

THERMAL IMAGING CAMERA USAGE WITHIN THE VENTURA COUNTY FIRE PROTECTION DISTRICT

Thermal Imaging Camera Usage within the Ventura County Fire Protection District

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ABSTRACT

This applied research project captured information regarding the current knowledge and use of thermal imaging cameras within the Ventura County Fire Protection District in 2012.

The problem is that the VCFPD has not updated TIC training since the purchase of newer devices. The purpose of this research was to identify how TIC's are being utilized and the level of user knowledge within the VCFPD.

The descriptive research method was used to answer the following questions:

1. What is the basic user knowledge of TICs within the VCFPD?
2. How is TIC training delivered to VCFPD personnel?
3. How are TIC's utilized by VCFPD personnel in the field?
4. How do partner agencies utilize TICs?

The major findings of this research project indicated that users show poor retention of vital knowledge as to the basic operations and limitations of TICs. Surprisingly, the vast majority of personnel surveyed had a firm grasp of when TICs can be used but lacked the detailed knowledge needed to operate effectively and safely in an IDLH environment.

The recommendations developed from this project are:

1. Create an instructor cadre of subject matter experts for TIC training delivery
2. Assure instructors receive the most up to date training available.
3. Integrate TIC use during other appropriate training including:

Search

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Live fire

RIC

Structure Operations

4. Update TIC training when new equipment enters service.
5. Create and post basic information for each TIC being used on the VCFPD “Ten Minute Topic”.
6. Utilize NFPA 1408: Standard on Thermal Imaging Training (Draft) when designing or updating TIC training
7. Update and maintain the VCFPD training manual whenever new equipment is placed in service.
8. Review other technical equipment training within the VCFPD and apply the above concepts to identify if the programs need updating.

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INTRODUCTION

The Ventura County Fire Protection District (VCFPD) has continually strived to provide the most up to date equipment for the safety of its fire fighters and efficient operations during emergency activities. In 1998, a research and development project was undertaken to assess the need for thermal imaging capabilities for VCFPD. The project included presentations from the manufacturers, field trials, and recommendations for use and deployment. Through this process, a thermal imaging camera (TIC), the ISG K-90 Talisman, was selected and eight TICS's purchased. At that time, training materials were developed and a deployment model established. Initial training was given for line-assigned personnel during VCFPD In-Service SCBA training. A training module was also developed for the new hire academy training including classroom and field exercises.

Since the original training, the VCFPD has not updated or delivered in-service training and has relied on academy training to new employees to be sufficient for TIC use. Additionally, new advances in technology and different TIC's have been purchased by VCFPD.

The problem is that the VCFPD has not updated TIC training since the purchase of newer devices. The purpose of this research is to identify how TIC's are being utilized and the level of user knowledge within the VCFPD. The descriptive research method was used to answer the following questions:

1. What is the basic user knowledge of TICs within the VCFPD?
2. How is TIC training delivered to VCFPD personnel?
3. How are TIC's utilized by VCFPD personnel in the field?

4. How do partner agencies utilize TICs?

BACKGROUND AND SIGNIFICANCE

In May 1928, the Ventura County Fire Protection District (VCFPD) was established with a primary mission of battling brush fires in the county of Ventura, California. As the County grew and became more populated, it became necessary to broaden this initial mission to include all types of fires. This included incendiary devices and the identification of “war gases”. During this time, and with the help of State funds, new, improved apparatuses and equipment were purchased to meet the needs of this ever changing environment.

Today, the VCFPD is an all-risk, full service fire department composed of 553 men and women. VCFPD proudly provides fire protection, medical aid, rescue, hazardous materials response, urban search and rescue, water rescue and a variety of other prevention and safety services to the public.

VCFPD covers 848 square miles and serves more than 480,000 people in unincorporated areas of Ventura County and six of its cities: Ojai, Port Hueneme, Moorpark, Camarillo, Simi Valley, and Thousand Oaks.

The VCFPD’s services are built around our mission of anticipating and responding to the dynamic public safety needs of our diverse community.

VCFPD partners with the community to identify safety risks and empower people with the tools to prepare and protect themselves. It reinforces those efforts with a dedicated team response to more than 33,500 incidents a year. All personnel in our 31 fire stations throughout Ventura County are trained to provide the highest level of firefighting, emergency medical care

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and rescue services to the citizens of Ventura County. In 2011, VCFPD responded to 23,596 emergency medical calls, 1,274 fires, 2,549 rescue calls, 3,795 public service calls, 1,545 alarms, and 805 calls involving hazardous materials. (Ventura County Fire Protection District, 2012) As a progressive department, VCFPD strives to maintain the most up to date equipment and training. By doing so, VCFPD provides the best service to its constituents and the safest working environment for its employees.

The fire service has relied on new technologies, primarily developed for military use, to enhance and augment its operations. As technologies become available, they have been adapted for use in many areas of emergency response. For example, since the Self Contained Breathing Apparatus was created, it has been adopted and used for structural fire fighting. This equipment was modified from a military apparatus to one that could be used in the mining industry and, later, firefighting. It allowed for radical changes in the tactics and strategies utilized in structural fire fighting; thus, allowing aggressive interior fire attacks in atmospheres that are immediately dangerous to life and health (Occupational Safety & Health Administration, 2011). Most importantly, the Self Contained Breathing Apparatus has enhanced personal safety for fire fighters by protecting the respiratory tract and nearly eliminating the inhalation hazardous materials of structure fires.

TIC's have followed a similar tract; initially these devices and the technologies they utilized were highly guarded secrets (Bullard, 2001). The devices were large, heavy, needed external cooling and most importantly very expensive to purchase and maintain. Today, TIC's are small, light weight, do not need external cooling, and are constructed of rugged thermal plastics, allowing them to be used in the demanding environment of fire fighting and rescue

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operations. As more of these devices are used, competition and advances in technologies have also reduced their costs, making them available to a wider market.

In 1999, the VCFPD purchased its first TICs and placed them in service on truck companies and Battalion Chiefs vehicles. This deployment model assured that two TICs arrived on any structure fire and at least one TIC was available on any multi-company incident including hazardous materials, rescue, traffic collision, or specialized rescue scenes.

When VCFPD first purchased TICs, training was developed for current employees during annual Self Contained Breathing Apparatus (SCBA) training. A classroom presentation was delivered, followed by hands-on field use. This same format of training has been used for new hires during academy training since the initial purchase of the TICs. Currently, training has been accomplished by Battalion and Company level drills for all employees.

Since initial purchase, four different makes and models of TICs have been placed into service with the VCFPD. This research project is designed to provide the VCFPD with information on how TICs are currently being utilized by first responders, assess the need for updated TIC training within the VCFPD to ensure for firefighter safety, and to collect information from partner agencies regarding their TIC programs.

This Applied Research Project is conducted in conjunction with the National Fire Academy Executive Fire Officer Program, Executive Development class. As leaders in the fire service, Executive Development students must be able to identify problems within the fire service and present solutions in a useful format. This project also meets the United States Fire Administrations operational objective to “Improve the fire and emergency services’ capability for response to and recovery from all hazards”.

LITERATURE REVIEW

The literature review included magazines, books, manuals and other materials found at the National Fire Academy Learning Resource Center, California State University at Northridge library and electronic sources.

Research Question 1. What is the basic user knowledge of TIC's within the VCFPD?

VCFPD currently operates three different TIC models. Although similar in basic function, each unit's operations vary. The three TIC models being utilized by the VCFPD are the ISG K-1000 Elite, the ISG Elite XR, and the Bullard T-3LT.

The operating manual for the ISG K-1000 Elite TIC refers to nineteen warnings regarding the use of any TIC (ISG Thermal Systems USA, Inc., 2005). The first of these warnings states that:

All users must be thoroughly trained on the K1000's proper operation, features and full functionality prior to use. This includes general understanding of thermal images and how they are interpreted. Improper use of the equipment in a hazardous atmosphere could result in death or serious injury. (ISG Thermal Systems USA, Inc., 2005).

Basic operational knowledge should include battery life. The three different models of TICs deployed by the VCFPD have different operating times based on the type of battery being used. The battery purchased with the K-1000 Elite has an operational time of three hours. The Elite XR's battery life is two hours and the Bullard T-3 battery will operate for two and one half hours. New battery technologies allow for up to five hours with extended life batteries, while "clam shell" batteries can operate for up to two hours. (ISG Thermal Systems USA, Inc., 2005)(E. D. Bullard Company, 2012).

Interpreting the colorization displayed by each TIC is also critical for user safety. ISG TICs utilize three color scales: red, yellow and gray to represent different temperatures within the field of view. The temperature indicated by red changes depending on the operating mode the TIC is in. The high sensitivity mode is generally utilized in ambient temperatures. The low sensitivity mode is used when temperatures are below 1000 degrees Fahrenheit, and thousand plus mode for temperatures over 2000 degrees Fahrenheit (ISG Thermal Systems USA, Inc., 2005).

Low battery warning and time remaining are also displayed differently in each TIC. The ISG products display “LOW BATT” when the TIC’s battery indicator bar shows three bars or less, and the user can expect ten minutes or less operating time (ISG Thermal Systems USA, Inc., 2005).

There are no warnings when the TIC’s become overheated. As the internal temperature rises in the TIC, the electronics become less reliable and can fail or power off automatically (ISG Thermal Systems USA, Inc., 2005).

Knowing how the TIC works is one part of user knowledge. Another important aspect is how to utilize the TIC during emergency operations. Understanding the concept of a “six sided search” (Woodworth, 1997) is critical so that all available information is collected by the user. Moreover, Bullard TIC training specialist Mike Richardson notes that “Lack of knowledge and Training” is one of six areas that clearly stand out as common problems encountered by TIC users (Richardson, 2002). A lack of understanding about the TIC’s capabilities and limitations can be dangerous to the user and impact the mission’s success.

Research question 2. How is TIC training delivered to VCFPD personnel?

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Placing personnel in “high risk, low frequency” (Graham, 1996) situations and expecting them to perform at peak proficiency requires and demands training. Graham asserts that an outcome can be predicted by understanding how personnel are trained. If one wants a specific behavior to occur, then that behavior must be explained, taught and practiced (Hanley & Tiger, 2011, p. 229).

The VCFPD delivers new employee training during a sixteen week academy. During this time, individual disciplines are broken into modules taught by subject experts. Subject experts are trained by attending classes, seminars, or showing proficiency. They are generally grouped into cadres and partnered with other subject expert to deliver the established curriculum. Behaviors and evolutions are practiced by academy participants until they can be repeatedly performed. A probationary period after academy graduation lasts for an additional eight months during which the basic fire fighter skills learned in the academy as well as advanced skills are tested.

TIC training occurs during search and rescue operations within the self contained breathing apparatus module of the academy. The training incorporates two hours of class where TIC theory, device functions, device specifications, capabilities, limitations and operations are covered. An additional six hours of hands-on training is performed during search and rescue scenarios. These scenarios become increasingly more challenging by altering the training environment (Warren, 1979, p. 163). Beginning training starts with low light conditions, progresses to theatrical smoke scenarios, and concludes with live fire training. Students are allowed to utilize different issued equipment dependent on the goal of the scenario to overcome the altered environment presented.

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For regular employees, training is handled by one of three methods: in-service training (which covers topics prioritized by VCFPD management and delivered either by subject experts or through self-study), battalion-level training (which is administered by a Battalion Chief), and company-level training (which covers areas or disciplines identified by the company officer). There is no standard set by the VCFPD that mandates TIC training.

Research Question 3 and 4. How are TIC's utilized by VCFPD personnel in the field, and how do VCFPD partner agencies utilize TIC's?

TICs can be utilized in a number of ways. They work because all matter absorbs and radiates heat at different rates (Schlessinger, 1989, p. 42). These differences can be displayed visually as a picture or video that can be interpreted by the user. The Infra-Red wavelength used by TIC's in the fire service range between 8-12 microns (JHA, 2000, p. 257). This frequency range allows the device to "see" through smoke – that is, the device can penetrate between and through the particulate matter and gases produced by fire and suspended in air (Conn & Avery, 1960, p. 66). TICs cannot see through solid objects, they can only pick up heat that has been transferred to the surface of the material (Vincent, 1990, p. 6). It is important to remember that infrared radiation can be emitted, absorbed, emitted again and reflected. Energy/Heat (infrared radiation) can travel by conduction, convection or by radiation.

When viewing infrared radiation on a thermal imaging device, the hottest objects appear white or a lighter shade while the cooler objects will appear black or as a darker shade. Color scales can also be added correlating to specified temperatures (ISG Thermal Systems USA, Inc., 2005). The display on a TIC is relative to the area being viewed. The shades displayed are relative to each other and the conditions within the displayed area. For example, in a very cold

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environment, a light switch may appear white but will be cold to the touch. Other items such as a steel pole will appear darker shade. Conclusively, it is up to the user to interpret the image being displayed.

Correctly interpreting the image delivered by a TIC is the key to user proficiency and their ultimate safety. Knowing how the TIC works in a given environment allows the user to collect appropriate data that will aid in the assigned mission. ISG Operational Training states that when utilizing a TIC, the following questions should be considered and assessed continually (ISG Thermal Systems USA, Inc, 2005):

- What is the heat source? Interpreting the image is the key to success. be asked:
- What should be hot/cold in this environment?
- What is the difference in relative temperatures?
- Notice the thermal layer:

Is the thermal layer rolling?

How high is the thermal layer?

How distinct is the thermal layer?

- Are there features that will block or reflect the image seen?
- Have I scanned the entire environment?

TIC can be utilized for many different missions. Some of these include search, structural firefighting, Fire Attack Groups, Support Groups, Rapid intervention Crews, Hazardous Materials Incidents, Disaster incidents, traffic collisions, water rescue, wildland fire incidents, and low-light conditions. (ISG Thermal Systems USA, Inc, 2005):

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Proper use of the thermal imaging camera includes a systematic approach to scanning an area. A six-sided scan (Woodworth, 1997) technique assures that all portions of a room are viewed. When entering a room, the floor should be scanned first. The user should begin at their location and scan side to side to the back of the room. This first scan will identify immediate hazards to the firefighter, show the room's layout and potential exits, and depict the location of victims. Once complete, the second scan begins at the ceiling in the back of the room and progresses side to side toward the front of the room. During this phase, the user looks for heat, heat movement/travel, and the thermal layer in this area. Finally, all other areas including the room's walls and areas not immediately visible should be explored (ISG Thermal Systems USA, Inc, 2005). The use of a TIC does not preclude the user from physically searching all areas. All heat sources should be investigated as well as any shape that could be a victim.

There are many uses for a TIC during structural firefighting operations. The Fire Attack Group can use the TIC to locate the seat of the fire, assess any hazards, locate hidden fire, visualize heat spread, aid interior hose placement and to verify the impact of water application (Roaf & Hancock, 1992, p. 172).

The Support Group can use this tool to aid interior support functions such as salvage and overhaul. Roof teams can use thermal imaging cameras during horizontal ventilation. The TIC can be used to identify the areas of greatest heat concentration as well as construction features that will benefit or hinder operations (Montagna, 2005).

Rapid intervention Crews (RIC) can use the thermal imaging camera during search and rescue efforts and to assess the structural integrity of a building. The TIC can be used to identify hose line placement and to monitor heat travel from the exterior of a building.

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Thermal imaging can also be used during Hazardous Materials Incidents. The fluid/material level of a container can be determined using a TIC. The shape of a container can be monitored for deformation and over pressurization. Hazardous atmospheres can be visualized as well as tracking vapor movement for some materials. The TIC can be used to verify the movement materials with specific gravities less than one on top of water.

During disasters such as earthquakes, flooding or landslides, Urban Search and Rescue teams can use TICs to search structures. They can identify potential exit points such as doors and windows, maintain reference points with lifelines, hose lines or exterior walls.

TIC's can be used in open areas and on traffic collisions (T.C.'s) to locate victims, identify downed power lines, track spill/vapor movement and identify sources of ignition.

Water Rescue teams can use TIC's to locate victims floating on top of the water and to access shore lines or river banks. One limitation of these devices is the inability to see through water.

Wildland Firefighters can use these devices for initial attack forces deployment, mop-up and planning. Fire behavior and fuel bed temperatures, as well as convection column fall-out can be seen using a TIC.

TICs can also be used in low light conditions. Although there are distinctions between Low Visibility/Night Vision and Thermal Imaging, TIC's allow a type of low light/night vision capability by displaying the thermal radiation of objects with in the field of view.

PROCEDURES

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Definitions of Terms

Fire Attack Group:	A group of firefighters with a supervisor assembled to perform interior structure fire suppression work. Responsibilities include tactics for hose placement, water application, establishing water supplies, and victim search.
Support Group:	to perform ventilation, control utilities, force entry, perform salvage and overhaul operations on structure fires.
RIC	Rapid Intervention Crew; a group of firefighters with a supervisor assembled for firefighter rescue in the event of building collapse or firefighter injury.
Ten Minute Topic	VCFPD training subjects electronically accessible by personnel on the VCFPD intranet known as “FireNet”.
Quint	A fire apparatus capable of five functions: pump, water tank, fire hose, aerial device, and ground ladders.
RTC	Ventura County Regional Training Center (RTC) is the training facility utilized by VCFPD for centralized training. The facilities have burn buildings, USAR props, Ventilation props, classrooms, drill tower and other areas utilized for training.

Literature Review

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A fire service literature review was conducted at the National Fire Academy's Learning Resource Center (Emmitsberg, MD), between March 19 and March 28, 2012. This search focused on Applied Research Projects that addressed Thermal Imaging in the fire service.

Searches were performed at the California State University at Northridge Library (Northridge, CA) between June and September, 2012. These searches targeted adult learning, thermal imaging fundamentals, and thermal imaging applications.

Additionally, searches were also performed on the Internet utilizing the Google search engine. These searches identified journals, manuals, and training specific to thermal imaging in the fire service.

Observation

Observation of training exercises and emergency operations were conducted by the author. Training observations included VCFPD in-service live fire training conducted at the VCPD Camarillo training facility between April 1, 2012 and July 19, 2012. Battalion level hose and rescue drills were also observed between April 1, 2012 and August 11, 2012.

Surveys

Two surveys were conducted to answer research questions. Surveys 1 and 2 were developed for VCFPD personnel and Survey 3 was developed for partner agencies; questions for these surveys are listed below.

Survey 1 Questions:

How long does a rechargeable battery last?

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How many different TICs does VCFPD have in operations?

What is the upper temperature range a TIC can be used?

How is an area scan performed?

What is thermal inversion?

How much operational time remains when low battery is indicated?

What temperature is indicated when you see yellow in the viewfinder?

What warning is given prior to TIC shut down due to overheating?

What is the procedure for repairing TICs?

How long does it take for the TIC to power up?

Survey 2 Questions:

What are your expectations for TIC Training?

When should TIC training be updated?

Who should conduct TIC training?

What should be included in TIC training?

How should TICs be utilized in training?

Should TIC training be incorporated into live fire training?

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What are your expectations for TIC use?

How can TIC's be utilized on emergencies?

Who carries the TIC on emergencies?

Who uses the TIC on emergencies?

Have you received formal TIC training from VCFPD? When? How? Type?

Have you received formal TIC training from another source? When? How? Type?

Survey 3 Questions:

Does your agency have thermal imaging cameras?

How are your TICs deployed?

Who administers TIC training?

What model TIC does your agency use?

Do you have formalized TIC training?

What are your expectations for TIC training?

How often does your agency train with TICs?

When should TIC training be conducted?

What should be included in TIC training?

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How should TICs be utilized during training?

What are your expectations for TIC use?

How can TICs be utilized on emergencies?

Who carries the TIC on emergencies?

Who uses the TIC on emergencies?

Assumptions

An assumption was made that the presence of the author at training would not alter behavior or TIC use once the nature of the research was known by field personnel and as time passed.

Participants were allowed to complete surveys at their leisure. It was assumed that they would answer questions without accessing reference materials.

Limitations

There were a number of limitations associated with this research project. The materials quoted during the literature review relied heavily on manufacturer materials.

Surveys allowed interpretation by participants and responses ranged from personal commentary to some questions not being answered. No statistical analysis was conducted on the data collected.

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Observations of drills and emergencies operations were limited to the author's presence and the limited number of opportunities to collect data.

RESULTS

The user knowledge portion of the study's surveys identified areas that need improvement. Of the forty five (45) surveys distributed, twenty four (24) were completed. Results for each question follows:

How long does a rechargeable battery last? 25% correct, 75% incorrect

How many different TICs does VCFPD have in operations? 25%, correct 75% incorrect

What is the upper temperature range a TIC can be used? 25% correct 75% incorrect

How is an area scan performed? 8% correct, 92% incorrect

What is thermal inversion? 4% correct, 96% incorrect

How much operational time remains when low battery is indicated? 4% correct, 96% incorrect

What temperature is indicated when you see yellow in the viewfinder? 45% correct, 55% incorrect

What warning is given prior to TIC shut down due to overheating? 12% correct, 88% incorrect

What is the procedure for repairing TICs? 4% correct, 96% incorrect

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How long does it take for the TIC to power up? 29% correct, 71% incorrect

This portion of the survey clearly shows a lack of basic knowledge of the functions, limitations and procedures needed to be proficient in the use of TICs.

Training for VCFPD, as explained earlier, consists of Academy, Battalion and Company level drills. The survey showed the following:

96% of VCFFD personnel stated that they have received some TIC training. 21% received TIC training as new hires during academy training.

79% of personnel received TIC training by either In-Service or Battalion/Company level drills. 71% remembered training when the TICs were initially purchased in 1999. 8% remember Battalion/Company training specifically geared towards TICs.

The surveys showed a wide range of understanding as to the possible uses of TICs and how they are actually used. Personnel who had additional training outside of VCFPD supplied training also had higher knowledge retention.

Expectations of training and use on emergencies were very consistent. All agreed that TIC training should occur within the academy environment. 71% felt that In-Service TIC training should be held annually; most thought during other related training such as RIC, structure operations, and live fire exercises.

Most personnel believed that the training should be realistic, functional, and have a hands-on component.

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The survey results also indicate that, although the fire fighters are the most likely to carry the TIC, it is viewed that anyone should have the understanding and knowledge to utilize this piece of equipment on any emergency where it might be beneficial.

Observations of six structure fire incidents, two Wildland fires, three Hazardous Materials incidents, one over the side rescue, seven multi-company live fire training drills and eight multi-company rescue based drills revealed the following:

TICs were utilized on all structure fires. Per VCFPD policy, functional groups responsible for identified tasks were established on each of the observed structure fires. The Fire Attack Group, which has the responsibility for interior fire suppression, utilized one or more TICs on each fire. The Support Group's interior fire fighter utilized the TIC on each fire. The Rapid Intervention Crew (RIC) had one TIC available in their equipment cache. A TIC was not utilized to assist in vertical ventilation.

No TICs were used during initial attack on the observed brush fires. The author utilized a TIC while assigned as a Division/Group supervisor to locate a hot spot observed in steep terrain during night operations but was not visible the next morning.

The TIC was utilized during two of three hazardous materials incidents. During one incident, crews used the TIC to determine the temperature of a reaction within a metal shavings waste container. On another incident, the TIC was used to establish a material level in a metal container. The third incident involved an open spill of an unknown material; a TIC was not used on this incident.

A TIC was utilized during an "over the side" traffic accident to identify possible ejected victims.

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A TIC was observed to be carried on one of seven observed live fire training drill. These drills, which are conducted at the VCFPD Regional Training Center (RTC), utilized two training props designed to show flash over and fire behavior. On the training day attended by the author, when asked if TICs could be taken into the props, the instructors showed concern that their presence may alter the drills goals.

TICs were not carried or used during any of the rescue based drills observed.

The survey was sent to seven partner agencies which includes Oxnard City Fire Department (OXN), Ventura City Fire Department (VEN), Santa Paula City Fire Department (SPFD), Fillmore City Fire Department (FIL), Ventura County Sheriff Department (VCSO) and two agencies that respond into the county by contract or automatic aid: Los Angeles City Fire Department (LAFD) in Bell Canyon and the Los Angeles County Fire Department (LACFD) in the Westlake area. All of the agencies that received surveys have TIC capabilities. Between the seven agencies, there are four different manufacturers represented and six models.

Deployment models vary depending on many factors. LAFD has over 150 TIC carried on all first run apparatus. LACFD has over forty TICs carried on truck companies, Quints and some engines. VEN, OXN, SPFD and FIL carry TICs on all first run apparatus. VCSO has thermal imaging available on helicopters in their aviation unit and the S.W.A.T. team has TICs.

With the exception of VEN, OXN and FIL, training is accomplished annually at the Battalion or Company level. VEN, OXN and FIL teach TIC use during their new hire academy training as well as annual training at the Battalion/Company level.

All agencies expect that any member of their organization be proficient in the use of these tools.

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There are some differences in who utilizes the TIC; while most agencies rely on the person assigned with the task or mission where the TIC could best be utilized to use the TIC, LAFD and FIL designate Captains (who act as supervisors) as the primary users.

Uses of the TICs during emergency operations included RIC, fire fighter survival, finding heat sources, search, hazardous material incidents and structure fire operations. Many also responded anywhere that the information would be pertinent to the incident.

DISCUSSION

The purpose of this research was to identify how TIC's are utilized and the level of user knowledge within the VCFPD. As expected, personnel with more training had a better knowledge base of the functions, operations and limitations of TICs (Rothwell, 2008). The data collected regarding user knowledge showed poor retention. Surprisingly, the vast majority of personnel surveyed had a firm grasp of when TICs can be used but lacked the detailed knowledge needed to operate safely in hazardous conditions (see APPENDIX D) (ISG Thermal Systems USA, Inc., 2005). Given the variety of user exposure to training and the lack of formalized review training, these results are predictable (Graham, 1996). Memories and therefore knowledge fades as time passes. Revisiting materials keeps it fresh in memory (Hanley & Tiger, 2011, p. 231). All respondents agreed that TIC training was needed for new hires and that refresher training should be scheduled with other topics when possible. The need to use the TICs in realistic training is vital to proficient operations on an emergency incident (Ruff-Eft, 2011, pp. 124-125). Standard repeatable training should be available for any employee.

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Training should follow the National Fire Protection Association's (NFPA) recommendations for thermal imaging training. "Before new or unfamiliar Thermal Imagers are placed into service, training and education relating to those imagers shall be provided for all affected members," (National Fire Protection Association, 2012, p. 2).

The research indicated that VCFPD personnel and partner agencies have a high level of understanding of how TICs can be utilized. TICs are currently used in many situations to gain information. Some of these uses included (a) finding heat sources including fire, electrical lines and malfunctioning equipment; (b) increasing visibility; seeing through smoke and low visibility/night operations; (c) identifying levels of material in a container; and (d) victim location.

Understanding when a TIC can be used does not guarantee proficiency in its use. Lack of knowledge about TIC basic functions such as the amount of time the TIC will operate after "LOW BATT" is indicated is critical for user safety (ISG Thermal Systems USA, Inc., 2005). Likewise, overconfidence when utilizing this highly technical piece of equipment is a concern given the low knowledge retention of its functions (Richardson, 2002).

RECOMMENDATIONS

The Ventura County Fire Protection District should update its thermal imaging camera training program. VCFD should

- create an instructor cadre of subject matter experts for TIC training delivery
- assure instructors receive the most up to date training available.

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- integrate TIC use during other appropriate training including
 - Search
 - Live fire
 - RIC
 - Structure Operations
- update TIC training when new equipment enters service.
- create and post basic information for each TIC being used on the VCFPD “Ten Minute Topic”.
- utilize NFPA 1408: Standard on Thermal Imaging Training (Draft) when designing or updating TIC training
- update and maintain the VCFPD training manual whenever new equipment is placed in service.
- review other technical equipment training within the VCFPD and apply the above concepts to identify if the programs need updating.

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APPENDIX A**User knowledge survey**

- 1) How long does a rechargeable battery last
- 2) How many different TIC's does VCFD have in operations
- 3) What is the upper temperature range a TIC can be used
- 4) How is an area scan performed
- 5) What is thermal inversion
- 6) How much operational time remains when low battery is indicated
- 7) What temperatures are indicated when you see yellow in the viewfinder
- 8) What warning is given prior to TIC shut-down due to overheating
- 9) What is the procedure for repairing TIC's
- 10) How long does it take for the TIC to power up

Appendix B

Thermal Imaging Camera Questions:

Name_____ Title_____ Agency_____

Training:

What are your expectations for TIC training

When should TIC training be updated

Who should conduct TIC training

What should be included in training

How should TIC's be utilized in training

Should TIC training be incorporated into live fire training

Expectations

What are your expectations for TIC use

How can TIC's be utilized on emergencies

Who carries the TIC on emergencies

Who uses the TIC on emergencies

Exposure to TIC's

Have you received formal TIC training from VCFD? When? How? Type?

Have you received formal TIC training from another source? When? How? Type?

APPENDIX C**Thermal Imaging Camera Questionnaire:**

Name_____ Title_____ Agency_____

Organizational Information:

Does your department have thermal imaging cameras

How are your TIC's deployed

Who administers TIC training

What model TIC does your department use

Training:

Do you have formalized TIC training

What are your expectations for TIC training

How often does your organization train with TIC's

When should TIC training be updated

What should be included in training

How should TIC's be utilized during training

Expectations

What are your expectations for TIC use

How can TIC's be utilized on emergencies

Who carries the TIC on emergencies

Who uses the TIC on emergencies

APPENDIX D**User Knowledge Survey Results**

1. How long does a rechargeable battery last?

25% correct, 75% incorrect

How many different TICs does VCFPD have in operations?

25%, correct 75% incorrect

What is the upper temperature range a TIC can be used?

25% correct 75% incorrect

How is an area scan performed?

8% correct, 92% incorrect

What is thermal inversion?

4% correct, 96% incorrect

How much operational time remains when low battery is indicated?

4% correct, 96% incorrect

What temperature is indicated when you see yellow in the viewfinder?

45% correct, 55% incorrect

What warning is given prior to TIC shut down due to overheating?

12% correct, 88% incorrect

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What is the procedure for repairing TICs?

4% correct, 96% incorrect

How long does it take for the TIC to power up?

29% correct, 71% incorrect