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# Vehicular Based Drug Box Temperature Control Study

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**Vehicular Based Drug Box Temperature Control Study**

**A Research Project  
Presented to the  
Department of Occupational and Technical Studies  
Old Dominion University**

**In Partial Fulfillment of the  
Requirement for the  
Degree of Master of Science in  
Occupational and Technical Education**

**by**

**Jonora Mejia**

**Winter, 2006**

**APPROVAL PAGE**

This project was prepared by Jonora D. Mejia under the direction of Dr. John Ritz in OTED 636, Problems in Education, as partial fulfillment of the requirements for the degree of Master of Science in Occupational and Technical Education.

Date: \_\_\_\_\_

Approved by \_\_\_\_\_

Dr. John Ritz

Advisor,  
Graduate Program Director

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Jonora D. Mejia

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## **CHAPTER I**

### **INTRODUCTION**

All paramedic drug boxes in the Verde Valley area of Northern Arizona are stored in one of two places; either on an ambulance in a designated compartment or on a rescue truck of a local fire agency. The Verde Valley is located in the northern half of Arizona in a high desert area that experiences wide swings of temperatures from 10° F. in the winter months to well over 110° F. during the summer. These temperature variations expose the medications in the drug boxes to temperatures both higher and lower than storage temperatures recommended by the drug manufacturers. Storage of these medications under less than ideal conditions can mean shortened expiration dates or even lessening of the effectiveness of the medications. The first possibility impacts patient care by adding to overall health care costs by increasing frequency of medication replacement in the drug boxes. The second has the possibility to impact patient care in a more direct manner. Medications stored in an uncontrolled environment have the potential to degrade in potency; this could mean ineffective or even dangerous treatment for the patient receiving the medications (Thermal Engineering, 2004).

In 2005 the Arizona Department of Health Services (ADHS) medical drug box committee proposed a change in Arizona Revised Statute designed to require all prehospital drug boxes to be temperature controlled by January 6, 2009. In March of 2006 the committee elected to remove this proposed change from the working draft (ADHS, 2006). There were several reasons for this decision. First, there is little

information at the present time on what the temperatures are in unprotected drug boxes in Arizona. As the climate varies from over 115° F. in the southern parts of the state to below zero in the northern regions, it was recognized that a “one size fits all” solution would not be workable. Secondly, the committee was unable to arrive at a standardized temperature range that could be used to determine if each drug box was in compliance. Thirdly, the cost of retrofitting each drug box in a commercially available temperature controlled unit was estimated at approximately \$3900.00 per unit (Mermaid, 2006). Since many emergency medical service (EMS) providers in Arizona are volunteer units it was determined that this type of requirement could constitute financial hardship for at least some of the agencies.

Almost all medications have a temperature range recommended for storage by the manufacturer. Many times it is simply defined as a controlled room temperature environment (Allegra, Brennan, Lanier, Lavery, & MacKenzie, 1999). Other medications have more specific requirements such as less than 40° F. this study will begin to look at the issue of temperature control by first assessing the temperature range in drug boxes that are stored without any additional insulation or temperature control attempts and then begin to look at options for temperature control that are readily available and cost conscious.

### **Statement of the Problem**

The purpose of this study was to determine temperature variations in prehospital drug boxes in the Verde Valley area of Arizona during the months of October and November 2006.

### **Research Goals**

Prehospital drug boxes in the Verde Valley area have never been studied for minimum and maximum temperature variances. this is now of importance as ADHS has indicated that there is a strong possibility that there will be a requirement for drug box temperature control and tracking in the future (ADHS, 2006). The following hypothesis was used as the basis of this study.

H<sub>1</sub>: Temperatures of the prehospital drug boxes will remain in an acceptable range when stored in a compartment insulated with rigid, solid foam.

### **Background and Significance**

The Verde Valley area of Arizona is situated approximately half way between the urban Phoenix area and the mountain community of Flagstaff. At approximately 3500 feet in elevation it has temperature swings from 10° F. in the winter to over 110° F. in the summer. Drug boxes contained in both ambulances and fire trucks are subjected to these temperature extremes. In the past there have been no requirements to attempt to regulate the storage temperatures of these drug boxes in spite of the fact that all medications have a recommended range of storage temperatures from their manufacturers. Many drugs are tested only at their laboratory's room air temperature and no effort is made to test their effectiveness at either cold or hot extremes. (Brown, Krumperman, & Fullagar, 2004). However, some medications are rendered ineffective outside a set temperature range. It is suspected that Verde Valley area prehospital drug boxes may at times fall outside of recommended storage ranges (Allegra et al., 1999). Following the manufacturer recommendations for all drugs currently in the Arizona drug box the temperature range should ideally stay between 68-77° F. to safely accommodate maximum expiration dates on all the drugs.

In 2005 the drug box committee that controls the content of the Arizona prehospital drug boxes made a recommendation that all Arizona drug boxes be temperature regulated by January 2009. In spring 2006 this recommendation was removed from the proposed amendment package (ADHS, 2006). In part this was done in response to the knowledge that very little was known about current temperature conditions under which the drug boxes are being stored. It was decided that until more information was gathered on drug box temperature variances no mandatory regulations should be put into effect.

This study has attempted to gather data on the variance in temperature in the drug boxes in the Verde Valley area of Arizona. This information will help agencies assess what measures, if any are necessary to limit temperature swings in the their drug boxes and help them to make decisions on future modifications in storage methods as it seem quite probable that the issue of drug box temperature control will be raised in the future at the state level. The data gather in this study will provide a baseline of information that can be used for comparison when implementing any future interventions directed at improving temperature control in the prehospital drug boxes.

### **Limitations**

The results of this study can be generalized only to other areas that have the same winter and summer range of temperature variations as the Verde Valley. Similarly, only drug boxes which are of similar make and mode would be applicable for comparison. Finally, all drug boxes in this study were stored on ambulances or rescue trucks that were housed in a garage or bay when not actively responding to a 9-1-1 call. Ambulances or rescue trucks housed in other conditions would not be easily generalized to this study.

### **Assumptions**

It was assumed that all drug boxes studied were either Plano or Pelican hard sided brands. Soft sided models were not included. All boxes were stored in a locked compartment in either an ambulance or rescue truck. None of the vehicles had supplemental heating or cooling units on board to regulate drug box temperatures.

### **Procedures**

Data were collected by placing minimum/maximum thermometers inside each drug box studied. The thermometers were read every third day for three weeks, consistent with an A-B-C shift rotation and temperatures were recorded in a log. This provided a baseline of temperature variance in existing compartments. Additional data were then gathered in the same manner from the same drug boxes after modifications were made with additions of rigid construction foam insulation. The min/max temperature variants were collected every third day. The data were compared to see if the modifications impacted the temperatures of the stored drug box medications.

### **Definition of Terms**

To establish consistent terminology and assist the reader in understanding the study, the following terms have been defined for use in the paper.

ADHS: Arizona Department of Health Services. The division of Arizona government which oversees public health related offices and agencies.

Drug box: A rigid, lockable, plastic container used to store the medications allowed for prehospital use by emergency medical services providers in Arizona.

EMS: Emergency medical services, care provided by EMTs and paramedics via the 9-1-1 system prior to a patient entering a hospital healthcare system.

Expiration date: A date printed on the medication that indicates last day of recommended usage before replacement is needed.

Indoor temperature environment: Term used to define common ranges of indoor temperature found during the testing of medications by the manufacturer. Commonly this range is designated as from 59° - 86° F.

Minimum/maximum thermometer: Special type of thermometer that measures lowest attained temperature and highest attained temperature during a predetermined time period. This thermometer will maintain recording the minimum/maximum range until reset by the user.

Prehospital: The healthcare environment that provides for patient care before arrival at a hospital, emergency department, or urgent care facility.

Rescue truck: A fire truck manned by personnel with ES certifications such as EMT or paramedic that carries equipment such as oxygen, medications, IV solutions, and bandages that provides patient care at the scene of a 9-1-1 call but does not transport the patient to a higher level of care such as an emergency room.

Temperature control: Any method that limits variation in temperature and tracks the results.

### **Overview of Chapters**

Chapter I has reviewed the need for assessment of temperature variance in drug boxes due to the strong probability of mandated temperature control in the near future.

Chapter II reviews current relevant literature from areas who have already implemented

some forms of temperature control (Mehta, Doran, Lavery, & Allegra, 2002). It will include exploring the results of research that have made adjustments similar to this study's. Chapter III outlines in detail the methodologies and procedures used to gather the data and specify types of materials and products used in this study. Specifically it provides detail about insulation materials and thermometers used during this study. Chapter IV present the results of the temperature logs in detail and looks at trends in temperature variances during the months of October and November 2006. Chapter V presents the summary of this study's results, conclusions derived from the data, and recommendations for continuing modifications in the management of drug box temperature control.

## **CHAPTER II**

### **REVIEW OF LITERATURE**

This chapter will review the literature concerning the temperature control issue surrounding out of hospital medication, specifically those carried in ambulances and rescue trucks. This topic is of interest because while it is well established that most medications have an optimal temperature range for storage, the medications used in prehospital emergency services (EMS) are not routinely stored under controlled conditions (Brown, Krumperman, & Fullagar, 2004). In this chapter the researcher will review current United States Pharmacopeia (USP) standards and definitions related to medication storage temperatures and recommendations specific for EMS situations. It will also look at products currently available which can provide a temperature controlled environment. Finally, the researcher will review relevant literature from areas who have already implemented some form of temperature control.

#### **Storage Factors Affecting Medication Stability**

Drugs used in the prehospital environment are in principle subject to the same storage recommendations as hospital based medications with the main stressors being sunlight, vibrations, and extreme temperatures (Helm, Castner, & Lampl, 2003). These stressors are not unique to ambulances and rescue trucks. Medications which are shipped via the mail and then delivered into a mailbox can also experience extreme exposure to heat. This exposure to heat extremes has been shown to decrease the effectiveness of

certain medications, causing them to deliver inaccurate dosages (Bowman, 2004).

While heat is a known cause of deteriorations, pharmaceutical manufacturers are not required the USP temperatures at which their products are stable. They are only required to manufacture products that are stable within the temperature range listed on the medication package insert (Brown, Krumperman, & Fullagar, 2004).

Approximately 15 years ago Johansen, Schafer, and Brown (1993) exposed four commonly used out of hospital medications to temperature extremes ranging from -20° to 70° C. with no significant changes in their chemical compositions. The temperature ranges recommended on these package inserts recommended safe temperatures only from 68° - 77° F. However other studies (Grant, Carroll, & Church et al, 1994; Gottenwald, Akers, & Liu et al, 1999; Church, Hu & Henry, 1994) have shown degradation of the quality of medications exposed to temperature extremes.

### **United States Pharmacopoeia recommendations for Storage**

The United States Pharmacopoeia National Formulary prescribes the packaging, storage and distribution of medication in the United States (Brown, Krumperman & Fullagar, 2004). These definitions can be both multifaceted and complex (Brown, Krumperman, and Fullagar, 2004). As an example most medications in the Arizona prehospital drug box are recommended to be stored between 68° - 77° F. (Table 1). this temperature range is defined by USP as “controlled room temperature” (USP, 2005). The definition goes on to quantify this by adding that temperatures can vary intermittently to a range of 59° - 86° F. It concludes by saying that medication recommended for storage at controlled room temperature can also be stored in a “cool” temperature which it defines

as any temperature between 46° and 59° F. Using this definition the medications in the Arizona drug boxes can be stored at temperatures between 46° and 86° F.

**Table 1.** Paramedic Drug Box Inventory

<u>Drug name</u>	<u>How supplied</u>	<u>Quantity</u>	<u>Minimum temp in degrees F.</u>	<u>Maximum temp in degrees in F.</u>
Adenosine	6mg/2ml	6	68	77
Albuterol	0.06%	6	36	77
Aspirin	81mg	100	68	77
Atropine	8mg/20ml	1	59	86
Calcium chloride	1gm/10ml	2	68	77
Charcoal	25 gms	4	59	86
Dextrose	25gm/50ml	2	59	86
Diazepam	10mg/2ml	2	None stated	None stated
Benedryl	50mg/ml	2	68	77
Dopamine	400mg/5ml	2	59	86
Epinephrine 1:1000	1mg/ml	2	68	77
Epinephrine 1: 1000	30cc vial	1	68	77
Epinephrine 1:10000	1mg/ml	6	68	77
Lasix	40mg/ml	4	59	86
Glucagon	1mg/ml	2	68	77

Atrovent	2.5ml/ud	4	59	86
Lidocaine	100mg/5ml	4	59	86
Magnesium sulfate	1gm/2ml	8	59	86
Solumedrol	125mg/2ml	1	68	77
Versed	5mg/5ml	4	59	86
Morphine	10mg/ml	2	59	86
Narcan	2mg/ml	5	59	86
Nitrostat	0.4mg/tab	1 bottle	59	86
Oxytocin	10 units/ml	2	59	86
Neosyneprine	0.50%	1 bottle	59	86
Sodium bicarb	50meq/50ml	2	59	86
Thiamine	100ml/ml	1	59	86
Verapamil	5mg/2ml	2	59	86
D5W	250cc	1	None stated	None stated
LR	1000cc	4	None stated	None stated
Normal Saline	1000cc	4	None stated	None stated
Normal Saline	250cc	3	None stated	None stated
Normal Saline	50cc	2	None stated	None stated

It is recognized that the out of hospital environment is frequently uncontrolled and that one of the uncontrolled factors is temperature (Brown, Krumperman, & Fullagar, 2004). In response to this situation the USP has generated EMS specific guidance for medication storage (Brown & Campagna, 2005). These recommendations include:

- Temperature monitoring devices in the drug boxes to assess and record temperatures on a weekly basis.
- Avoiding temperature extremes by parking emergency vehicles in the shade or heated/air conditioned garages.
- Developing a program of regular stock rotation with particular attention to medications with low rates of turnover.
- Using insulated carrying cases for transport and storage of medications.
- Protection from temperatures over 104° F.
- Using the medications with the most stringent storage requirements to determine storage conditions for mixed loads (Pharmacopeial Forum, 2006).

Using these guidelines and recommendations agencies bear the responsibility to keep their out of hospital medications within a 40° ranges of temperature changes.

**Products Currently Available to Provide a Temperature Controlled Environment.**

There are several commercial products on the market in response to the need for a way to provide temperature control to drugs in and out of the hospital environments. Many focus on the needs of ambulances and emergency medical service companies. One product is the Medi-Kool 747 (Mermaid). This is a cabinet design unit made of stainless steel this is powered by a 12 volt power supply. It can be fitted into a rescue truck or ambulance in an existing compartment. The dimensions allow for two Pelican brand drug boxes to be placed inside. Additional features include a stainless steel lock and circuit board that can be preset to heat and cool. The circuit board also monitors and store up to six months of data. It requires professional installation and the base model lists for \$3900.00.

Advantages are its excellent construction materials, preset circuit board, and generous

inside dimensions. Drawbacks are the power drain on the vehicles battery supply and high initial cost of purchase and installation.

A second option is the Steady-Temp (Engel). It is also fabricated of stainless steel and powered by the unit's 12 volt system. It holds one Pelican brand drug box and automatically heats and cools to a preset temperature range. Temperature data logger keys are sold separately from the unit. This unit is designed to be free standing within an ambulance and does not mount inside an existing cabinet. It does not require professional installation and lists for \$1989.00 Advantages are the lower cost of each unit and smaller outside dimensions. Disadvantages are the power drain on the vehicle power supply and the space needed inside the ambulance where space is already at a premium.

A new product called Pharm Guard mounts on the inside of the existing drug box cabinet and heats or cools the entire compartment, not just the drug box (Biomedical Equipment & Engineering Services Co.). It is programmed to keep the cabinet temperature between 59°-75° F. It has a dual power system that can be run by a 12 volt vehicle system or by a 120 volt connection. It lists for \$2150.00. Advantages are the dual source power system and the ease of installation into an existing cabinet. The major drawback is the loss of temperature control each time the compartment is opened.

There are several disadvantages to choosing any of these products. Overall they all provide temperature control within the range defined as acceptable by the USP. However, the price per unit may be prohibitive to smaller agencies working with volunteer or limited budgets. The reliance on 12 volt power coming from the vehicle runs the risk of draining the unit's battery system to the extent that the vehicle will not be able to start up in the event of an EMS service call. This could contribute to a significant delay

in delivering care in an emergent situation. Finally, reliance on a compressor driven device could result in unknown maintenance and repair costs and possibly take a vehicle out of service due to a malfunctioning unit.

On the lower tech side of products there are several possible options. Solid foam insulation can be added to the walls of the drug box compartments. Soft sided coolers large enough to accommodate the drug box could be used possibly in conjunction with a refreezable blue ice type product in the warmer months. Using one of these options or a combination of them has both advantages and disadvantages. One primary disadvantage is the need to monitor the product through varying temperatures to access the usefulness of the product in this situation. In addition during the monitoring period, it may be found that the products do not guarantee temperatures within the accepted range. Advantages are many: the materials are cost efficient and readily available, they need no special skills to install or maintain, and they do not place a drain on the vehicle electrical system or on an agency's equipment budget. A unique advantage of a soft sided insulated cooler would be the ability to carry the drug box to a remote or extended scene in a more controlled manner.

### **Attempts to Improve Out of Hospital Medication Storage Practices**

Agencies throughout the United States have begun to make adjustments in their medication storage practices in the last 15 years. A New Jersey phone survey conducted in 2000 showed that 85% of programs surveyed had changed their practices in the last five years based on information from previous research on temperature control (Mehta, Doran, Lavery, & Allegra, 2002). Changes include adding heating and/or cooling units, using a temperature monitoring device, planned rotation of medications (Brown, Wojcik,

Bailey & Tran), and adapting policy and procedure documents to reflect the need for temperature control.

Operations policies established to plan for security and storage of supplies and medications tend to follow USP EMS specific recommendations. Measures include procedures such as removing drug boxes from units that are not temperature controlled and housing them inside the station except when in use, rotating medications in boxes known to have been exposed to prolonged periods of extreme temperatures, and storing boxes in designated climate controlled compartments (Virginia Beach Department of Emergency Medical Services, 02005). Research has prompted some states to amend regulations to include a requirement that medications should be stored per the manufacturer's recommendations (Palmer et al, 1985). It is noted however that simply requiring this kind of action may be counterproductive if it is not easily achieved and documented by individual agencies. Palmer et al (1985) notes in a look to the future that extreme measures such as removal of all medications from ambulances or requiring immediate installation of active heating and cooling units seem unwarranted. They advocate an interim policy of encouraging each EMS system to develop a plan of action aimed toward better understanding of all facets of this issue and towards identifying potential solutions.

### **Summary**

the United States emergency medical services community has been aware of the difficulties in maintaining a controlled environment for medications for over a decade. This awareness has prompted specific recommendations from the USP for out of hospital

storage conditions. It has also resulted in several companies producing products that can be used in an ambulance for supplemental heating and cooling.

The State of Arizona has looked at the need to develop standards for temperature control in drug boxes in this state, most recently in 2006. Decisions on this topic were delayed to at least 2007 due to lack of information on current temperatures in Arizona drug boxes and lack of a plan of action that would be applicable to all EMS agencies in the state. This study attempts to fill some of the gaps in data by assessing temperature ranges in the drug boxes located in the Verde Valley area of Arizona.

Chapter III will examine the methods and procedures used to gather the data for this study. It will also cover the instrument design and details of analysis.

### **CHAPTER III**

#### **METHODS AND PROCEDURES**

Chapter III contains a description of the methods and procedures needed to collect the data needed for this study. It includes the population, research variables, field procedures, methods of data collection, statistical analysis, and the summary.

#### **Population**

The population selected for this study was out of hospital drug boxes located on ambulances and rescue trucks in the Verde Valley area of Arizona. These drug boxes are located on the equipment of three different agencies: Sedona Fire District, Verde Valley Fire District, and Verde Valley Ambulance Company. The response areas of these companies cover the entire Verde Valley area. This is useful as it allows for the widest variety of terrain and elevation.

All three of these agencies maintain their equipment in heated/cooled garages except when out on an EMS assignment. None of the equipment is stored in the open without protection or has any temperature control devices in place at the present time. In addition, all the agencies use either a Plano or Pelican brand drug box for storage of their out of hospital medications.

#### **Research Variables**

This study centers around the minimum and maximum temperatures reached in the out of hospital drug boxes in the Verde Valley. The control variable was the temperatures reached in the drug boxes without any temperature control devices or

interventions. The interventions consisted of additions of solid foam insulation to the drug box compartments. The goal of the study was to compare the temperatures of the drug boxes with and without insulation. The two sets of temperatures will be assessed for compliance with the acceptable temperature range of 46° - 86° F.

### **Field Procedures**

Reading of the temperature ranges were done by the on duty crew at each of the fire/EMS stations. The temperatures were recorded for the first response ambulance or rescue truck for each agency for a total of three vehicles. Readings took place every third day and the results were collected by the principle investigator. The results were reviewed and tabulated to analysis.

### **Methods of Collection**

Data were collected by placing a minimum/maximum thermometer in each of the designated drug boxes. The temperatures were read every third day for three weeks, consistent with an A-B-C shift rotation. The temperatures were read when the duty crew was doing mandatory drug box checks. Additional data were gathered in the same manner from the same drug boxes after modifications were made. Modifications consisted of rigid foam insulation readily available at a local home improvement center.

### **Statistical Analysis**

A t-test design was used to determine if there was a significant difference between the two sample means. The first sample was the control group using no means of temperature control in the drug boxes. The second sample was the experimental group using solid foam insulations in the drug box compartments.

### **Summary**

In this chapter the research variables for the control and experimental groups were defined. The characteristics of the chosen population were outlined along with a discussion of field procedures and methods of collection. Chapter IV discusses the findings of the study and data analysis.

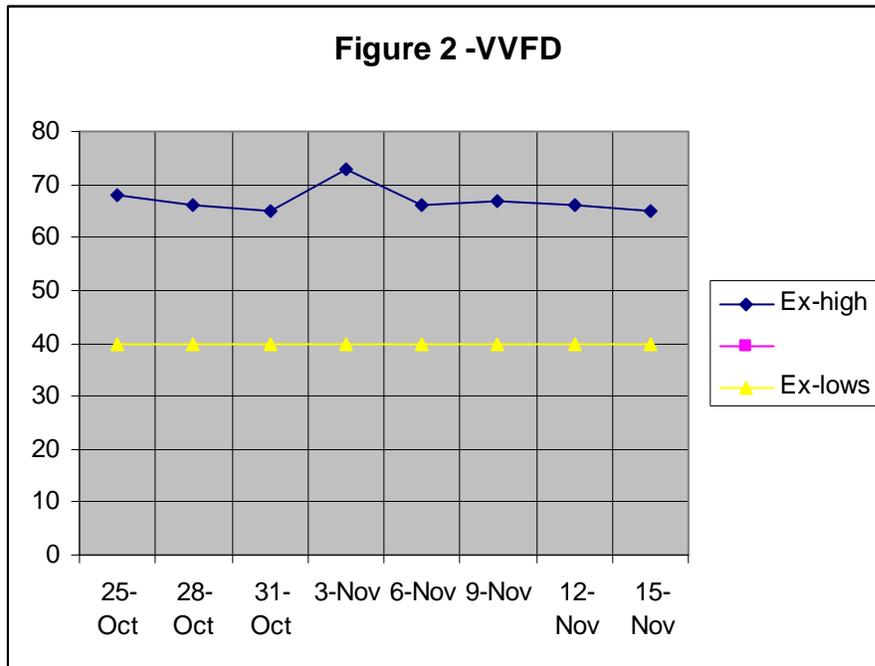
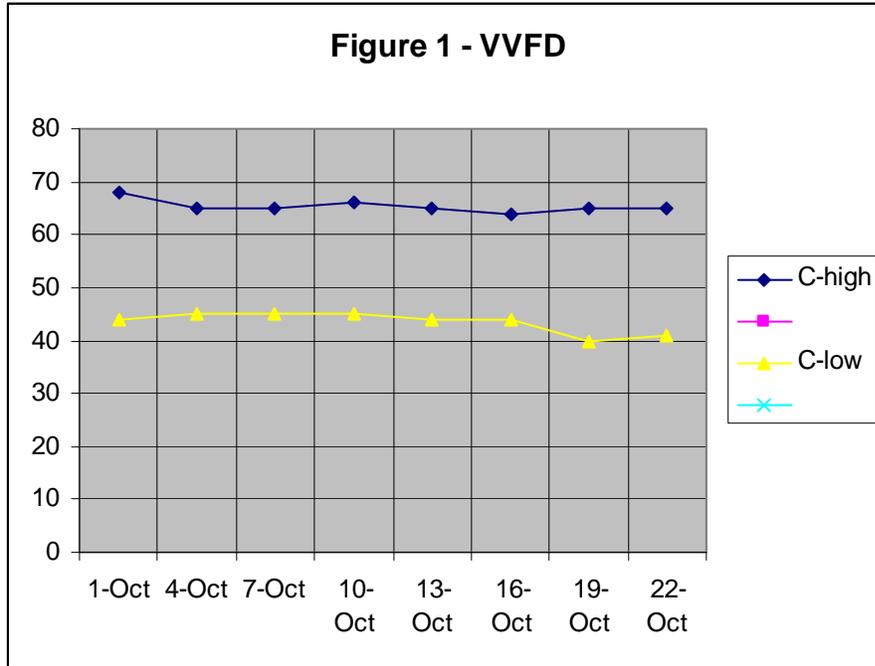
## **CHAPTER IV**

### **FINDINGS**

This chapter presents the findings of this study. The research hypothesis will be discussed in relation to temperature ranges and variations. The control group data provides a baseline of temperature ranges, with the control group addressing the hypothesis. All findings are correlated with the hypotheses stating the temperatures will remain in an acceptable range when rigid insulating foam is used. In brief, the addition of the rigid foam insulation did not contribute significantly to keeping drug box temperatures in an acceptable range. Details of temperature ranges, averages, and statistical significance will be covered in the data collection results.

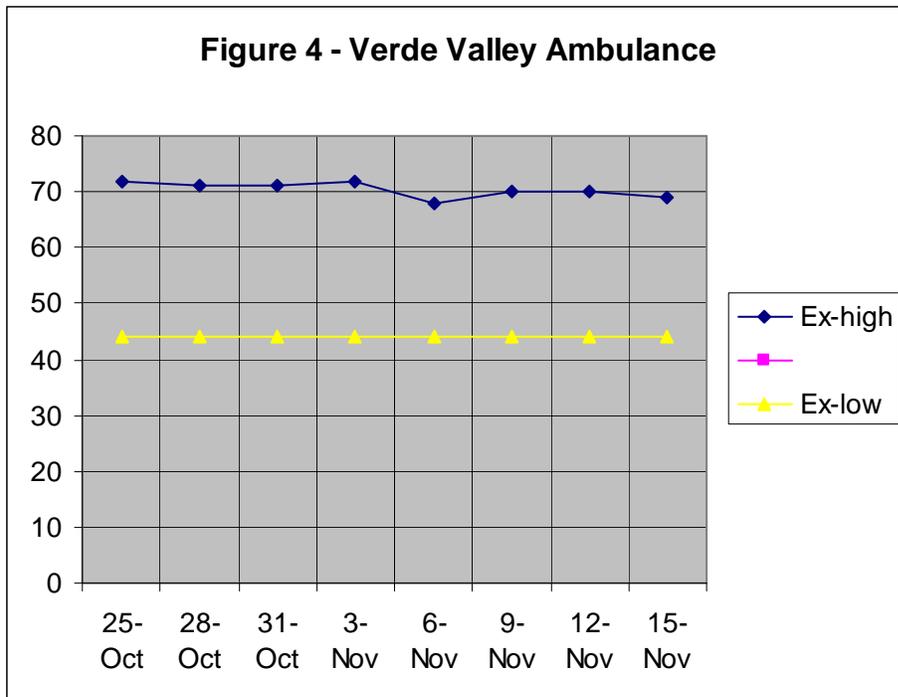
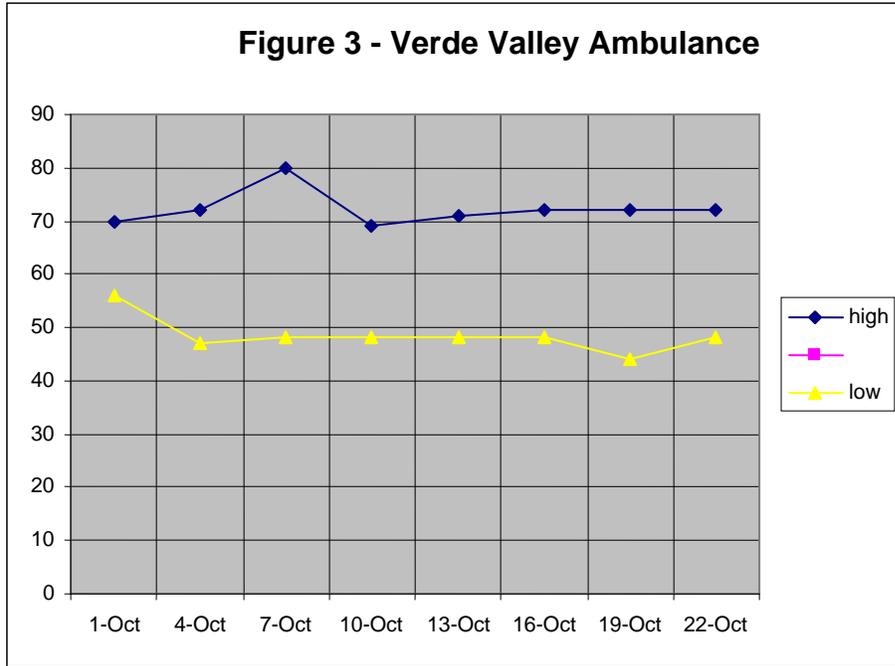
#### **Data Collection Results**

Verde Valley Fire District was the first agency chosen to carry a min/max thermometer in its drug box compartment. Data were gathered in compliance with the stated methods of collection. The maximum temperature in the control data was 68° F., the minimum was 40° F., and the average was 54° F. The maximum temperature for the experimental data was 73° F, the minimum was 40° F and the average was 53.5° F. Figures 1 and 2 show the complete sets of data for the control and experimental groups respectively. Results are presented in graphical form for ease of visualization.

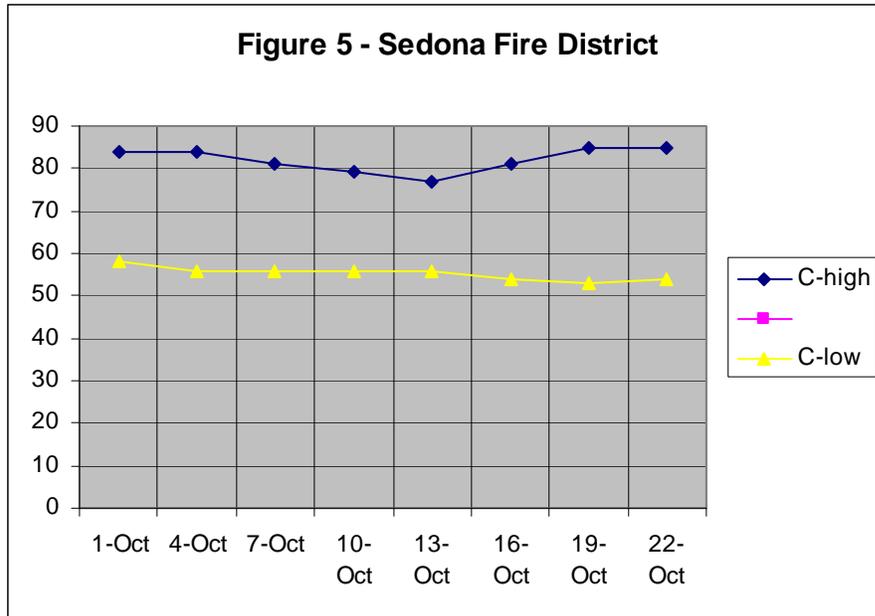


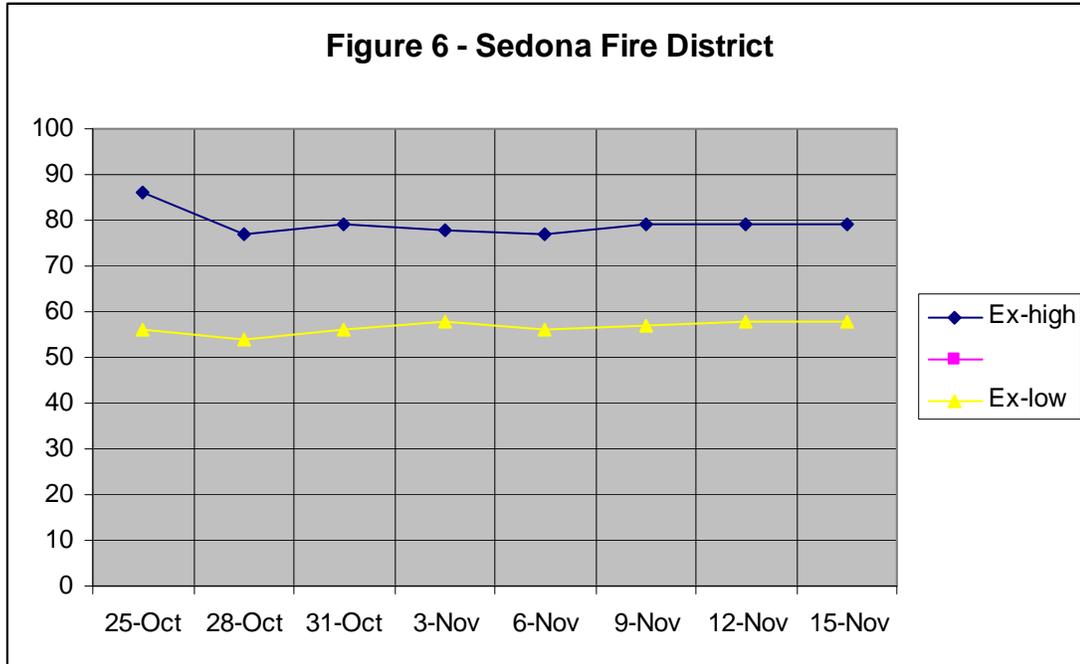
The second agency is Verde Valley Ambulance Company. The drug compartment control temperatures for this agency ranged from a low of 44° F. to a high of 80° F. The average temperature was 60° F. Temperatures from the control data ranged from a low of

44° F to a high of 72° F, with an average of 57° F. Figures 3 and 4 show the complete sets of data in a graphical format.

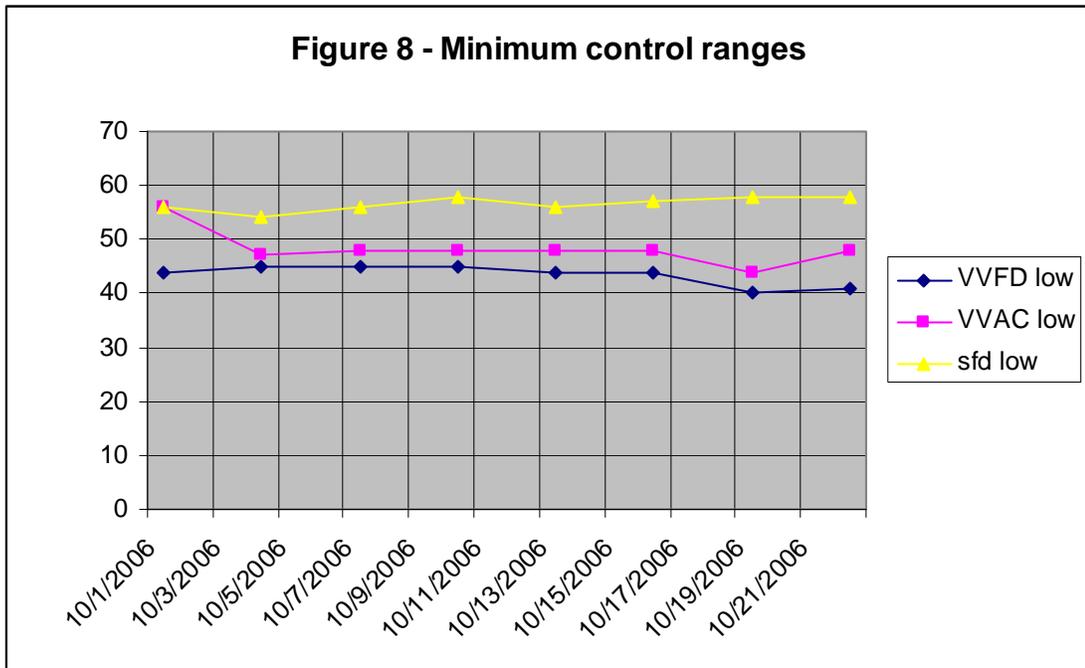
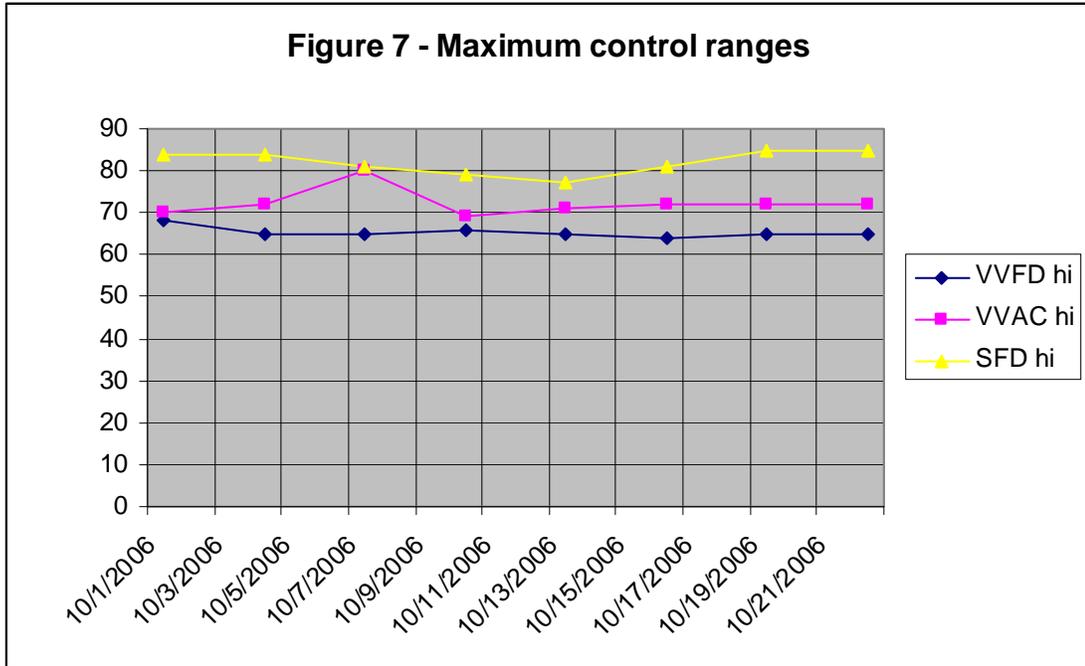


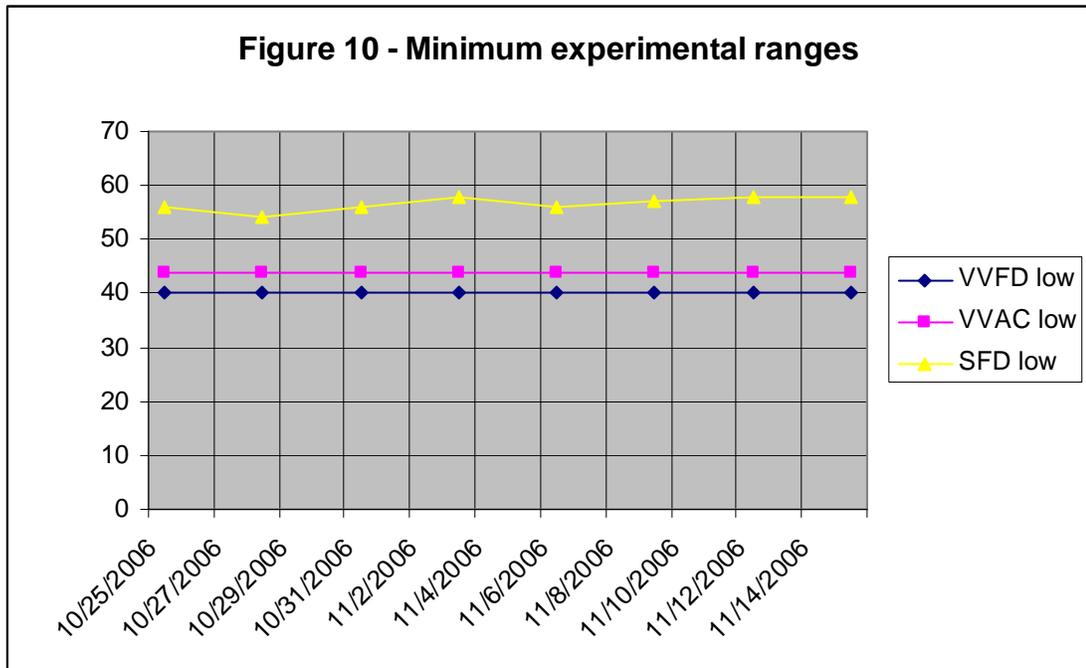
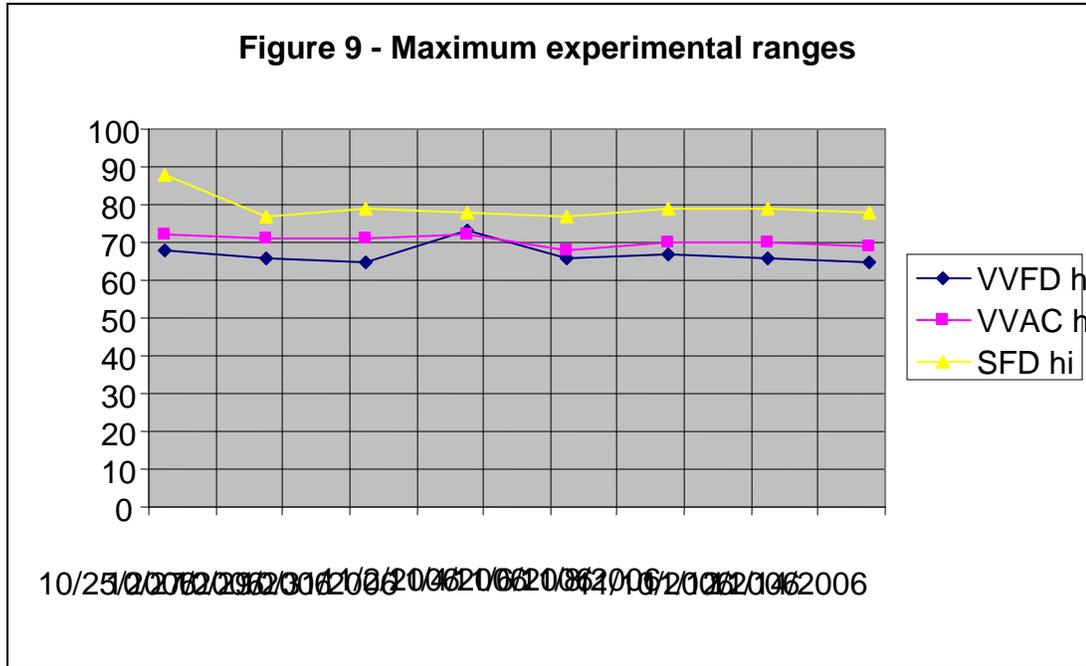
The third and final agency that carried a min/max thermometer in its drug box was Sedona fire District. This agency is at the highest elevation of the three and houses it's engines and ambulances in a heated bay. The temperatures for the control data ranged from a low of 53° F. to a high of 84° F. with an average of 68° F. The full set of data for control and experimental groups are shown in figures 5 and 6 respectively.





It is of interest to note that while each grouping of data shows variation within its own temperature ranges there is very little overlap in temperature ranges between the three agencies. This shows the need for much individualization of planning as data from one elevation or geographical area do not easily or accurately transfer to others. Figure 7 attempts to demonstrate this stratification of maximum control temperature ranges for all three agencies. See figure 8 for control minimum ranges, figure 9 for experimental maximums and figure 10 for experimental minimums.





### Statistical Analysis of the Data

A t-test design was used to determine if there was statistical significance between the temperature ranges of the control group and the experimental group. A total of 3 t-tests were performed. The first was on the maximum temperatures, the second on the

minimums, and the third on the daily average temperatures. A software formula available on the internet was used to perform the t-test computations (Student's t-test). The results are as follows:

- For the maximum temperatures the  $t = 0.495$  with a standard deviation of 6.71 and 46 degrees of freedom.
- For the minimum temperatures the  $t = 1.19$  with a standard deviation of 6.45 and 46 degrees of freedom.
- For the average daily temperatures the  $t = 0.882$  with a standard deviation of 6.30 and 46 degrees of freedom.

Using the t-test tables for a one-tailed test the level of significance at the 0.05 level is 1.6775.

Using this data the study must reject the initial hypothesis that stated use of a foam insulator would keep drug temperatures within an acceptable range. For this study the significance is that using solid foam insulation alone as will not reliably keep the drug box temperature between the recommended 46° to 86° F. range.

### **Summary**

The data collected for this study has shown the temperature variations for both un-insulated and insulated drug boxes. It has shown that each agency has a very specific temperature range that does not overlap the ranges of the other agencies, but does show consistency of storage within each agency.

Analysis of the data has shown that using a solid foam insulator alone does not significantly impact temperature swings enough to reliably keep the drug boxes within the recommended temperature range.

## **CHAPTER V**

### **SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS**

#### **Summary**

The purpose of this study was to determine the effect solid foam insulation had on the temperature variations in prehospital drug boxes during the months of October and November 2006. Specifically if the insulation would keep the drug boxes within the recommended temperature range of 46° to 86° F. The study was prompted by indications from ADHS that temperature controls for drug boxes would soon be required in all prehospital drug boxes. The hypothesis: drug box temperatures will remain within an acceptable range when insulated with solid foam was used to guide the direction of this study. Three agencies in the Verde Valley allowed min/max thermometers to be placed in their drug boxes. One agency, Verde Valley Ambulance was based within the city limits; the second Verde Valley Fire in the suburban foothills; and the third, Sedona Fire in Oak Creek Canyon. Min/max temperatures were collected every three days at approximately 9am from the drug box compartments that had no insulation. Then additional data were gathered from the same drug boxes after 2” solid foam insulation was added to the drug box compartments. Min/max temperatures were again gathered and then compared to the control results.

#### **Conclusions**

The conclusions of this study are based on the hypothesis that states use of solid foam insulation in the drug box compartments will keep the drug boxes within an acceptable temperature range. This temperature range was based on recommendations from the USP (USP, 2005).

The t-test values obtained from this study indicate that this hypothesis can not be upheld. All t-values were below the 0.05 level of significance for a one tailed t-test. This can be interpreted to mean that the addition of solid foam insulation to the drug box compartments did not make significant difference in the maintenance of the required range of temperatures. This study indicates that the original hypothesis must be rejected.

### **Recommendations**

The data collected for this study were done during the months of October and November 2006. In order to make decisions for year round storage, further studies are recommended that cover temperature variations for an entire calendar year. This would make available data from all seasonal temperature extremes for this area.

In retrospect, this author feels that future studies should include daily min/max air temperature for the Verde Valley area in addition to the actual drug box temperatures. This would allow for a correlation between variations in air temperatures, weather patterns, and drug box temperatures. A future study might build on this data by including a commercial storage product and a product such as frozen blue ice to the experimental variables for comparison with the solid foam insulation data.

Finally, a study of the cost of adding a commercial unit to each ambulance compared to the yearly cost of drug replacement due to temperature swings might help clarify the usefulness of the commercial unit and put their costs into perspective.

## References

- Allegra, J.R., Brennan, J., Lanier, V., Lavery, R., & MacKenzie, B. (1999). Storage Temperatures of Out of Hospital Medications. *Academic Emergency Medicine*. v. 6-11, 1098-1103.
- Arizona Department of Health Services, Bureau of Emergency Medical Services. (2005). *R9-25-101 Working Draft Revision 4*. Retrieved June 1, 2006 from [www.azdhs.gov/diro/admin\\_rules/art1.2&10\\_rev4.doc](http://www.azdhs.gov/diro/admin_rules/art1.2&10_rev4.doc)
- Biomedical Equipment & Engineering Services Company. (2006). PharmGuard. Retrieved July 6, 2006 from <http://www.beescolle.com/pharmguard.htm>
- Bowman, L. (2004). *Study: shipping through mail can degrade medicine*. Scripts Howard News Service). Retrieved June 22, 2006 from <http://www.pharmacychoices.org/News2.html?id=59>
- Brown, L.H. & Campagna, J.D. (2005). Medication storage in the EMS environment: understanding the science and meeting the standards. *Emergency Medical Services*. v.34(4). 73-77.
- Brown, L.H., Krumperman, K., & Fullagar, C.J. (2004). Out of hospital medication storage temperatures: a review of the literature and directions for the future. *Prehospital Emergency Care*. v.8, April-June 2004, 200-206.
- Brown, L., Wojcik, S., Bailey, L., & Tran, C. (2004). Medications storage temperatures on U.S. ambulances: exposures of varying durations and the effects of a simple stock rotation scheme. *Prehospital Emergency Care*. v.8, 83.
- Church, W.H., Hu, S.S., & Henry, A.J. (1994). *Thermal degradation of injectable*

*epinephrine*. *American Journal of Emergency Medicine*. v. 12, 206-309.

Engel Corporation. (2006). SteadyTemp. Retrieved July 11, 2006 from

<http://www.i-m-d.com/engel/steadytemp.htm>

Gottenwald, M.D., Akers, L.C., Liu, & PK et al. (1994). Prehospital stability of

diazepam and lorazepam. *American Journal of Emergency Medicine*. v. 17, 333-337.

Grant, T.A., Carroll, R.G., Church, W.H. et al. (1994). Environmental temperature

variations cause degradation in epinephrine concentrations and biologic activity. *American Journal of Emergency Medicine*. v.12, 319-322.

Helm, M., Castner, T., & Lampl, L. (2003). Environmental temperature stress on drugs

in prehospital emergency medical services. *Acta Anaesthesiologic Scandinavica*. v. 47, 425.

Johansen, R.B., Schafer, N.C., & Brown, P.I. (1993). Effects of extreme temperatures on

drugs for prehospital ACLS. *American Journal of Emergency Medicine*. v. 11, 450-452.

Mermaid Manufacturing. MK747: Medi-Kool Unit. (2006). Retrieved June 22, 2006

from

[http://mmair.com/index/php/mermaid/layout/set/print/medical\\_division/medi\\_kool\\_747\\_unit](http://mmair.com/index/php/mermaid/layout/set/print/medical_division/medi_kool_747_unit)

Mehta, S.H., Doran, J.V. Lavery, R.F. & Allegra, J.R., (2002) Improvements in

prehospital medication storage practices in response to research. *Prehospital Emergency Care*. Jul/Sept 2002; 6(3):319-321.

Palmer, R.G., Zimmerman, J., Brown, P.C., & Clawson, J.J. (1985). Altered states:

the influence of temperature on prehospital drugs. *Journal of Emergency Medical Services*. v. 10, 29-31.

Pharmacoepial Forum. (2006, June). *Emergency Medical Services Vehicles and Ambulance-Storage of Preparations*. In process revision. U.S. Pharmacopeia  
12501 Twinbrook Parkway, Rockville, MD 20852.

Students t-test. Retrieved November 20, 2006 from

[www.physics.csbsju.edu/stats/ttest.html](http://www.physics.csbsju.edu/stats/ttest.html)

Thermal Engineering Branch Website. (2004). *Thermally stabilized paramedic drug box for fire trucks*. Retrieved June 7, 2006 from

<http://mscweb.gsfc.nasa.gov/545web/Groups/P2/Technology/FireBox.html>

The United States Pharmacopeial Convention, Inc. (2005). Toronto, Ontario: WebCom  
Limited.

Virginia Beach Department of Emergency Medical Services. (2005). *Medication storage policy*.