceField:	TDose	
	SourceTable:	TDoseData	
CumTDose		Double	8
	AllowZeroLength:	False	
	Attributes:	Fixed Size	
	CollatingOrder:	General	
	ColumnHidden:	False	
	ColumnOrder:	Default	
	ColumnWidth:	Default	
	DataUpdatable:	False	
	DecimalPlaces:	Auto	
	Description:	Cummulative Thermal Dose - Current plus all previous	
	DisplayControl:	Text Box	
	GUID:	{guid {CAF21861-103C-48EA-B5E6-3C9354210C3C}}	
	OrdinalPosition:	5	
	Required:	False	
	SourceField:	CumTDose	
	SourceTable:	TDoseData	

Table Indexes

Name	Number of Fields
PrimaryKey	3
Clustered:	False
DistinctCount:	0
Foreign:	False
IgnoreNulls:	False
Name:	PrimaryKey
Primary:	True
Required:	True
Unique:	True
Fields:	
Simulation	Ascending
Time	Ascending
Node	Ascending
SimNode	2
Clustered:	False
DistinctCount:	0
Foreign:	False
IgnoreNulls:	False
Name:	SimNode
Primary:	False
Required:	False
Unique:	False
Fields:	
Simulation	Ascending
Node	Ascending

Table: ValidNodes

Properties

DateCreated:	5/30/2003 8:03:27 AM	DefaultView:	Datasheet
GUID:	{guid {6B2E4CA6-81F3-41DC-A293-EA07A8EE6F32}}	LastUpdated:	8/28/2003 12:57:48 PM
NameMap:	Long binary data	OrderByOn:	False
Orientation:	Left-to-Right	RecordCount:	441
Updatable:	True		

Columns

Name		Type	Size
Node		Long Integer	4
AllowZeroLength:	False		
Attributes:	Fixed Size		
CollatingOrder:	General		
ColumnHidden:	False		
ColumnOrder:	Default		
ColumnWidth:	Default		
DataUpdatable:	False		
DecimalPlaces:	Auto		
Description:	Node		
DisplayControl:	Text Box		
OrdinalPosition:	0		
Required:	True		
SourceField:	Node		
SourceTable:	ValidNodes		

Table Indexes

Name	Number of Fields
PrimaryKey	1
Clustered:	False
DistinctCount:	441
Foreign:	False
IgnoreNulls:	False
Name:	PrimaryKey
Primary:	True
Required:	True
Unique:	True
Fields:	
Node	Ascending

Query: SimulationList

Properties

DateCreated:	6/29/2003 9:14:33 PM	DefaultView:	Datasheet
DOL:	Long binary data	GUID:	{guid {34E079B1-50CF-4524-B047-C40E68CFE8F8}}
LastUpdated:	6/29/2003 9:14:58 PM	MaxRecords:	0
NameMap:	Long binary data	ODBCTimeout:	60
OrderByOn:	False	Orientation:	Left-to-Right
RecordLocks:	No Locks	RecordsAffected:	0
RecordsetType:	Dynaset	ReturnsRecords:	True
Type:	0	Updatable:	True

SQL

```
SELECT TDoseData.Simulation
FROM TDoseData
GROUP BY TDoseData.Simulation;
```

Columns

Name		Type	Size
Simulation		Text	20
AllowZeroLength:	False		
Attributes:	Variable Length		
CollatingOrder:	General		
ColumnHidden:	False		
ColumnOrder:	Default		
ColumnWidth:	Default		
DataUpdatable:	False		
Description:	Simulation Name		
DisplayControl:	Text Box		
GUID:	{guid {C50ABDDD-0F10-4823-BAFF-8DE5ABF923C3}}		
IMEMode:	0		
IMESentenceMode:	3		
OrdinalPosition:	0		
Required:	True		
SourceField:	Simulation		
SourceTable:	TDoseData		
UnicodeCompression:	True		

Table Indexes

Name	Number of Fields
PrimaryKey	3
Clustered:	False
DistinctCount:	0
Foreign:	False
IgnoreNulls:	False
Name:	PrimaryKey
Primary:	True
Required:	True
Unique:	True

Query: SimulationList

Fields:	
Simulation	Ascending
Time	Ascending
Node	Ascending
SimNode	2
Clustered:	False
DistinctCount:	0
Foreign:	False
IgnoreNulls:	False
Name:	SimNode
Primary:	False
Required:	False
Unique:	False
Fields:	
Simulation	Ascending
Node	Ascending

User Permissions

admin	Delete, Read Permissions, Set Permissions, Change Owner, Read Definition, Write Definition, Read Data, Insert Data, Update Data, Delete Data

Group Permissions

Admins	Delete, Read Permissions, Set Permissions, Change Owner, Read Definition, Write Definition, Read Data, Insert Data, Update Data, Delete Data
Users	Delete, Read Permissions, Set Permissions, Change Owner, Read Definition, Write Definition, Read Data, Insert Data, Update Data, Delete Data

Query: TDoseData_Node

Properties

DateCreated:	5/28/2003 12:58:12 AM	DefaultView:	Datasheet
DOL:	Long binary data	GUID:	{guid {1770A3AE-ADCB-462D-AD86-6300EBD7F5F7}}

LastUpdated:	7/1/2003 1:16:26 PM	MaxRecords:	0
NameMap:	Long binary data	ODBCTimeout:	60
OrderByOn:	False	Orientation:	Left-to-Right
RecordLocks:	No Locks	RecordsAffected:	0
RecordsetType:	Dynaset	ReturnsRecords:	True
Type:	0	Updatable:	True

SQL

```
PARAMETERS Simulation Text ( 255 ), Node Short;
SELECT TDoseData.*
FROM TDoseData
WHERE (((TDoseData.Node)=[Node]) AND ((TDoseData.Simulation)=[Simulation]))
ORDER BY TDoseData.Time, TDoseData.Time;
```

Query Parameters

Name	Type
Simulation	Text
Node	Integer

Columns

Name		Type	Size
Simulation		Text	20
	AllowZeroLength:	False	
	Attributes:	Variable Length, Updatable	
	CollatingOrder:	General	
	ColumnHidden:	False	
	ColumnOrder:	Default	
	ColumnWidth:	Default	
	DataUpdatable:	True	
	Description:	Simulation Name	
	DisplayControl:	Text Box	
	GUID:	{guid {C50ABDDD-0F10-4823-BAFF-8DE5ABF923C3}}	
	IMEMode:	0	
	IMESentenceMode:	3	
	OrdinalPosition:	0	
	Required:	True	
	SourceField:	Simulation	
	SourceTable:	TDoseData	
	UnicodeCompression:	True	
Time		Integer	2
	AllowZeroLength:	False	
	Attributes:	Fixed Size, Updatable	
	CollatingOrder:	General	
	ColumnHidden:	False	

ColumnOrder:	Default
ColumnWidth:	Default
DataUpdatable:	True
DecimalPlaces:	Auto
Description:	Time
DisplayControl:	Text Box
GUID:	{guid {454D86BE-B80C-4457-8EFA-8D644916CCE1}}
OrdinalPosition:	1

	Required:	True	
	SourceField:	Time	
	SourceTable:	TDoseData	
Node		Long Integer	4
	AllowZeroLength:	False	
	Attributes:	Fixed Size, Updatable	
	CollatingOrder:	General	
	ColumnHidden:	False	
	ColumnOrder:	Default	
	ColumnWidth:	Default	
	DataUpdatable:	True	
	DecimalPlaces:	Auto	
	Description:	Node	
	DisplayControl:	Text Box	
	GUID:	{guid {C20C871B-55E0-452A-8C71-3ED2284D7CB4}}	
	OrdinalPosition:	2	
	Required:	True	
	SourceField:	Node	
	SourceTable:	TDoseData	
Temp		Single	4
	AllowZeroLength:	False	
	Attributes:	Fixed Size, Updatable	
	CollatingOrder:	General	
	ColumnHidden:	False	
	ColumnOrder:	Default	
	ColumnWidth:	Default	
	DataUpdatable:	True	
	DecimalPlaces:	Auto	
	Description:	Node Temp	
	DisplayControl:	Text Box	
	GUID:	{guid {F28C7DA8-FB97-4B66-A65A-ADFFB92C053B}}	
	OrdinalPosition:	3	
	Required:	True	
	SourceField:	Temp	
	SourceTable:	TDoseData	
TDose		Double	8
	AllowZeroLength:	False	
	Attributes:	Fixed Size, Updatable	
	CollatingOrder:	General	
	ColumnHidden:	False	
	ColumnOrder:	Default	
	ColumnWidth:	Default	
	DataUpdatable:	True	
	DecimalPlaces:	Auto	
	Description:	Thermal Dose - This Time Entry Only	

	DisplayControl:	Text Box	
	GUID:	{guid {9A916298-FC40-458D-AEE4-B646D9B0A618}}	
	OrdinalPosition:	4	
	Required:	False	
	SourceField:	TDose	
	SourceTable:	TDoseData	
CumTDose		Double	8
	AllowZeroLength:	False	
	Attributes:	Fixed Size, Updatable	
	CollatingOrder:	General	

ColumnHidden:	False
ColumnOrder:	Default
ColumnWidth:	Default
DataUpdatable:	True
DecimalPlaces:	Auto
Description:	Cummulative Thermal Dose - Current plus all previous
DisplayControl:	Text Box
GUID:	{guid {CAF21861-103C-48EA-B5E6-3C9354210C3C}}
OrdinalPosition:	5
Required:	False
SourceField:	CumTDose
SourceTable:	TDoseData

Table Indexes

Name	Number of Fields
PrimaryKey	3
Clustered:	False
DistinctCount:	0
Foreign:	False
IgnoreNulls:	False
Name:	PrimaryKey
Primary:	True
Required:	True
Unique:	True
Fields:	
Simulation	Ascending
Time	Ascending
Node	Ascending
SimNode	2
Clustered:	False
DistinctCount:	0
Foreign:	False
IgnoreNulls:	False
Name:	SimNode
Primary:	False
Required:	False
Unique:	False
Fields:	
Simulation	Ascending
Node	Ascending

Query: TDoseData_Node

User Permissions

admin	Delete, Read Permissions, Set Permissions, Change Owner, Read Definition, Write Definition, Read Data, Insert Data, Update Data, Delete Data

Group Permissions

Admins	Delete, Read Permissions, Set Permissions, Change Owner, Read Definition, Write Definition, Read Data, Insert Data, Update Data, Delete Data
Users	Delete, Read Permissions, Set Permissions, Change Owner, Read Definition, Write Definition, Read Data, Insert Data, Update Data, Delete Data

Query: TDoseData_Simulation

Properties

DateCreated:	6/29/2003 9:36:07 PM	DefaultView:	Datasheet
DOL:	Long binary data	GUID:	{guid {AF8DA3FA-8E7B-4C83-B08D-7245F88DB7AC}}
LastUpdated:	7/1/2003 1:16:50 PM	MaxRecords:	0
NameMap:	Long binary data	ODBCTimeout:	60
OrderByOn:	False	Orientation:	Left-to-Right
RecordLocks:	No Locks	RecordsAffected:	0
RecordsetType:	Dynaset	ReturnsRecords:	True
Type:	0	Updatable:	True

SQL

```
PARAMETERS Simulation Text ( 255 );
SELECT TDoseData.*
FROM TDoseData
WHERE (((TDoseData.Simulation)=[Simulation]))
ORDER BY TDoseData.Time, TDoseData.Time, TDoseData.Node;
```

Query Parameters

Name	Type
Simulation	Text

Columns

Name	Type	Size
Simulation	Text	20

AllowZeroLength:	False
Attributes:	Variable Length, Updatable
CollatingOrder:	General
ColumnHidden:	False
ColumnOrder:	Default
ColumnWidth:	Default
DataUpdatable:	True
Description:	Simulation Name
DisplayControl:	Text Box
GUID:	{guid {C50ABDDD-0F10-4823-BAFF-8DE5ABF923C3}}
IMEMode:	0
IMESentenceMode:	3
OrdinalPosition:	0
Required:	True
SourceField:	Simulation
SourceTable:	TDoseData
UnicodeCompression:	True

Name	Type	Size
Time	Integer	2

AllowZeroLength:	False
Attributes:	Fixed Size, Updatable
CollatingOrder:	General
ColumnHidden:	False
ColumnOrder:	Default
ColumnWidth:	Default
DataUpdatable:	True

	DecimalPlaces:	Auto	
	Description:	Time	
	DisplayControl:	Text Box	
	GUID:	{guid {454D86BE-B80C-4457-8EFA-8D644916CCE1}}	
	OrdinalPosition:	1	
	Required:	True	
	SourceField:	Time	
	SourceTable:	TDoseData	
Node		Long Integer	4
	AllowZeroLength:	False	
	Attributes:	Fixed Size, Updatable	
	CollatingOrder:	General	
	ColumnHidden:	False	
	ColumnOrder:	Default	
	ColumnWidth:	Default	
	DataUpdatable:	True	
	DecimalPlaces:	Auto	
	Description:	Node	
	DisplayControl:	Text Box	
	GUID:	{guid {C20C871B-55E0-452A-8C71-3ED2284D7CB4}}	
	OrdinalPosition:	2	
	Required:	True	
	SourceField:	Node	
	SourceTable:	TDoseData	
Temp		Single	4
	AllowZeroLength:	False	
	Attributes:	Fixed Size, Updatable	
	CollatingOrder:	General	
	ColumnHidden:	False	
	ColumnOrder:	Default	
	ColumnWidth:	Default	
	DataUpdatable:	True	
	DecimalPlaces:	Auto	
	Description:	Node Temp	
	DisplayControl:	Text Box	
	GUID:	{guid {F28C7DA8-FB97-4B66-A65A-ADFFB92C053B}}	
	OrdinalPosition:	3	
	Required:	True	
	SourceField:	Temp	
	SourceTable:	TDoseData	
TDose		Double	8
	AllowZeroLength:	False	
	Attributes:	Fixed Size, Updatable	
	CollatingOrder:	General	
	ColumnHidden:	False	
	ColumnOrder:	Default	
	ColumnWidth:	Default	
	DataUpdatable:	True	
	DecimalPlaces:	Auto	
	Description:	Thermal Dose - This Time Entry Only	
	DisplayControl:	Text Box	
	GUID:	{guid {9A916298-FC40-458D-AEE4-B646D9B0A618}}	
	OrdinalPosition:	4	
	Required:	False	
	SourceField:	TDose	
	SourceTable:	TDoseData	
CumTDose		Double	8
	AllowZeroLength:	False	

Attributes:	Fixed Size, Updatable
CollatingOrder:	General
ColumnHidden:	False
ColumnOrder:	Default
ColumnWidth:	Default
DataUpdatable:	True
DecimalPlaces:	Auto
Description:	Cummulative Thermal Dose - Current plus all previous
DisplayControl:	Text Box
GUID:	{guid {CAF21861-103C-48EA-B5E6-3C9354210C3C}}
OrdinalPosition:	5
Required:	False
SourceField:	CumTDose
SourceTable:	TDoseData

Table Indexes

Name	Number of Fields
PrimaryKey	3
Clustered:	False
DistinctCount:	0
Foreign:	False
IgnoreNulls:	False
Name:	PrimaryKey
Primary:	True
Required:	True
Unique:	True
Fields:	
Simulation	Ascending
Time	Ascending
Node	Ascending
SimNode	2
Clustered:	False
DistinctCount:	0
Foreign:	False
IgnoreNulls:	False
Name:	SimNode
Primary:	False
Required:	False
Unique:	False
Fields:	
Simulation	Ascending
Node	Ascending

User Permissions

admin Delete, Read Permissions, Set Permissions, Change Owner, Read Definition,
Write Definition, Read Data, Insert Data, Update Data, Delete Data

Group Permissions

Admins	Delete, Read Permissions, Set Permissions, Change Owner, Read Definition, Write Definition, Read Data, Insert Data, Update Data, Delete Data
Users	Delete, Read Permissions, Set Permissions, Change Owner, Read Definition, Write Definition, Read Data, Insert Data, Update Data, Delete Data

Query: TDoseData_Time

Properties

DateCreated:	6/29/2003 8:08:46 PM	DefaultView:	Datasheet
DOL:	Long binary data	GUID:	{guid {0EEAC70C-9D6C-418E-913B-D60F8D0B02F4}}
LastUpdated:	7/1/2003 1:16:08 PM	MaxRecords:	0
NameMap:	Long binary data	ODBCTimeout:	60
OrderByOn:	False	Orientation:	Left-to-Right
RecordLocks:	No Locks	RecordsAffected:	0
RecordsetType:	Dynaset	ReturnsRecords:	True
Type:	0	Updatable:	True

SQL

```
PARAMETERS Simulation Text ( 255 ), [Time] Short;
SELECT TDoseData.*
FROM TDoseData
WHERE (((TDoseData.Time)=[Time]) AND ((TDoseData.Simulation)=[Simulation]))
ORDER BY TDoseData.Time, TDoseData.Node;
```

Query Parameters

Name	Type
Simulation	Text
Time	Integer

Columns

Name	Type	Size
Simulation	Text	20

AllowZeroLength:	False
Attributes:	Variable Length, Updatable
CollatingOrder:	General
ColumnHidden:	False
ColumnOrder:	Default
ColumnWidth:	Default
DataUpdatable:	True
Description:	Simulation Name
DisplayControl:	Text Box
GUID:	{guid {C50ABDDD-0F10-4823-BAFF-8DE5ABF923C3}}
IMEMode:	0
IMESentenceMode:	3
OrdinalPosition:	0
Required:	True
SourceField:	Simulation
SourceTable:	TDoseData
UnicodeCompression:	True

Name	Type	Size
Time	Integer	2

AllowZeroLength:	False
Attributes:	Fixed Size, Updatable
CollatingOrder:	General
ColumnHidden:	False
ColumnOrder:	Default
ColumnWidth:	Default

	DataUpdatable:	True	
	DecimalPlaces:	Auto	
	Description:	Time	
	DisplayControl:	Text Box	
	GUID:	{guid {454D86BE-B80C-4457-8EFA-8D644916CCE1}}	
	OrdinalPosition:	1	
	Required:	True	
	SourceField:	Time	
	SourceTable:	TDoseData	
Node		Long Integer	4
	AllowZeroLength:	False	
	Attributes:	Fixed Size, Updatable	
	CollatingOrder:	General	
	ColumnHidden:	False	
	ColumnOrder:	Default	
	ColumnWidth:	Default	
	DataUpdatable:	True	
	DecimalPlaces:	Auto	
	Description:	Node	
	DisplayControl:	Text Box	
	GUID:	{guid {C20C871B-55E0-452A-8C71-3ED2284D7CB4}}	
	OrdinalPosition:	2	
	Required:	True	
	SourceField:	Node	
	SourceTable:	TDoseData	
Temp		Single	4
	AllowZeroLength:	False	
	Attributes:	Fixed Size, Updatable	
	CollatingOrder:	General	
	ColumnHidden:	False	
	ColumnOrder:	Default	
	ColumnWidth:	Default	
	DataUpdatable:	True	
	DecimalPlaces:	Auto	
	Description:	Node Temp	
	DisplayControl:	Text Box	
	GUID:	{guid {F28C7DA8-FB97-4B66-A65A-ADFFB92C053B}}	
	OrdinalPosition:	3	
	Required:	True	
	SourceField:	Temp	
	SourceTable:	TDoseData	
TDose		Double	8
	AllowZeroLength:	False	
	Attributes:	Fixed Size, Updatable	
	CollatingOrder:	General	
	ColumnHidden:	False	
	ColumnOrder:	Default	
	ColumnWidth:	Default	
	DataUpdatable:	True	
	DecimalPlaces:	Auto	
	Description:	Thermal Dose - This Time Entry Only	
	DisplayControl:	Text Box	
	GUID:	{guid {9A916298-FC40-458D-AEE4-B646D9B0A618}}	
	OrdinalPosition:	4	
	Required:	False	
	SourceField:	TDose	
	SourceTable:	TDoseData	
CumTDose		Double	8

AllowZeroLength:	False
Attributes:	Fixed Size, Updatable
CollatingOrder:	General
ColumnHidden:	False
ColumnOrder:	Default
ColumnWidth:	Default
DataUpdatable:	True
DecimalPlaces:	Auto
Description:	Cummulative Thermal Dose - Current plus all previous
DisplayControl:	Text Box
GUID:	{guid {CAF21861-103C-48EA-B5E6-3C9354210C3C}}
OrdinalPosition:	5
Required:	False
SourceField:	CumTDose
SourceTable:	TDoseData

Table Indexes

Name		Number of Fields
PrimaryKey		3
	Clustered:	False
	DistinctCount:	0
	Foreign:	False
	IgnoreNulls:	False
	Name:	PrimaryKey
	Primary:	True
	Required:	True
	Unique:	True
	Fields:	
	Simulation	Ascending
	Time	Ascending
	Node	Ascending
SimNode		2
	Clustered:	False
	DistinctCount:	0
	Foreign:	False
	IgnoreNulls:	False
	Name:	SimNode
	Primary:	False
	Required:	False
	Unique:	False
	Fields:	
	Simulation	Ascending
	Node	Ascending

User Permissions

admin	Delete, Read Permissions, Set Permissions, Change Owner, Read Definition, Write Definition, Read Data, Insert Data, Update Data, Delete Data

Group Permissions

Admins	Delete, Read Permissions, Set Permissions, Change Owner, Read Definition, Write Definition, Read Data, Insert Data, Update Data, Delete Data
Users	Delete, Read Permissions, Set Permissions, Change Owner, Read Definition, Write Definition, Read Data, Insert Data, Update Data, Delete Data

Form: DeleteData

Properties

AllowAdditions:	True	AllowDatasheetView:	False
AllowDeletions:	True	AllowDesignChanges:	True
AllowEditing:	True	AllowEdits:	True
AllowFilters:	False	AllowFormView:	True
AllowPivotChartView:	False	AllowPivotTableView:	False
AllowUpdating:	No	AutoCenter:	False
AutoResize:	True	BorderStyle:	Dialog
Caption:	Delete Thermal Dose Data	CloseButton:	True
Container:	Forms	ControlBox:	True
Count:	3	CurrentView:	0
Cycle:	All Records	DataEntry:	False
DatasheetBackColor:	16777215	DatasheetBorderLineStyle:	1
DatasheetCellsEffect:	Flat	DatasheetColumnHeaderUn	1
DatasheetFontHeight:	10	DatasheetFontItalic:	False
DatasheetFontName:	Arial	DatasheetFontUnderline:	False
DatasheetFontWeight:	Normal	DatasheetForeColor:	0
DatasheetGridlinesBehavior:	Both	DatasheetGridlinesColor:	12632256
DateCreated:	6/29/2003 11:00:22 PM	DefaultEditing:	2
DefaultView:	Single Form	DividingLines:	False
FastLaserPrinting:	True	FetchDefaults:	True
FilterOn:	False	FrozenColumns:	1
GridX:	24	GridY:	24
GUID:	{guid {A052E89C-7F09-4FB4-9F70-81E38116B230}}	HasModule:	True
HelpContextId:	0	HorizontalDatasheetGridline	1
Hwnd:	1770442	InsideHeight:	1425
InsideWidth:	2880	KeyPreview:	False
LastUpdated:	6/29/2003 11:00:22 PM	LayoutForPrint:	False
LogicalPageWidth:	9360	MaxButton:	False
MinButton:	False	MinMaxButtons:	None
Modal:	False	Moveable:	True
NameMap:	Long binary data	NavigationButtons:	False
OrderByOn:	False	Orientation:	Left-to-Right
Owner:	admin	Painting:	True
PaletteSource:	(Default)	Picture:	(none)
PictureAlignment:	Center	PictureSizeMode:	Clip
PictureTiling:	False	PictureType:	0
PopUp:	False	PrtDevMode:	Long binary data
PrtDevNames:	Long binary data	PrtMip:	Long binary data
RecordLocks:	No Locks	RecordSelectors:	False
RecordsetType:	Dynaset	RowHeight:	Default
ScrollBars:	Neither	ShortcutMenu:	True
ShowGrid:	True	SubdatasheetExpanded:	False
SubdatasheetHeight:	0	TimerInterval:	0
UserName:	admin	VerticalDatasheetGridlineSty	1
ViewsAllowed:	Form	Visible:	False
WhatsThisButton:	False	Width:	2880
WindowHeight:	2130	WindowLeft:	3750
WindowTop:	15	WindowWidth:	3300

Objects

Section: Detail

BackColor:	-2147483633	CanGrow:	False
CanShrink:	False	DisplayWhen:	Always
EventProcPrefix:	Detail	ForceNewPage:	None

HasContinued:	False	Height:	1440
InSelection:	False	KeepTogether:	False
Name:	Detail	NewRowOrCol:	None
SpecialEffect:	Flat	Visible:	True
WillContinue:	False		

Combo Box: cboSimulation

AfterUpdate:	[Event Procedure]	AllowAutoCorrect:	True
AutoExpand:	True	BackColor:	16777215
BackStyle:	Normal	BeforeUpdate:	[Event Procedure]
BorderColor:	0	BorderLineStyle:	Solid
BorderStyle:	Solid	BorderWidth:	Hairline
BoundColumn:	1	ColumnCount:	1
ColumnHeads:	False	ColumnHidden:	False
ColumnOrder:	Default	ColumnWidth:	Default
ColumnWidths:	2880	ControlType:	111
DecimalPlaces:	Auto	DisplayWhen:	Always
Enabled:	True	EventProcPrefix:	cboSimulation
FontBold:	No	FontItalic:	False
FontName:	Tahoma	FontSize:	8
FontUnderline:	False	FontWeight:	Normal
ForeColor:	0	Height:	240
HelpContextId:	0	IMEHold:	False
IMEMode:	0	IMESentenceMode:	3
IsHyperlink:	False	KeyboardLanguage:	0
Left:	180	LimitToList:	True
ListRows:	8	ListWidth:	2880
Locked:	False	Name:	cboSimulation
NumeralShapes:	System	OldBorderStyle:	1
ReadingOrder:	Context	RowSource:	SELECT SimulationList.Simulation FROM SimulationList;
RowSourceType:	Table/Query	ScrollBarAlign:	System
Section:	0	SpecialEffect:	Sunken
TabIndex:	0	TabStop:	True
TextAlign:	General	TextFontCharSet:	0
Top:	420	Visible:	True
Width:	2520		

Command Button: cmdDelete

AutoRepeat:	False	Cancel:	False
Caption:	Delete	ControlType:	104
Default:	False	DisplayWhen:	Always
Enabled:	False	EventProcPrefix:	cmdDelete
FontBold:	No	FontItalic:	False
FontName:	Tahoma	FontSize:	8
FontUnderline:	False	FontWeight:	Normal
ForeColor:	-2147483630	Height:	300
HelpContextId:	0	Left:	720
Name:	cmdDelete	OnClick:	[Event Procedure]
Picture:	(none)	PictureType:	0
ReadingOrder:	Context	Section:	0
TabIndex:	1	TabStop:	True
TextFontCharSet:	0	Top:	960
Transparent:	False	Visible:	True
Width:	1440		

Label: Label5

BackColor:	16777215	BackStyle:	Transparent
BorderColor:	0	BorderLineStyle:	Solid
BorderStyle:	Transparent	BorderWidth:	Hairline

BottomMargin: 0
ControlType: 100
EventProcPrefix:
FontItalic: False
FontSize: 8
FontWeight: Normal
Height: 210
Left: 180
LineSpacing: 0
NumeralShapes:
ReadingOrder: Context
Section: 0
TextAlign: General
Top: 180
Vertical: False
Width: 1245

Caption: Simulation Name
DisplayWhen: Always
Label5 FontBold: No
FontName: Tahoma
FontUnderline: False
ForeColor: 0
HelpContextId: 0
LeftMargin: 0
Name: Label5
System OldBorderStyle: 0
RightMargin: 0
SpecialEffect: Flat
TextFontCharSet: 0
TopMargin: 0
Visible: True

<u>Code</u>

```
VERSION 1.0 CLASS
BEGIN
  MultiUse = -1  'True
END
Attribute VB_Name = "Form_DeleteData"
Attribute VB_GlobalNameSpace = False
Attribute VB_Creatable = True
Attribute VB_PredeclaredId = True
Attribute VB_Exposed = False
Option Compare Database
Option Explicit

Private Sub cboSimulation_AfterUpdate()

End Sub

Private Sub cboSimulation_BeforeUpdate(Cancel As Integer)

    ' Enable/Disable Button
    If cboSimulation.Value = "" Or IsNull(cboSimulation.Value) Then
        cmdDelete.Enabled = False
    Else
        cmdDelete.Enabled = True
    End If

End Sub

Private Sub cmdDelete_Click()

    Dim lngResult As Long
    Dim strSQL As String

    ' Verify Delete
    lngResult = MsgBox("This will delete ALL data for simulation [" & cboSimulation.Value & _
                   "]!  Are you sure you want to delete?", vbYesNo, "Verify Simulation Delete")

    ' Delete simulation if user responded YES
    If lngResult = vbYes Then

        ' Build SQL Statement
        strSQL = "DELETE FROM TDoseData WHERE Simulation = '" & cboSimulation.Value
```

```
& """

        ' Execute SQL Statement
        DoCmd.SetWarnings False
        DoCmd.RunSQL strSQL
        DoCmd.SetWarnings True

        ' ReQuery Combo Box
        cboSimulation.Requery
        cboSimulation.SetFocus
        cboSimulation.Value = ""

        ' Disable Command Button
        cmdDelete.Enabled = False

    End If

End Sub
```

User Permissions

admin	Delete, Read Permissions, Set Permissions, Change Owner, Read Definition, Modify Definition, Execute

Group Permissions

Admins	Delete, Read Permissions, Set Permissions, Change Owner, Read Definition, Modify Definition, Execute
Users	Delete, Read Permissions, Set Permissions, Change Owner, Read Definition, Modify Definition, Execute

Form: LoadData

Properties

AllowAdditions:	True	AllowDatasheetView:	False
AllowDeletions:	True	AllowDesignChanges:	True
AllowEditing:	True	AllowEdits:	True
AllowFilters:	True	AllowFormView:	True
AllowPivotChartView:	False	AllowPivotTableView:	False
AllowUpdating:	No	AutoCenter:	False
AutoResize:	True	BorderStyle:	Dialog
Caption:	Load Thermal Dose Data	CloseButton:	True
Container:	Forms	ControlBox:	True
Count:	18	CurrentView:	0
Cycle:	All Records	DataEntry:	False
DatasheetBackColor:	16777215	DatasheetBorderLineStyle:	1
DatasheetCellsEffect:	Flat	DatasheetColumnHeaderUn	1
DatasheetFontHeight:	10	DatasheetFontItalic:	False
DatasheetFontName:	Arial	DatasheetFontUnderline:	False
DatasheetFontWeight:	Normal	DatasheetForeColor:	0
DatasheetGridlinesBehavior:		Both	DatasheetGridlinesColor:
12632256			
DateCreated:	5/29/2003 11:25:36 PM	DefaultEditing:	2
DefaultView:	Single Form	DividingLines:	True
FastLaserPrinting:	True	FetchDefaults:	True
FilterOn:	False	FrozenColumns:	1
GridX:	24	GridY:	24

GUID:	{guid {79B2010A-F3F8-4B35-A488-2284E94E9D26}}	HasModule:	True
HelpContextId:	0	HorizontalDatasheetGridline	1
Hwnd:	1835978	InsideHeight:	5715
InsideWidth:	9255	KeyPreview:	False
LastUpdated:	5/29/2003 11:25:36 PM	LayoutForPrint:	False
LogicalPageWidth:	9360	MaxButton:	False
MinButton:	True	MinMaxButtons:	Min Enabled
Modal:	False	Moveable:	True
NameMap:	Long binary data	NavigationButtons:	False
OnLoad:	[Event Procedure]	OnUnload:	[Event Procedure]
OrderByOn:	False	Orientation:	Left-to-Right
Owner:	admin	Painting:	True
PaletteSource:	(Default)	Picture:	(none)
PictureAlignment:	Center	PictureSizeMode:	Clip
PictureTiling:	False	PictureType:	0
PopUp:	False	PrtDevMode:	Long binary data
PrtDevNames:	Long binary data	PrtMip:	Long binary data
RecordLocks:	No Locks	RecordSelectors:	False
RecordsetType:	Dynaset	RowHeight:	Default
ScrollBars:	Neither	ShortcutMenu:	True
ShowGrid:	True	SubdatasheetExpanded:	False
SubdatasheetHeight:	0	TimerInterval:	0
UserName:	admin	VerticalDatasheetGridlineSty	1
ViewsAllowed:	Form	Visible:	False
WhatsThisButton:	False	Width:	6360
WindowHeight:	6420	WindowLeft:	1080
WindowTop:	330	WindowWidth:	9675

<u>Objects</u>

Section: Detail

BackColor:	-2147483633	CanGrow:	False
CanShrink:	False	DisplayWhen:	Always
EventProcPrefix:	Detail	ForceNewPage:	None
HasContinued:	False	Height:	3060
InSelection:	False	KeepTogether:	False
Name:	Detail	NewRowOrCol:	None
SpecialEffect:	Flat	Visible:	True
WillContinue:	False		

Command Button: cmdFolder

AutoRepeat:	False	Cancel:	False
Caption:	...	ControlType:	104
Default:	False	DisplayWhen:	Always
Enabled:	True	EventProcPrefix:	cmdFolder
FontBold:	No	FontItalic:	False
FontName:	Tahoma	FontSize:	8
FontUnderline:	False	FontWeight:	Normal
ForeColor:	-2147483630	Height:	300
HelpContextId:	0	Left:	5820
Name:	cmdFolder	OnClick:	[Event Procedure]
Picture:	(none)	PictureType:	0
ReadingOrder:	Context	Section:	0
TabIndex:	9	TabStop:	True
TextFontCharSet:	0	Top:	180
Transparent:	False	Visible:	True
Width:	360		

Command Button: cmdProcess

AutoRepeat:	False	Cancel:	False
Caption:	Process	ControlType:	104

Default:	False	DisplayWhen:	Always
Enabled:	False	EventProcPrefix:	cmdProcess
FontBold:	No	FontItalic:	False
FontName:	Tahoma	FontSize:	8
FontUnderline:	False	FontWeight:	Normal
ForeColor:	-2147483630	Height:	360
HelpContextId:	0	Left:	4800
Name:	cmdProcess	OnClick:	[Event Procedure]
Picture:	(none)	PictureType:	0
ReadingOrder:	Context	Section:	0
TabIndex:	2	TabStop:	True
TextFontCharSet:		0	Top: 2580
Transparent:	False	Visible:	True
Width:	1440		

Option Group: frmStatus

BackColor:	16777215	BackStyle:	Transparent
BorderColor:	0	BorderLineStyle:	Solid
BorderStyle:	Solid	BorderWidth:	Hairline
ColumnHidden:	False	ColumnOrder:	Default
ColumnWidth:	Default	ControlType:	107
DisplayWhen:	Always	Enabled:	True
EventProcPrefix:		frmStatus	Height: 1380
HelpContextId:	0	Left:	120
Locked:	False	Name:	frmStatus
OldBorderStyle:	1	Section:	0
SpecialEffect:	Etched	TabIndex:	3
TabStop:	True	Top:	1080
Visible:	True	Width:	6120

Label: lblFileCount

BackColor:	16777215	BackStyle:	Transparent
BorderColor:	0	BorderLineStyle:	Solid
BorderStyle:	Transparent	BorderWidth:	Hairline
BottomMargin:	0	Caption:	Files Processed
ControlType:	100	DisplayWhen:	Always
EventProcPrefix:		lblFileCount	FontBold: No
FontItalic:	False	FontName:	Tahoma
FontSize:	8	FontUnderline:	False
FontWeight:	Normal	ForeColor:	0
Height:	210	HelpContextId:	0
Left:	180	LeftMargin:	0
LineSpacing:	0	Name:	lblFileCount
NumeralShapes:		System	OldBorderStyle: 0
ReadingOrder:	Context	RightMargin:	0
Section:	0	SpecialEffect:	Flat
TextAlign:	Right	TextFontCharSet:	0
Top:	1320	TopMargin:	0
Vertical:	False	Visible:	True
Width:	1320		

Label: lblFinishTime

BackColor:	16777215	BackStyle:	Transparent
BorderColor:	0	BorderLineStyle:	Solid
BorderStyle:	Transparent	BorderWidth:	Hairline
BottomMargin:	0	Caption:	Finish Time
ControlType:	100	DisplayWhen:	Always
EventProcPrefix:		lblFinishTime	FontBold: No
FontItalic:	False	FontName:	Tahoma
FontSize:	8	FontUnderline:	False
FontWeight:	Normal	ForeColor:	0
Height:	210	HelpContextId:	0
Left:	3060	LeftMargin:	0

LineSpacing: 0
NumeralShapes: System
ReadingOrder: Context
Section: 0
TextAlign: Right
Top: 1680
Vertical: False
Width: 1020

Name: lblFinishTime
OldBorderStyle: 0
RightMargin: 0
SpecialEffect: Flat
TextFontCharSet: 0
TopMargin: 0
Visible: True

Label: lblFolder

BackColor: 16777215
BorderColor: 0
BorderStyle: Transparent
BottomMargin: 0
ControlType: 100
EventProcPrefix: lblFolder
FontItalic: False
FontSize: 8
FontWeight: Normal
Height: 240
Left: 180
LineSpacing: 0
NumeralShapes: System
ReadingOrder: Context
Section: 0
TextAlign: Right
Top: 180
Vertical: False
Width: 1185

BackStyle: Transparent
BorderLineStyle: Solid
BorderWidth: Hairline
Caption: Source Folder
DisplayWhen: Always
FontBold: No
FontName: Tahoma
FontUnderline: False
ForeColor: 0
HelpContextId: 0
LeftMargin: 0
Name: lblFolder
OldBorderStyle: 0
RightMargin: 0
SpecialEffect: Flat
TextFontCharSet: 0
TopMargin: 0
Visible: True

Label: lblFrame

BackColor: -2147483633
BorderColor: 0
BorderStyle: Transparent
BottomMargin: 0
ControlType: 100
EventProcPrefix: lblFrame
FontItalic: False
FontSize: 8
FontWeight: Normal
Height: 240
Left: 300
LineSpacing: 0
NumeralShapes: System
ReadingOrder: Context
Section: 0
TextAlign: General
Top: 960
Vertical: False
Width: 1440

BackStyle: Normal
BorderLineStyle: Solid
BorderWidth: Hairline
Caption: Status Information
DisplayWhen: Always
FontBold: No
FontName: Tahoma
FontUnderline: False
ForeColor: 0
HelpContextId: 0
LeftMargin: 0
Name: lblFrame
OldBorderStyle: 0
RightMargin: 0
SpecialEffect: Flat
TextFontCharSet: 0
TopMargin: 0
Visible: True

Label: lblNodeCount

BackColor: 16777215
BorderColor: 0
BorderStyle: Transparent
BottomMargin: 0
ControlType: 100
EventProcPrefix: lblNodeCount
FontItalic: False
FontSize: 8
FontWeight: Normal
Height: 210
Left: 180

BackStyle: Transparent
BorderLineStyle: Solid
BorderWidth: Hairline
Caption: Nodes Processed
DisplayWhen: Always
FontBold: No
FontName: Tahoma
FontUnderline: False
ForeColor: 0
HelpContextId: 0
LeftMargin: 0

LineSpacing:	0	Name:	lblNodeCount	
NumeralShapes:		System	OldBorderStyle:	0
ReadingOrder:	Context	RightMargin:	0	
Section:	0	SpecialEffect:	Flat	
TextAlign:	Right	TextFontCharSet:	0	
Top:	1680	TopMargin:	0	
Vertical:	False	Visible:	True	
Width:	1320			

Label: lblSimulation

BackColor:	16777215	BackStyle:	Transparent	
BorderColor:	0	BorderLineStyle:	Solid	
BorderStyle:	Transparent	BorderWidth:	Hairline	
BottomMargin:	0	Caption:	Simulation	
ControlType:	100	DisplayWhen:	Always	
EventProcPrefix:		lblSimulation	FontBold:	No
FontItalic:	False	FontName:	Tahoma	
FontSize:	8	FontUnderline:	False	
FontWeight:	Normal	ForeColor:	0	
Height:	240	HelpContextId:	0	
Left:	60	LeftMargin:	0	
LineSpacing:	0	Name:	lblSimulation	
NumeralShapes:		System	OldBorderStyle:	0
ReadingOrder:	Context	RightMargin:	0	
Section:	0	SpecialEffect:	Flat	
TextAlign:	Right	TextFontCharSet:	0	
Top:	540	TopMargin:	0	
Vertical:	False	Visible:	True	
Width:	1305			

Label: lblStartTime

BackColor:	16777215	BackStyle:	Transparent	
BorderColor:	0	BorderLineStyle:	Solid	
BorderStyle:	Transparent	BorderWidth:	Hairline	
BottomMargin:	0	Caption:	Start Time	
ControlType:	100	DisplayWhen:	Always	
EventProcPrefix:		lblStartTime	FontBold:	No
FontItalic:	False	FontName:	Tahoma	
FontSize:	8	FontUnderline:	False	
FontWeight:	Normal	ForeColor:	0	
Height:	210	HelpContextId:	0	
Left:	3060	LeftMargin:	0	
LineSpacing:	0	Name:	lblStartTime	
NumeralShapes:		System	OldBorderStyle:	0
ReadingOrder:	Context	RightMargin:	0	
Section:	0	SpecialEffect:	Flat	
TextAlign:	Right	TextFontCharSet:	0	
Top:	1320	TopMargin:	0	
Vertical:	False	Visible:	True	
Width:	1020			

Label: lblStatus

BackColor:	16777215	BackStyle:	Transparent	
BorderColor:	0	BorderLineStyle:	Solid	
BorderStyle:	Transparent	BorderWidth:	Hairline	
BottomMargin:	0	Caption:	Current Status	
ControlType:	100	DisplayWhen:	Always	
EventProcPrefix:		lblStatus	FontBold:	No
FontItalic:	False	FontName:	Tahoma	
FontSize:	8	FontUnderline:	False	
FontWeight:	Normal	ForeColor:	0	
Height:	210	HelpContextId:	0	
Left:	180	LeftMargin:	0	

LineSpacing:	0	Name:	lblStatus	
NumeralShapes:		System	OldBorderStyle:	0
ReadingOrder:	Context	RightMargin:	0	
Section:	0	SpecialEffect:	Flat	
TextAlign:	Right	TextFontCharSet:	0	
Top:	2100	TopMargin:	0	
Vertical:	False	Visible:	True	
Width:	1320			

Text Box: txtFileCount

AllowAutoCorrect:		True	AutoTab:	False
BackColor:	16777215	BackStyle:	Normal	
BorderColor:	0	BorderLineStyle:	Solid	
BorderStyle:	Transparent	BorderWidth:	Hairline	
BottomMargin:	0	CanGrow:	False	
CanShrink:	False	ColumnHidden:	False	
ColumnOrder:	Default	ColumnWidth:	Default	
ControlType:	109	DecimalPlaces:	Auto	
DisplayWhen:	Always	Enabled:	False	
EnterKeyBehavior:		False	EventProcPrefix:	txtFileCount
FilterLookup:	Database Default	FontBold:	No	
FontItalic:	False	FontName:	Tahoma	
FontSize:	8	FontUnderline:	False	
FontWeight:	Normal	ForeColor:	0	
Height:	240	HelpContextId:	0	
IMEHold:	False	IMEMode:	0	
IMESentenceMode:		3	IsHyperlink:	False
KeyboardLanguage:		0	Left:	1560
LeftMargin:	0	LineSpacing:	0	
Locked:	False	Name:	txtFileCount	
NumeralShapes:		System	OldBorderStyle:	0
ReadingOrder:	Context	RightMargin:	0	
ScrollBarAlign:	System	ScrollBars:	Neither	
Section:	0	SpecialEffect:	Sunken	
TabIndex:	4	TabStop:	True	
TextAlign:	Right	TextFontCharSet:	0	
Top:	1320	TopMargin:	0	
Vertical:	False	Visible:	True	
Width:	1440			

Text Box: txtFinishTime

AllowAutoCorrect:		True	AutoTab:	False
BackColor:	16777215	BackStyle:	Normal	
BorderColor:	0	BorderLineStyle:	Solid	
BorderStyle:	Transparent	BorderWidth:	Hairline	
BottomMargin:	0	CanGrow:	False	
CanShrink:	False	ColumnHidden:	False	
ColumnOrder:	Default	ColumnWidth:	Default	
ControlType:	109	DecimalPlaces:	Auto	
DisplayWhen:	Always	Enabled:	False	
EnterKeyBehavior:		False	EventProcPrefix:	txtFinishTime
FilterLookup:	Database Default	FontBold:	No	
FontItalic:	False	FontName:	Tahoma	
FontSize:	8	FontUnderline:	False	
FontWeight:	Normal	ForeColor:	0	
Height:	240	HelpContextId:	0	
IMEHold:	False	IMEMode:	0	
IMESentenceMode:		3	IsHyperlink:	False
KeyboardLanguage:		0	Left:	4140
LeftMargin:	0	LineSpacing:	0	

Locked:	False	Name:	txtFinishTime	
NumeralShapes:		System	OldBorderStyle:	0
ReadingOrder:	Context	RightMargin:	0	
ScrollBarAlign:	System	ScrollBars:	Neither	
Section:	0	SpecialEffect:	Sunken	
TabIndex:	7	TabStop:	True	
TextAlign:	Right	TextFontCharSet:	0	
Top:	1680	TopMargin:	0	
Vertical:	False	Visible:	True	
Width:	1980			

Text Box: txtFolder

AfterUpdate:	[Event Procedure]	AllowAutoCorrect:	True	
AutoTab:	False	BackColor:	16777215	
BackStyle:	Normal	BeforeUpdate:	[Event Procedure]	
BorderColor:	0	BorderLineStyle:	Solid	
BorderStyle:	Transparent	BorderWidth:	Hairline	
BottomMargin:	0	CanGrow:	False	
CanShrink:	False	ColumnHidden:	False	
ColumnOrder:	Default	ColumnWidth:	Default	
ControlType:	109	DecimalPlaces:	Auto	
DisplayWhen:	Always	Enabled:	True	
EnterKeyBehavior:		False	EventProcPrefix:	txtFolder
FilterLookup:	Database Default	FontBold:	No	
FontItalic:	False	FontName:	Tahoma	
FontSize:	8	FontUnderline:	False	
FontWeight:	Normal	ForeColor:	0	
Height:	240	HelpContextId:	0	
IMEHold:	False	IMEMode:	0	
IMESentenceMode:		3	IsHyperlink:	False
KeyboardLanguage:		0	Left:	1440
LeftMargin:	0	LineSpacing:	0	
Locked:	False	Name:	txtFolder	
NumeralShapes:		System	OldBorderStyle:	0
ReadingOrder:	Context	RightMargin:	0	
ScrollBarAlign:	System	ScrollBars:	Neither	
Section:	0	SpecialEffect:	Sunken	
TabIndex:	0	TabStop:	True	
TextAlign:	General	TextFontCharSet:	0	
Top:	180	TopMargin:	0	
Vertical:	False	Visible:	True	
Width:	4320			

Text Box: txtNodeCount

AllowAutoCorrect:		True	AutoTab:	False
BackColor:	16777215	BackStyle:	Normal	
BorderColor:	0	BorderLineStyle:	Solid	
BorderStyle:	Transparent	BorderWidth:	Hairline	
BottomMargin:	0	CanGrow:	False	
CanShrink:	False	ColumnHidden:	False	
ColumnOrder:	Default	ColumnWidth:	Default	
ControlType:	109	DecimalPlaces:	Auto	
DisplayWhen:	Always	Enabled:	False	
EnterKeyBehavior:		False	EventProcPrefix:	txtNodeCount
FilterLookup:	Database Default	FontBold:	No	
FontItalic:	False	FontName:	Tahoma	
FontSize:	8	FontUnderline:	False	
FontWeight:	Normal	ForeColor:	0	
Height:	240	HelpContextId:	0	
IMEHold:	False	IMEMode:	0	
IMESentenceMode:		3	IsHyperlink:	False

KeyboardLanguage:	0	Left:	1560
LeftMargin:	0	LineSpacing:	0
Locked:	False	Name:	txtNodeCount
NumeralShapes:	System	OldBorderStyle:	0
ReadingOrder:	Context	RightMargin:	0
ScrollBarAlign:	System	ScrollBars:	Neither
Section:	0	SpecialEffect:	Sunken
TabIndex:	5	TabStop:	True
TextAlign:	Right	TextFontCharSet:	0
Top:	1680	TopMargin:	0
Vertical:	False	Visible:	True
Width:	1440		

Text Box: txtSimulation

AfterUpdate:	[Event Procedure]	AllowAutoCorrect:	True
AutoTab:	False	BackColor:	16777215
BackStyle:	Normal	BeforeUpdate:	[Event Procedure]
BorderColor:	0	BorderLineStyle:	Solid
BorderStyle:	Transparent	BorderWidth:	Hairline
BottomMargin:	0	CanGrow:	False
CanShrink:	False	ColumnHidden:	False
ColumnOrder:	Default	ColumnWidth:	Default
ControlType:	109	DecimalPlaces:	Auto
DisplayWhen:	Always	Enabled:	True
EnterKeyBehavior:	False	EventProcPrefix:	txtSimulation
FilterLookup:	Database Default	FontBold:	No
FontItalic:	False	FontName:	Tahoma
FontSize:	8	FontUnderline:	False
FontWeight:	Normal	ForeColor:	0
Height:	240	HelpContextId:	0
IMEHold:	False	IMEMode:	0
IMESentenceMode:	3	IsHyperlink:	False
KeyboardLanguage:	0	Left:	1440
LeftMargin:	0	LineSpacing:	0
Locked:	False	Name:	txtSimulation
NumeralShapes:	System	OldBorderStyle:	0
ReadingOrder:	Context	RightMargin:	0
ScrollBarAlign:	System	ScrollBars:	Neither
Section:	0	SpecialEffect:	Sunken
TabIndex:	1	TabStop:	True
TextAlign:	General	TextFontCharSet:	0
Top:	540	TopMargin:	0
Vertical:	False	Visible:	True
Width:	2880		

Text Box: txtStartTime

AllowAutoCorrect:	True	AutoTab:	False
BackColor:	16777215	BackStyle:	Normal
BorderColor:	0	BorderLineStyle:	Solid
BorderStyle:	Transparent	BorderWidth:	Hairline
BottomMargin:	0	CanGrow:	False
CanShrink:	False	ColumnHidden:	False
ColumnOrder:	Default	ColumnWidth:	Default
ControlType:	109	DecimalPlaces:	Auto
DisplayWhen:	Always	Enabled:	False
EnterKeyBehavior:	False	EventProcPrefix:	txtStartTime
FilterLookup:	Database Default	FontBold:	No

FontItalic: False | FontName: Tahoma
FontSize: 8 | FontUnderline: False
FontWeight: Normal | ForeColor: 0
Height: 240 | HelpContextId: 0
IMEHold: False | IMEMode: 0
IMESentenceMode: 3 | IsHyperlink: False
KeyboardLanguage: 0 | Left: 4140
LeftMargin: 0 | LineSpacing: 0
Locked: False | Name: txtStartTime
NumeralShapes: System | OldBorderStyle: 0
ReadingOrder: Context | RightMargin: 0
ScrollBarAlign: System | ScrollBars: Neither
Section: 0 | SpecialEffect: Sunken
TabIndex: 6 | TabStop: True
TextAlign: Right | TextFontCharSet: 0
Top: 1320 | TopMargin: 0
Vertical: False | Visible: True
Width: 1980

Text Box: txtStatus

AllowAutoCorrect: True | AutoTab: False
BackColor: 16777215 | BackStyle: Normal
BorderColor: 0 | BorderLineStyle: Solid
BorderStyle: Transparent | BorderWidth: Hairline
BottomMargin: 0 | CanGrow: False
CanShrink: False | ColumnHidden: False
ColumnOrder: Default | ColumnWidth: Default
ControlType: 109 | DecimalPlaces: Auto
DisplayWhen: Always | Enabled: False
EnterKeyBehavior: False | EventProcPrefix: txtStatus
FilterLookup: Database Default | FontBold: No
FontItalic: False | FontName: Tahoma
FontSize: 8 | FontUnderline: False
FontWeight: Normal | ForeColor: 0
Height: 240 | HelpContextId: 0
IMEHold: False | IMEMode: 0
IMESentenceMode: 3 | IsHyperlink: False
KeyboardLanguage: 0 | Left: 1560
LeftMargin: 0 | LineSpacing: 0
Locked: False | Name: txtStatus
NumeralShapes: System | OldBorderStyle: 0
ReadingOrder: Context | RightMargin: 0
ScrollBarAlign: System | ScrollBars: Neither
Section: 0 | SpecialEffect: Sunken
TabIndex: 8 | TabStop: True
TextAlign: General | TextFontCharSet: 0
Top: 2100 | TopMargin: 0
Vertical: False | Visible: True
Width: 4560

Code

```
VERSION 1.0 CLASS
BEGIN
  MultiUse = -1  'True
END
Attribute VB_Name = "Form_LoadData"
```

```
Attribute VB_GlobalNameSpace = False
Attribute VB_Creatable = True
Attribute VB_PredeclaredId = True
Attribute VB_Exposed = False
Option Compare Database
Option Explicit

Private WithEvents objTDoseData As TDoseData
Attribute objTDoseData.VB_VarHelpID = -1

Private Sub cmdFolder_Click()

    Dim objFD As FileDialog
    Dim varFolder As Variant

    ' Create FileDialog Object
    Set objFD = Application.FileDialog(msoFileDialogFolderPicker)

    ' Set Initial Folder Name
    If Not IsNull(txtFolder.Value) And txtFolder.Value <> "" Then
        objFD.InitialFileName = txtFolder.Value
    End If

    ' Show Dialog and Update txtFolder
    If objFD.Show = -1 Then
        For Each varFolder In objFD.SelectedItems

            ' Update TDoseData Folder
            objTDoseData.Folder = varFolder

            ' Handle Error Condition
            If Err.Number <> 0 Then
                MsgBox Err.Description, vbExclamation, "Invalid Folder!"
            End If

            ' Set txtFolder Value
            txtFolder.Value = objTDoseData.Folder
            txtFolder_AfterUpdate

        Next varFolder
    End If

    ' Release Object
    Set objFD = Nothing

End Sub

Private Sub cmdProcess_Click()

    ' Turn Hourglass On
    DoCmd.Hourglass True

    ' Move Focus
    txtFolder.SetFocus

    ' Disable Button
    cmdProcess.Enabled = False

    ' Clear Status Info
    txtFileCount.Value = ""
    txtNodeCount.Value = ""
    txtStartTime.Value = ""
```

```
    txtFinishTime.Value = ""
    txtStatus.Value = ""

    ' Load and Calculate Data
    objTDoseData.Process

    ' Update Status Info
    txtFileCount.Value = CStr(objTDoseData.FileCount)
    txtNodeCount.Value = CStr(objTDoseData.NodeCount)
    txtStartTime.Value = CStr(objTDoseData.StartTime)
    txtFinishTime.Value = CStr(objTDoseData.FinishTime)
    txtStatus.Value = objTDoseData.Status

    ' Turn Hourglass Off
    DoCmd.Hourglass False

End Sub

Private Sub Form_Load()

    Set objTDoseData = New TDoseData

End Sub

Private Sub Form_Unload(Cancel As Integer)

    Set objTDoseData = Nothing

    DoCmd.Hourglass False

End Sub

Private Sub objTDoseData_StatusUpdate()

    ' Update Status Info
    txtFileCount.Value = CStr(objTDoseData.FileCount)
    txtNodeCount.Value = CStr(objTDoseData.NodeCount)
    txtStartTime.Value = CStr(objTDoseData.StartTime)
    txtStatus.Value = objTDoseData.Status

    ' Repaint Form
    Me.Repaint

End Sub

Private Sub txtFolder_AfterUpdate()

    ' Enable Process Button?
    If Not IsNull(txtFolder.Value) And Not IsNull(txtSimulation.Value) Then
        If txtFolder.Value <> "" And txtSimulation.Value <> "" Then
            cmdProcess.Enabled = True
        Else
            cmdProcess.Enabled = False
        End If
    Else
        cmdProcess.Enabled = False
    End If

End Sub

Private Sub txtFolder_BeforeUpdate(Cancel As Integer)

```

```
    On Error Resume Next

    ' Update Folder
    If Not IsNull(txtFolder.Value) Then
       objTDoseData.Folder = txtFolder.Value
    Else
       objTDoseData.Folder = ""
    End If

    ' Handle Error Condition
    If Err.Number <> 0 Then
       MsgBox Err.Description, vbExclamation, "Invalid Folder"
       txtFolder.Value = objTDoseData.Folder
       Cancel = True
    End If

End Sub

Private Sub txtSimulation_AfterUpdate()

            ' Enable Process Button?
    If Not IsNull(txtFolder.Value) And Not IsNull(txtSimulation.Value) Then
       If txtFolder.Value <> "" And txtSimulation.Value <> "" Then
          cmdProcess.Enabled = True
       Else
          cmdProcess.Enabled = False
       End If
    Else
       cmdProcess.Enabled = False
    End If

End Sub

Private Sub txtSimulation_BeforeUpdate(Cancel As Integer)

    On Error Resume Next

    ' Update Simulation Name
    If Not IsNull(txtSimulation.Value) Then
       objTDoseData.Simulation = txtSimulation.Value
    Else
       objTDoseData.Simulation = ""
    End If

    ' Handle Error Condition
    If Err.Number <> 0 Then
       MsgBox Err.Description, vbExclamation, "Invalid Simulation Name"
       txtSimulation.Value = objTDoseData.Simulation
       Cancel = True
    End If

End Sub

```

User Permissions

admin	Delete, Read Permissions, Set Permissions, Change Owner, Read Definition, Modify Definition, Execute

Group Permissions

Admins	Delete, Read Permissions, Set Permissions, Change Owner, Read Definition, Modify Definition, Execute
Users	Delete, Read Permissions, Set Permissions, Change Owner, Read Definition, Modify Definition, Execute

Form: MainMenu

Properties

AllowAdditions:	False	AllowDatasheetView:	False
AllowDeletions:	False	AllowDesignChanges:	True
AllowEditing:	True	AllowEdits:	False
AllowFilters:	False	AllowFormView:	True
AllowPivotChartView:	False	AllowPivotTableView:	False
AllowUpdating:	No	AutoCenter:	False
AutoResize:	True	BorderStyle:	Thin
Caption:	Main Menu	CloseButton:	True
Container:	Forms	ControlBox:	True
Count:	14	CurrentView:	0
Cycle:	All Records	DataEntry:	False
DatasheetBackColor:	16777215	DatasheetBorderLineStyle:	1
DatasheetCellsEffect:	Flat	DatasheetColumnHeaderUn	1
DatasheetFontHeight:	10	DatasheetFontItalic:	False
DatasheetFontName:	Arial	DatasheetFontUnderline:	False
DatasheetFontWeight:	Normal	DatasheetForeColor:	0
DatasheetGridlinesBehavior:	Both	DatasheetGridlinesColor:	12632256
DateCreated:	6/29/2003 10:18:54 PM	DefaultEditing:	3
DefaultView:	Single Form	DividingLines:	False
FastLaserPrinting:	True	FetchDefaults:	True
FilterOn:	False	FrozenColumns:	1
GridX:	24	GridY:	24
GUID:	{guid {6F2B5A18-517E-43F7-98F7-C06FAE2FAD0B}}	HasModule:	True
HelpContextId:	0	HorizontalDatasheetGridline	1
Hwnd:	1901514	InsideHeight:	6420
InsideWidth:	7605	KeyPreview:	False
LastUpdated:	6/29/2003 10:18:54 PM	LayoutForPrint:	False
LogicalPageWidth:	9360	MaxButton:	False
MinButton:	False	MinMaxButtons:	None
Modal:	False	Moveable:	True
NameMap:	Long binary data	NavigationButtons:	False
OrderByOn:	False	Orientation:	Left-to-Right
Owner:	admin	Painting:	True
PaletteSource:	(Default)	Picture:	(none)
PictureAlignment:	Center	PictureSizeMode:	Clip
PictureTiling:	False	PictureType:	0
PopUp:	False	PrtDevMode:	Long binary data
PrtDevNames:	Long binary data	PrtMip:	Long binary data
RecordLocks:	No Locks	RecordSelectors:	False
RecordsetType:	Dynaset	RowHeight:	Default
ScrollBars:	Neither	ShortcutMenu:	True
ShowGrid:	True	SubdatasheetExpanded:	False
SubdatasheetHeight:	0	TimerInterval:	0
UserName:	admin	VerticalDatasheetGridlineSty	1
ViewsAllowed:	Form	Visible:	False
WhatsThisButton:	False	Width:	5280
WindowHeight:	7125	WindowLeft:	735
WindowTop:	135	WindowWidth:	8025

Objects

Section: Detail

BackColor:	-2147483633	CanGrow:	False
CanShrink:	False	DisplayWhen:	Always
EventProcPrefix:		Detail	ForceNewPage: None
HasContinued:	False	Height:	4320
InSelection:	False	KeepTogether:	False
Name:	Detail	NewRowOrCol:	None
SpecialEffect:	Flat	Visible:	True
WillContinue:	False		

Command Button: cmdCompact

AutoRepeat:	False	Cancel:	False
Caption:	Compact Database	ControlType:	104
Default:	False	DisplayWhen:	Always
Enabled:	True	EventProcPrefix:	cmdCompact
FontBold:	No	FontItalic:	False
FontName:	Tahoma	FontSize:	8
FontUnderline:	False	FontWeight:	Normal
ForeColor:	-2147483630	Height:	420
HelpContextId:	0	Left:	240
Name:	cmdCompact	OnClick:	[Event Procedure]
Picture:	(none)	PictureType:	0
ReadingOrder:	Context	Section:	0
TabIndex:	9	TabStop:	True
TextFontCharSet:		0	Top: 3840
Transparent:	False	Visible:	True
Width:	1728		

Command Button: cmdDelete

AutoRepeat:	False	Cancel:	False
Caption:	Delete Simulation ...	ControlType:	104
Default:	False	DisplayWhen:	Always
Enabled:	True	EventProcPrefix:	cmdDelete
FontBold:	No	FontItalic:	False
FontName:	Tahoma	FontSize:	8
FontUnderline:	False	FontWeight:	Normal
ForeColor:	-2147483630	Height:	405
HelpContextId:	0	Left:	3060
Name:	cmdDelete	OnClick:	[Event Procedure]
Picture:	(none)	PictureType:	0
ReadingOrder:	Context	Section:	0
TabIndex:	4	TabStop:	True
TextFontCharSet:		0	Top: 1920
Transparent:	False	Visible:	True
Width:	1728		

Command Button: cmdEditNodes

AutoRepeat:	False	Cancel:	False
Caption:	Edit Valid Nodes ...	ControlType:	104
Default:	False	DisplayWhen:	Always
Enabled:	True	EventProcPrefix:	cmdEditNodes
FontBold:	No	FontItalic:	False
FontName:	Tahoma	FontSize:	8
FontUnderline:	False	FontWeight:	Normal
ForeColor:	-2147483630	Height:	405
HelpContextId:	0	Left:	3060
Name:	cmdEditNodes	OnClick:	[Event Procedure]
Picture:	(none)	PictureType:	0
ReadingOrder:	Context	Section:	0
TabIndex:	10	TabStop:	True
TextFontCharSet:		0	Top: 2520

Transparent:	False	Visible:	True
Width:	1728		

Command Button: cmdExit

AutoRepeat:	False	Cancel:	False
Caption:	Exit	ControlType:	104
Default:	False	DisplayWhen:	Always
Enabled:	True	EventProcPrefix:	cmdExit
FontBold:	No	FontItalic:	False
FontName:	Tahoma	FontSize:	8
FontUnderline:	False	FontWeight:	Normal
ForeColor:	-2147483630	Height:	405
HelpContextId:	0	Left:	3600
Name:	cmdExit	OnClick:	[Event Procedure]
Picture:	(none)	PictureType:	0
ReadingOrder:	Context	Section:	0
TabIndex:	8	TabStop:	True
TextFontCharSet:		0	Top: 3840
Transparent:	False	Visible:	True
Width:	1440		

Command Button: cmdLoad

AutoRepeat:	False	Cancel:	False
Caption:	Load Simulation ...	ControlType:	104
Default:	False	DisplayWhen:	Always
Enabled:	True	EventProcPrefix:	cmdLoad
FontBold:	No	FontItalic:	False
FontName:	Tahoma	FontSize:	8
FontUnderline:	False	FontWeight:	Normal
ForeColor:	-2147483630	Height:	405
HelpContextId:	0	Left:	3060
Name:	cmdLoad	OnClick:	[Event Procedure]
Picture:	(none)	PictureType:	0
ReadingOrder:	Context	Section:	0
TabIndex:	5	TabStop:	True
TextFontCharSet:		0	Top: 1320
Transparent:	False	Visible:	True
Width:	1728		

Command Button: cmdSimData

AutoRepeat:	False	Cancel:	False
Caption:	Simulation Data	ControlType:	104
Default:	False	DisplayWhen:	Always
Enabled:	True	EventProcPrefix:	cmdSimData
FontBold:	No	FontItalic:	False
FontName:	Tahoma	FontSize:	8
FontUnderline:	False	FontWeight:	Normal
ForeColor:	-2147483630	Height:	405
HelpContextId:	0	Left:	480
Name:	cmdSimData	OnClick:	[Event Procedure]
Picture:	(none)	PictureType:	0
ReadingOrder:	Context	Section:	0
TabIndex:	1	TabStop:	True
TextFontCharSet:		0	Top: 1920
Transparent:	False	Visible:	True
Width:	1728		

Command Button: cmdSimDataNode

AutoRepeat:	False	Cancel:	False
Caption:	Simulation Node	ControlType:	104
Default:	False	DisplayWhen:	Always
Enabled:	True	EventProcPrefix:	cmdSimDataNode
FontBold:	No	FontItalic:	False

FontName:	Tahoma	FontSize:	8
FontUnderline:	False	FontWeight:	Normal
ForeColor:	-2147483630	Height:	405
HelpContextId:	0	Left:	480
Name:	cmdSimDataNode	OnClick:	[Event Procedure]
Picture:	(none)	PictureType:	0
ReadingOrder:	Context	Section:	0
TabIndex:	2	TabStop:	True
TextFontCharSet:		0	Top: 2520
Transparent:	False	Visible:	True
Width:	1728		

Command Button: cmdSimDataTime

AutoRepeat:	False	Cancel:	False
Caption:	Simulation Time	ControlType:	104
Default:	False	DisplayWhen:	Always
Enabled:	True	EventProcPrefix:	cmdSimDataTime
FontBold:	No	FontItalic:	False
FontName:	Tahoma	FontSize:	8
FontUnderline:	False	FontWeight:	Normal
ForeColor:	-2147483630	Height:	405
HelpContextId:	0	Left:	480
Name:	cmdSimDataTime	OnClick:	[Event Procedure]
Picture:	(none)	PictureType:	0
ReadingOrder:	Context	Section:	0
TabIndex:	3	TabStop:	True
TextFontCharSet:		0	Top: 3120
Transparent:	False	Visible:	True
Width:	1728		

Command Button: cmdSimList

AutoRepeat:	False	Cancel:	False
Caption:	Simulation List	ControlType:	104
Default:	False	DisplayWhen:	Always
Enabled:	True	EventProcPrefix:	cmdSimList
FontBold:	No	FontItalic:	False
FontName:	Tahoma	FontSize:	8
FontUnderline:	False	FontWeight:	Normal
ForeColor:	-2147483630	Height:	405
HelpContextId:	0	Left:	480
Name:	cmdSimList	OnClick:	[Event Procedure]
Picture:	(none)	PictureType:	0
ReadingOrder:	Context	Section:	0
TabIndex:	0	TabStop:	True
TextFontCharSet:		0	Top: 1320
Transparent:	False	Visible:	True
Width:	1728		

Option Group: Frame11

BackColor:	16777215	BackStyle:	Transparent
BorderColor:	0	BorderLineStyle:	Solid
BorderStyle:	Solid	BorderWidth:	Hairline
ColumnHidden:	False	ColumnOrder:	Default
ColumnWidth:	Default	ControlType:	107
DisplayWhen:	Always	Enabled:	True
EventProcPrefix:		Frame11	Height: 2760
HelpContextId:	0	Left:	240
Locked:	False	Name:	Frame11
OldBorderStyle:	1	Section:	0
SpecialEffect:	Etched	TabIndex:	7
TabStop:	True	Top:	960
Visible:	True	Width:	2220

Option Group: Frame9

BackColor:	16777215	BackStyle:	Transparent
BorderColor:	0	BorderLineStyle:	Solid
BorderStyle:	Solid	BorderWidth:	Hairline
ColumnHidden:	False	ColumnOrder:	Default
ColumnWidth:	Default	ControlType:	107
DisplayWhen:	Always	Enabled:	True
EventProcPrefix:	Frame9	Height:	2760
HelpContextId:	0	Left:	2820
Locked:	False	Name:	Frame9
OldBorderStyle:	1	Section:	0
SpecialEffect:	Etched	TabIndex:	6
TabStop:	True	Top:	960
Visible:	True	Width:	2220

Label: Label10

BackColor:	-2147483633	BackStyle:	Normal
BorderColor:	0	BorderLineStyle:	Solid
BorderStyle:	Transparent	BorderWidth:	Hairline
BottomMargin:	0	Caption:	Load / Modify Data
ControlType:	100	DisplayWhen:	Always
EventProcPrefix:	Label10	FontBold:	No
FontItalic:	False	FontName:	Tahoma
FontSize:	8	FontUnderline:	False
FontWeight:	Normal	ForeColor:	0
Height:	240	HelpContextId:	0
Left:	2940	LeftMargin:	0
LineSpacing:	0	Name:	Label10
NumeralShapes:	System	OldBorderStyle:	0
ReadingOrder:	Context	RightMargin:	0
Section:	0	SpecialEffect:	Flat
TextAlign:	General	TextFontCharSet:	0
Top:	840	TopMargin:	0
Vertical:	False	Visible:	True
Width:	1440		

Label: Label12

BackColor:	-2147483633	BackStyle:	Normal
BorderColor:	0	BorderLineStyle:	Solid
BorderStyle:	Transparent	BorderWidth:	Hairline
BottomMargin:	0	Caption:	Query Data
ControlType:	100	DisplayWhen:	Always
EventProcPrefix:	Label12	FontBold:	No
FontItalic:	False	FontName:	Tahoma
FontSize:	8	FontUnderline:	False
FontWeight:	Normal	ForeColor:	0
Height:	240	HelpContextId:	0
Left:	360	LeftMargin:	0
LineSpacing:	0	Name:	Label12
NumeralShapes:	System	OldBorderStyle:	0
ReadingOrder:	Context	RightMargin:	0
Section:	0	SpecialEffect:	Flat
TextAlign:	General	TextFontCharSet:	0
Top:	840	TopMargin:	0
Vertical:	False	Visible:	True
Width:	960		

Label: lblTitle

BackColor:	16777215	BackStyle:	Transparent
BorderColor:	0	BorderLineStyle:	Solid
BorderStyle:	Transparent	BorderWidth:	Hairline
BottomMargin:	0	Caption:	Thermal Dose Database
ControlType:	100	DisplayWhen:	Always

EventProcPrefix:
FontItalic: False
FontSize: 18
FontWeight: Bold
Height: 540
Left: 120
LineSpacing: 0
NumeralShapes:
ReadingOrder: Context
Section: 0
TextAlign: Center
Top: 120
Vertical: False
Width: 5040

lblTitle FontBold: Yes
FontName: Tahoma
FontUnderline: False
ForeColor: 0
HelpContextId: 0
LeftMargin: 0
Name: lblTitle
System OldBorderStyle: 0
RightMargin: 0
SpecialEffect: Flat
TextFontCharSet: 0
TopMargin: 0
Visible: True

Code

```
VERSION 1.0 CLASS
BEGIN
  MultiUse = -1  'True
END
Attribute VB_Name = "Form_MainMenu"
Attribute VB_GlobalNameSpace = False
Attribute VB_Creatable = True
Attribute VB_PredeclaredId = True
Attribute VB_Exposed = False
Option Compare Database
Option Explicit

Private Sub cmdCompact_Click()

        DoCmd.RunCommand acCmdCompactDatabase

End Sub

Private Sub cmdSimList_Click()
On Error GoTo Err_cmdSimList_Click

    Dim stDocName As String

    stDocName = "SimulationList"
    DoCmd.OpenQuery stDocName, acNormal, acReadOnly

Exit_cmdSimList_Click:
    Exit Sub

Err_cmdSimList_Click:
    MsgBox Err.Description
    Resume Exit_cmdSimList_Click

End Sub

Private Sub cmdSimData_Click()
On Error GoTo Err_cmdSimData_Click

    Dim stDocName As String

    stDocName = "TDoseData_Simulation"
    DoCmd.OpenQuery stDocName, acNormal, acReadOnly

Exit_cmdSimData_Click:
```

```
    Exit Sub

Err_cmdSimData_Click:
    MsgBox Err.Description
    Resume Exit_cmdSimData_Click

End Sub

Private Sub cmdSimDataNode_Click()
On Error GoTo Err_cmdSimDataNode_Click

    Dim stDocName As String

    stDocName = "TDoseData_Node"
    DoCmd.OpenQuery stDocName, acNormal, acReadOnly

Exit_cmdSimDataNode_Click:
    Exit Sub

Err_cmdSimDataNode_Click:
    MsgBox Err.Description
    Resume Exit_cmdSimDataNode_Click

End Sub

Private Sub cmdSimDataTime_Click()
On Error GoTo Err_cmdSimDataTime_Click

    Dim stDocName As String

    stDocName = "TDoseData_Time"
    DoCmd.OpenQuery stDocName, acNormal, acReadOnly

Exit_cmdSimDataTime_Click:
    Exit Sub

Err_cmdSimDataTime_Click:
    MsgBox Err.Description
    Resume Exit_cmdSimDataTime_Click

End Sub
Private Sub cmdSimDataDelete_Click()
On Error GoTo Err_cmdSimDataDelete_Click

    Dim stDocName As String

    stDocName = "SimulationDelete"
    DoCmd.SetWarnings False
    DoCmd.OpenQuery stDocName, acNormal, acEdit
    DoCmd.SetWarnings True

Exit_cmdSimDataDelete_Click:
    Exit Sub

Err_cmdSimDataDelete_Click:
    MsgBox Err.Description
    Resume Exit_cmdSimDataDelete_Click

End Sub
Private Sub cmdDelete_Click()
On Error GoTo Err_cmdDelete_Click
```

```
    Dim stDocName As String
    Dim stLinkCriteria As String

    stDocName = "DeleteData"
    DoCmd.OpenForm stDocName, , , stLinkCriteria

Exit_cmdDelete_Click:
    Exit Sub

Err_cmdDelete_Click:
    MsgBox Err.Description
    Resume Exit_cmdDelete_Click

End Sub
Private Sub cmdLoad_Click()
On Error GoTo Err_cmdLoad_Click

    Dim stDocName As String
    Dim stLinkCriteria As String

    stDocName = "LoadData"
    DoCmd.OpenForm stDocName, , , stLinkCriteria

Exit_cmdLoad_Click:
    Exit Sub

Err_cmdLoad_Click:
    MsgBox Err.Description
    Resume Exit_cmdLoad_Click

End Sub
Private Sub cmdExit_Click()
On Error GoTo Err_cmdExit_Click


    DoCmd.Quit

Exit_cmdExit_Click:
    Exit Sub

Err_cmdExit_Click:
    MsgBox Err.Description
    Resume Exit_cmdExit_Click

End Sub
Private Sub cmdEditNodes_Click()
On Error GoTo Err_cmdEditNodes_Click

    Dim stDocName As String
    Dim stLinkCriteria As String

    stDocName = "ValidNodes"
    DoCmd.OpenForm stDocName, acFormDS, , stLinkCriteria

Exit_cmdEditNodes_Click:
    Exit Sub

Err_cmdEditNodes_Click:
    MsgBox Err.Description
    Resume Exit_cmdEditNodes_Click

End Sub
```

User Permissions

admin	Delete, Read Permissions, Set Permissions, Change Owner, Read Definition, Modify Definition, Execute

Group Permissions

Admins	Delete, Read Permissions, Set Permissions, Change Owner, Read Definition, Modify Definition, Execute
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Form: ValidNodes

Properties

AllowAdditions:	True	AllowDatasheetView:	True
AllowDeletions:	True	AllowDesignChanges:	True
AllowEditing:	True	AllowEdits:	True
AllowFilters:	True	AllowFormView:	True
AllowPivotChartView:	True	AllowPivotTableView:	True
AllowUpdating:	No	AutoCenter:	True
AutoResize:	True	BorderStyle:	Sizable
Caption:	Edit Valid Nodes	CloseButton:	True
Container:	Forms	ControlBox:	True
Count:	2	CurrentView:	0
Cycle:	All Records	DataEntry:	False
DatasheetBackColor:	16777215	DatasheetBorderLineStyle:	1
DatasheetCellsEffect:	Flat	DatasheetColumnHeaderUn	1
DatasheetFontHeight:	10	DatasheetFontItalic:	False
DatasheetFontName:	Arial	DatasheetFontUnderline:	False
DatasheetFontWeight:	Normal	DatasheetForeColor:	0
DatasheetGridlinesBehavior:	Both	DatasheetGridlinesColor:	12632256
DateCreated:	6/30/2003 1:29:01 AM	DefaultEditing:	2
DefaultView:	Datasheet	DividingLines:	True
FastLaserPrinting:	True	FetchDefaults:	True
FilterOn:	False	FrozenColumns:	1
GridX:	24	GridY:	24
GUID:	{guid {D649C0E9-6B5B-4AD3-818F-7570BD4D1FBF}}	HasModule:	False
HelpContextId:	0	HorizontalDatasheetGridline	1
Hwnd:	1967050	InsideHeight:	5400
InsideWidth:	10920	KeyPreview:	False
LastUpdated:	6/30/2003 1:29:01 AM	LayoutForPrint:	False
LogicalPageWidth:	9360	MaxButton:	True
MinButton:	True	MinMaxButtons:	Both Enabled
Modal:	False	Moveable:	True
NameMap:	Long binary data	NavigationButtons:	True
OrderByOn:	False	Orientation:	Left-to-Right
Owner:	admin	Painting:	True
PaletteSource:	(Default)	Picture:	(none)
PictureAlignment:	Center	PictureSizeMode:	Clip
PictureTiling:	False	PictureType:	0
PopUp:	False	PrtDevMode:	Long binary data
PrtDevNames:	Long binary data	PrtMip:	Long binary data
RecordLocks:	No Locks	RecordSelectors:	True
RecordsetType:	Dynaset	RecordSource:	ValidNodes
RowHeight:	Default	ScrollBars:	Both
ShortcutMenu:	True	ShowGrid:	True
SubdatasheetExpanded:	False	SubdatasheetHeight:	0

TimerInterval:	0	UserName:	admin	
VerticalDatasheetGridlineSty		1	ViewsAllowed:	Both
Visible:	False	WhatsThisButton:	False	
Width:	2340	WindowHeight:	6105	
WindowLeft:	270	WindowTop:	210	
WindowWidth:	11340			

Objects

Section: Detail

BackColor:	-2147483633	CanGrow:	False	
CanShrink:	False	DisplayWhen:	Always	
EventProcPrefix:		Detail	ForceNewPage:	None
HasContinued:	False	Height:	495	
InSelection:	False	KeepTogether:	False	
Name:	Detail	NewRowOrCol:	None	
SpecialEffect:	Flat	Visible:	True	
WillContinue:	False			

Section: FormFooter

BackColor:	-2147483633	CanGrow:	False	
CanShrink:	False	DisplayWhen:	Always	
EventProcPrefix:		FormFooter	ForceNewPage:	None
HasContinued:	False	Height:	0	
InSelection:	False	KeepTogether:	False	
Name:	FormFooter	NewRowOrCol:	None	
SpecialEffect:	Flat	Visible:	True	
WillContinue:	False			

Section: FormHeader

BackColor:	-2147483633	CanGrow:	False	
CanShrink:	False	DisplayWhen:	Always	
EventProcPrefix:		FormHeader	ForceNewPage:	None
HasContinued:	False	Height:	0	
InSelection:	False	KeepTogether:	False	
Name:	FormHeader	NewRowOrCol:	None	
SpecialEffect:	Flat	Visible:	True	
WillContinue:	False			

Text Box: Node

AllowAutoCorrect:		True	AutoTab:	False
BackColor:	-2147483643	BackStyle:	Normal	
BorderColor:	0	BorderLineStyle:	Solid	
BorderStyle:	Solid	BorderWidth:	Hairline	
BottomMargin:	0	CanGrow:	False	
CanShrink:	False	ColumnHidden:	False	
ColumnOrder:	Default	ColumnWidth:	600	
ControlSource:	Node	ControlType:	109	
DecimalPlaces:	Auto	DisplayWhen:	Always	
Enabled:	True	EnterKeyBehavior:	False	
EventProcPrefix:		Node	FilterLookup:	Database Default
FontBold:	No	FontItalic:	False	
FontName:	MS Sans Serif	FontSize:	8	
FontUnderline:	False	FontWeight:	Normal	
ForeColor:	-2147483640	Height:	255	
HelpContextId:	0	IMEHold:	False	
IMEMode:	0	IMESentenceMode:	3	
IsHyperlink:	False	KeyboardLanguage:	0	
Left:	1680	LeftMargin:	0	
LineSpacing:	0	Locked:	False	
Name:	Node	NumeralShapes:	System	

OldBorderStyle:	1	ReadingOrder:	Context
RightMargin:	0	ScrollBarAlign:	System
ScrollBars:	Neither	Section:	0
SpecialEffect:	Sunken	StatusBarText:	Node
TabIndex:	0	TabStop:	True
TextAlign:	General	TextFontCharSet:	0
Top:	120	TopMargin:	0
Vertical:	False	Visible:	True
Width:	600		

Label: Node_Label

BackColor:	-2147483633	BackStyle:	Transparent	
BorderColor:	0	BorderLineStyle:	Solid	
BorderStyle:	Transparent	BorderWidth:	Hairline	
BottomMargin:	0	Caption:	Node	
ControlType:	100	DisplayWhen:	Always	
EventProcPrefix:		Node_Label	FontBold:	No
FontItalic:	False	FontName:	MS Sans Serif	
FontSize:	8	FontUnderline:	False	
FontWeight:	Normal	ForeColor:	-2147483630	
Height:	255	HelpContextId:	0	
Left:	60	LeftMargin:	0	
LineSpacing:	0	Name:	Node_Label	
NumeralShapes:		System	OldBorderStyle:	0
ReadingOrder:	Context	RightMargin:	0	
Section:	0	SpecialEffect:	Flat	
TextAlign:	General	TextFontCharSet:	0	
Top:	120	TopMargin:	0	
Vertical:	False	Visible:	True	
Width:	1560			

User Permissions

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Group Permissions

Admins	Delete, Read Permissions, Set Permissions, Change Owner, Read Definition, Modify Definition, Execute
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Module: TDoseData

Properties

Container:	Modules	DateCreated:	5/29/2003 10:21:33 PM
LastUpdated:	5/29/2003 10:21:33 PM	Owner:	admin
UserName:	admin		

Code

```
VERSION 1.0 CLASS
BEGIN
  MultiUse = -1  'True
```

```
END
Attribute VB_Name = "TDoseData"
Attribute VB_GlobalNameSpace = False
Attribute VB_Creatable = False
Attribute VB_PredeclaredId = False
Attribute VB_Exposed = False
Option Compare Database
Option Explicit

Private Const mcstrTableName = "TDoseData"
Private Const mcstrClassName = "TDoseData"

Private mstrStatus As String
Private mstrFolder As String
Private mstrSimulation As String

Private mlngFileCount As Long
Private mlngNodeCount As Long

Private marrValidNodes(130000) As Boolean

Private mdteStartTime As Date
Private mdteFinishTime As Date

Private mobjFS As FileSystemObject
Private mobjDB As Database

Public Event StatusUpdate()

Public Property Get Status() As String

   Status = mstrStatus

End Property

Public Property Let Folder(strFolder As String)

   ' Verify that Folder Exists
   If mobjFS.FolderExists(strFolder) = True Or strFolder = "" Then
      mstrFolder = strFolder
   Else
      Err.Raise vbObjectError + 76, mcstrClassName, "Folder Not Found!"
   End If

End Property

Public Property Get Folder() As String

   Folder = mstrFolder

End Property

Public Property Let Simulation(strSimulation As String)

   ' Verify Simulation Name Length
   If Len(strSimulation) <= 20 Then
      mstrSimulation = strSimulation
   Else
      Err.Raise vbObjectError + 77, mcstrClassName, "Simulation Name Too Long!"
   End If

End Property
```

```

Public Property Get Simulation() As String

   Simulation = mstrSimulation

End Property

Public Property Get FileCount() As Long

   FileCount = mlngFileCount

End Property

Public Property Get NodeCount() As Long

   NodeCount = mlngNodeCount

End Property

Public Property Get StartTime() As Date

   StartTime = mdteStartTime

End Property

Public Property Get FinishTime() As Date

   FinishTime = mdteFinishTime

End Property

Private Sub Class_Initialize()

         Set mobjFS = CreateObject("Scripting.FileSystemObject")
   Set mobjDB = Application.CurrentDb

   mlngFileCount = 0
   mlngNodeCount = 0

   mstrFolder = ""
   mstrSimulation = ""
   mstrStatus = ""

End Sub

Public Sub Process()

   Dim lngResult As Long

   ' Capture Start Time
   mdteStartTime = Now

   ' Reset Information
   mlngFileCount = 0
   mlngNodeCount = 0
   mstrStatus = "Initializing Environment ..."

   ' Raise StatusUpdate Event
   RaiseEvent StatusUpdate

   ' Verify that Folder Exists
   If mobjFS.FolderExists(mstrFolder) = False Then
```

```
        mdteFinishTime = Now
        Err.Raise vbObjectError + 76, mcstrClassName, "Folder Not Found!"
    End If

    ' Does Simulation Data already exist?
    If SimulationExists(mstrSimulation) = True Then
        lngResult = MsgBox("Data already exists for this Simulation Name!  Do you wish to
overwrite existing data?", _
                vbYesNo, "Overwrite Simulation?")

        If lngResult = vbYes Then

            ' Update Status
            mstrStatus = "Deleting existing data ..."
            RaiseEvent StatusUpdate

            ' Delete Existing Simulation Data
            DeleteSimulation mstrSimulation

            ' Update Status
            mstrStatus = "Initializing Environment ..."
            RaiseEvent StatusUpdate

        Else

            ' Capture Finish Time
            mdteFinishTime = Now

            ' Update Status
            mstrStatus = "Process Aborted ... Data Already Exists!"

            Exit Sub

        End If
    End If

    ' Load Valid Nodes
    LoadValidNodes

    ' Load Raw Data
    LoadRawData

    ' Calc Thermal Dose Data
    CalcThermalDose

    ' Capture Finish Time
    mdteFinishTime = Now

    ' Update Status
    mstrStatus = "Completed in " & _
            DateDiff("s", mdteStartTime, mdteFinishTime) & _
            " seconds"

End Sub

Private Sub LoadRawData()

    Dim objFolder As Folder
    Dim objFile As File

    Set objFolder = mobjFS.GetFolder(mstrFolder)

```

```
   For Each objFile In objFolder.Files

      ' Update Status
      mstrStatus = "Processing '" & objFile.Name & "' ..."
      RaiseEvent StatusUpdate

      ' Load File
      LoadFile objFile.Path

      ' Update File Count
      mlngFileCount = mlngFileCount + 1

   Next

   ' Update Status
   mstrStatus = "Data Loaded ... Starting Calculations"
   RaiseEvent StatusUpdate

   ' Releae Objects
   Set objFolder = Nothing
   Set objFile = Nothing

End Sub

Private Sub CalcThermalDose()

  Dim objRS As DAO.Recordset
  Dim strSQL As String

  ' Build Query String
  strSQL = "SELECT DISTINCT NODE FROM " & mcstrTableName & _
        " WHERE Simulation = '" & mstrSimulation & "' ORDER BY NODE"

  ' Open Recordset
  Set objRS = mobjDB.OpenRecordset(strSQL)

  ' Process Recordset
  Do Until objRS.EOF

    ' Update Status
    mstrStatus = "Calculating Node " & objRS!Node & " ..."
    RaiseEvent StatusUpdate

    ' Calculate Node Info
    CalcNode objRS!Node

    ' Increment Node Count
    mlngNodeCount = mlngNodeCount + 1

    ' Move to next record
    objRS.MoveNext

  Loop

  ' Close and Release Recordset
  objRS.Close
  Set objRS = Nothing

End Sub

Private Sub Class_Terminate()
```

```
    ' Close Database
    mobjDB.Close

    ' Release Objects
    Set mobjDB = Nothing
    Set mobjFS = Nothing

End Sub

       Private Sub LoadFile(ByVal strFileName As String)

    Dim objFile As Scripting.TextStream
    Dim objRS As DAO.Recordset

    Dim strLine As String
    Dim strTime As String
    Dim strNode As String
    Dim strTemp As String
    Dim strSQL As String

    Dim intPos As Integer

    ' Open File
    Set objFile = mobjFS.OpenTextFile(strFileName, ForReading, False)

    ' Find Time Info
    Do Until objFile.AtEndOfStream

        ' Read Line
        strLine = objFile.ReadLine

        ' Look for Time Info (Exit loop if found)
        intPos = InStr(1, strLine, "TIME=", vbTextCompare)
        If intPos > 0 Then
            strTime = CInt(Mid(strLine, intPos + 5, 10))
            Exit Do
        End If

    Loop

    ' Open Recordset
    strSQL = "SELECT * FROM " & mcstrTableName & _
             " WHERE Simulation = '" & mstrSimulation & "' AND Time = " & strTime
    Set objRS = mobjDB.OpenRecordset(strSQL)

    ' Process File Data
    Do Until objFile.AtEndOfStream

        ' Read Line
        strLine = objFile.ReadLine

        ' Process Data
        strNode = Mid(strLine, 1, 8)
        strTemp = Mid(strLine, 9, 10)
        If IsNumeric(strNode) And IsNumeric(strTemp) Then

            ' Valid Node to Load?
            If marrValidNodes(CLng(strNode)) = True Then

                ' Write Data to Table
                objRS.AddNew
                objRS!Simulation = mstrSimulation
```

```
                objRS!Time = CInt(strTime)
                objRS!Node = CLng(strNode)
                objRS!Temp = CSng(strTemp)
                objRS.Update

            End If

        End If

    Loop

    ' Close and Release RecordSet
    objRS.Close
    Set objRS = Nothing

    ' Close and Relase File
    objFile.Close
    Set objFile = Nothing

End Sub

Private Sub CalcNode(ByVal lngNode As Long)

   Dim objRS As DAO.Recordset
   Dim strSQL As String
   Dim sngTempDiff As Single
   Dim dblTDose As Double
   Dim dblCumTDose As Double
   Dim intLastTime As Integer

   ' Initialize Variables
   intLastTime = 0
   dblTDose = 0
   dblCumTDose = 0

   ' Build Query String
   strSQL = "SELECT * FROM " & mcstrTableName & _
         " WHERE Simulation = '" & mstrSimulation & "' AND Node = " & lngNode & _
         " ORDER BY Node, Time"

   ' Open Recordset
   Set objRS = mobjDB.OpenRecordset(strSQL)

   ' Process Recordset
   Do Until objRS.EOF

      ' Calc Temp Difference
      sngTempDiff = 43 - objRS!Temp

      ' Calc Thermal Dose
      If sngTempDiff > 0 Then
         dblTDose = (0.25 ^ sngTempDiff) * (objRS!Time - intLastTime)
      Else
         dblTDose = (0.5 ^ sngTempDiff) * (objRS!Time - intLastTime)
      End If

      ' Update Cummulative Thermal Dose
      dblCumTDose = dblCumTDose + dblTDose

      ' Update Record
      objRS.Edit
      objRS!TDose = dblTDose
```

```
      objRS!CumTDose = dblCumTDose
      objRS.Update

      ' Move to next record
      intLastTime = objRS!Time
      objRS.MoveNext

   Loop

   ' Close and Release Recordset
   objRS.Close
   Set objRS = Nothing

End Sub

Private Function SimulationExists(ByVal strSimulation) As Boolean

    Dim objRS As DAO.Recordset
    Dim strSQL As String

    ' Build SQL Statement
    strSQL = "SELECT COUNT(*) AS REC_COUNT FROM " & mcstrTableName & _
             " WHERE Simulation = '" & strSimulation & "'"

    ' Open Recordset
    Set objRS = mobjDB.OpenRecordset(strSQL)

    ' Set Return Value
    If objRS!REC_COUNT > 0 Then
        SimulationExists = True
    Else
        SimulationExists = False
    End If

    ' Close and Release Recordset
    objRS.Close
    Set objRS = Nothing

End Function

Private Sub DeleteSimulation(ByVal strSimulation)

    Dim strSQL As String

    ' Build SQL Statement
    strSQL = "DELETE FROM " & mcstrTableName & " WHERE Simulation = '" & strSimulation & "'"

    ' Execute SQL Statement
    mobjDB.Execute strSQL, dbFailOnError

End Sub

Private Sub LoadValidNodes()

    Dim objRS As DAO.Recordset
    Dim strSQL As String
    Dim lngPos As Long

    ' Initialize Array
    For lngPos = 0 To UBound(marrValidNodes, 1) - 1
```

```
        marrValidNodes(lngPos) = False
    Next

    ' Build Query String
    strSQL = "SELECT Node FROM ValidNodes"

    ' Open Recordset
    Set objRS = mobjDB.OpenRecordset(strSQL)

    ' Process Recordset
    Do Until objRS.EOF

        ' Update Array
        marrValidNodes(objRS!Node) = True

        ' Move to next record
        objRS.MoveNext

    Loop

    ' Close and Release Recordset
    objRS.Close
    Set objRS = Nothing

End Sub
```

User Permissions

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Group Permissions

Admins	Delete, Read Permissions, Set Permissions, Change Owner, Read Definition, Modify Definition
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Module: TDoseData

Properties

AccessVersion:	08.50	AllowBuiltInToolbars:	True
AllowFullMenus:	True	AllowShortcutMenus:	True
AllowSpecialKeys:	True	AllowToolbarChanges:	True
ANSI Query Mode:	0	AppTitle:	Thermal Dose Database
Build:	501	CollatingOrder:	General
ProjVer:	24	QueryTimeout:	60
RecordsAffected:	0	StartUpForm:	Form.MainMenu
StartUpShowDBWindow:		False	StartUpShowStatusBar:
True			
Transactions:	True	Updatable:	True
UseAppIconForFrmRpt:	False	Version:	4.0

User Permissions

admin

Group Permissions

Admins
Users

Vita

Sandra K. Smith was born in Litchfield, Minnesota. She began the pursuit of her Bachelor of Science degree in Mechanical Engineering (BSME) at the University of Minnesota, Minneapolis, Minnesota. In August 2002 she received her Bachelor of Science degree in Mechanical Engineering from Virginia Tech, Blacksburg, Virginia. After receiving her BSME she began her Master of Science program at Virginia Tech. She conducted her master's research in heat transfer with a biomedical emphasis under the guidance of Dr. Elaine P. Scott. She received her Master of Science degree in Mechanical Engineering with a Biomedical emphasis in May 2004.