Infrared Camera System for TRU Waste Drum Remediation Activities at the Savannah River Site, Aiken, South Carolina, USA – 11555

*Monica H. Phillips, *Kenneth M. Gibbs, **Brent A. Daugherty
*Savannah River National Laboratory, Aiken, South Carolina 29808
**Savannah River Site, Aiken, South Carolina 29808

ABSTRACT

The Mound Facility and LASL (Los Alamos Scientific Laboratory) wastes stored at the Savannah River Site (SRS) since the early 1970's are being retrieved for process and preparation for shipment to the Waste Isolation Pilot Plant (WIPP) in Carlsbad, New Mexico. There are 241 thirty gallon drums from LASL containing plutonium oxide metal / debris and 729 fifty-five gallon drums from Mound containing debris and equipment. These containers collectively contain 13,665 grams of Pu-238. The current TRUPACT II shipping container limit is forty watts; therefore gram splitting represents a viable technique to assist in reducing individual package loadings to meet shipping limits. Since Pu-238 is a heat source material, it was believed that thermal imaging could provide a valuable tool to assist operators in identification of Pu-238 oxide in the waste during the gram-splitting process. Therefore, the Savannah River National Laboratory (SRNL) designed an infrared (IR) camera system to aid operators in these remediation activities as part of the American Recovery and Reinvestment Act (ARRA) at SRS. This visual capability combined with gamma scan assay will minimize the necessity of multiple attempts to repackage remediated containers. The operators will be able to determine an approximate quantity based on the IR image before sending the repackaged drum to assay. This will prevent packages from being returned from the assay facility due to excess quantities of Pu-238. The IR camera system featured an infrared camera with a custom electronic focusing mechanism, a pan/tilt unit, USB repeaters, a laptop with custom software, and both local and remote viewing monitors. The custom software package, designed by SRNL, was able to adjust the color scale of the live image, control the electronic focusing mechanism of the camera lens, and record video to the hard drive when prompted. A full-scale mockup was fabricated at SRNL to test the system before installing it into a contaminated area. The mockup also allowed for training of the operators in a clean environment. The system was installed in the facility in February 2010, and to date, operators have been successful in locating Pu-238 with the IR camera system.

INTRODUCTION

An infrared camera system has been designed for F-Canyon remediation activities at the Savannah River Site as part of the American Recovery and Reinvestment Act (ARRA). This project was initiated to develop a tool to assist in identifying and splitting the Pu-238 waste. The purpose of this camera system is to aid operators in identifying Pu-238 in the waste drums that are being repackaged for shipment to WIPP. Since Pu-238 is a heat source material (producing 0.5 Watt/gram), it was determined that thermal imaging with an IR camera could be a valuable tool for the operators. This tool will be particularly helpful in gram-splitting the Pu-238, since there are limits on the quantity of material that can be placed in each package. The current repackaging limit is 20 grams per container. The operators will be able to determine an approximate quantity based on the IR image before sending the repackaged drum to assay. This will prevent packages from being returned from the E-Area assay facility due to excess quantities of Pu-238.

INFRARED TECHNOLOGY

Infrared imaging is the process of viewing and measuring the amount of thermal energy that is emitted from an object. Every object with a temperature above absolute zero emits heat or infrared radiation. Infrared radiation is electromagnetic radiation whose wavelength is longer than that of visible light and therefore not detectable by the human eye. Infrared radiation is a form of light and obeys all principles of light. The higher the temperature of an object is, the greater the amount of infrared radiation that is emitted. An infrared camera detects the infrared radiation given off by objects in a scene and converts it to an electronic signal. This signal is processed and produces a thermal image on the screen. Precise temperature measurements can be made if an object’s emissivity is known. The emissivity of an object is the radiation of heat according to the Stefan-Boltzmann Law compared with the radiation of heat from an ideal “black body” with emissivity coefficient equal to one. For example, the emissivity of polished brass is 0.03 while the emissivity of concrete is 0.85.

For this application, infrared technology is being used as a qualitative tool instead of a quantitative tool. Measuring the mass of Pu-238 by thermal imaging is a complex problem requiring the knowledge of emissivity of the surface material, air flow, heat transfer coefficient, thermal conductivities of intermediate layers among countless other uncontrolled variables. This technology is able to detect an accumulation of material, but if the material is spread thinly, the infrared camera may not be able to detect the Pu-238 due to the sensitivity of the camera or the “thermal noise” present.

SYSTEM COMPONENTS

Many infrared cameras were investigated for this application. It was desirable to have a camera that was small and able to be controlled remotely, since the camera would be mounted inside a glovebox enclosure in a radiological contamination area (RCA). It was also desired that the camera have a relatively fast frame rate and high resolution (640x480). A suitable IR camera was procured with a custom-designed electronic focus mechanism so that the focus could be controlled remotely. The camera communicated via a USB 2.0 interface, but because the control area was approximately 150 feet away, USB extenders were used. The USB extenders transmitted the signal over CAT 6 ethernet and converted it back to USB at the control end. The camera was mounted to a pan/tilt unit in the top of a glove box enclosure. The pan/tilt (PT) unit had a joystick controller so that it could be controlled remotely as well. A photograph of the camera mounted to the PT unit is shown in Figure 1. The system also used two TV monitors, one in the radiological contamination area for the operators to view, and one in the control area. A schematic of the system is shown in Figure 2.

Figure 1 - ICI 7640S Infrared Camera Mounted to Pan and Tilt Unit

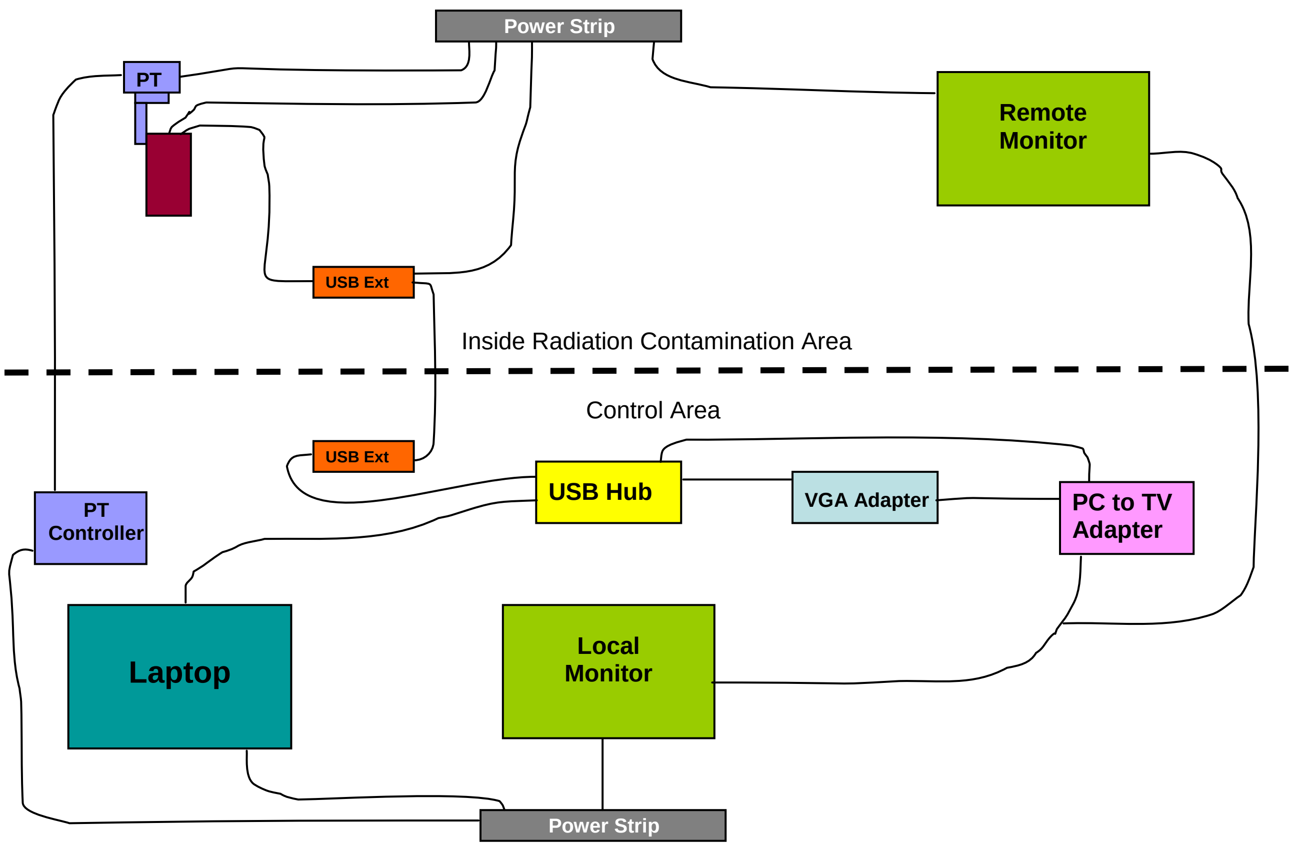

Figure 2 - Schematic of Infrared Camera System

A laptop loaded with custom software developed in LabVIEW was used to control the various functions of the camera as well as record video from the camera. The software enabled the operator to change the color scale, focus the camera, determine temperature, and start and stop video recording. It is important to note that only a relative temperature could be determined with this system. This is due to the unknown emissivities of the objects in the camera scene. If these emissivities were known, a calibration could be performed to calculate the precise temperature of the object. This was not possible for this system since the waste objects were unknown. The relative temperature information was able to give the operator an idea of the temperature difference of objects in the scene. This tool is useful since the quantities of Pu-238 (and heat given off) would vary. The operator could determine if an object was even slightly warmer than ambient in the enclosure. A screenshot of the software interface is shown in Figure 3.

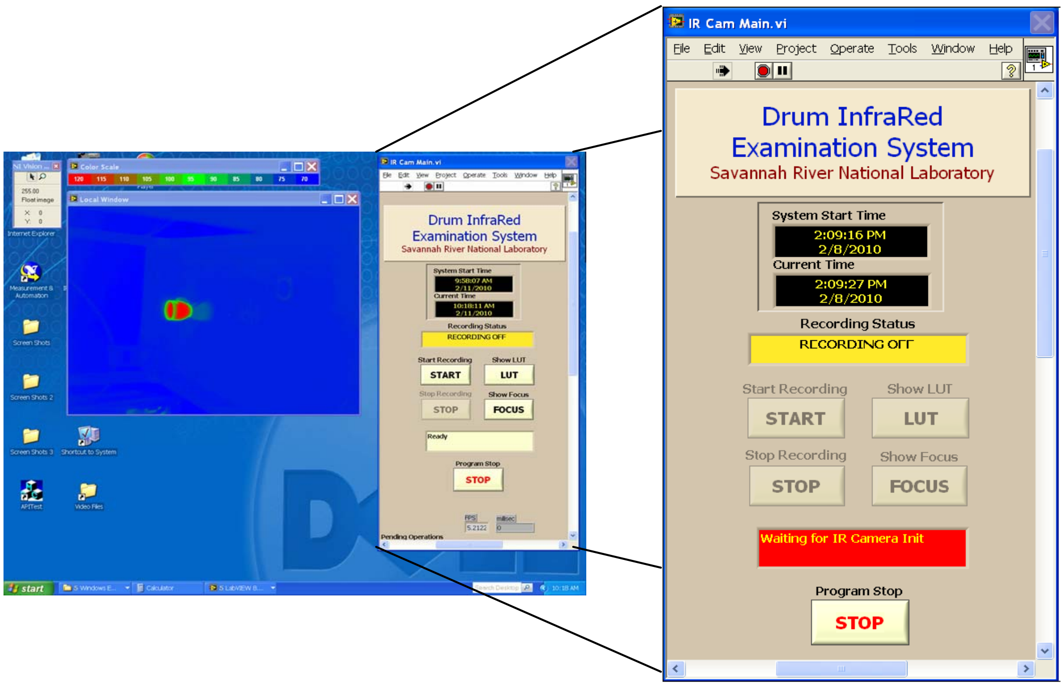

Figure 3 - Screenshot of Custom Software Interface

The infrared camera system was comprised of the components listed in Table 1.

Table 1 - Infrared Camera System Components

Description	Model Number	Manufacturer
Infrared Camera with Electronic Focus Mechanism	7640S	Infrared Cameras, Inc.
Laptop	Mobile Precision M6400	Dell
19" LCD Monitor (x2)	M-LYNX-19	Marshall
Pan and Tilt Unit	DPT 115	Electronic Systems Integration, Inc.
Pan and Tilt Controller	80	Electronic Systems Integration, Inc.
PC to TV Adapter	KW-PCTV-1600	K World
USB 2.0 Extender	00-00231 and 00-00234	Ircon
USB 2.0 Hub	F5U701-BLK	Belkin

All equipment, software, and cabling was mocked up in a full sized enclosure at the Savannah River National Laboratory. This mock-up enabled engineers to test operation over actual lengths of cable, determine the best way to mount the camera in the existing enclosure, and ensure that the camera could be manipulated to see the desired areas of the enclosure. The mock-up also allowed F-Canyon personnel including Engineering, Operations, Training, Procedure Writers, Construction, and Management to see and operate the system before installation into the radiological contamination area.

The system was installed in the F-Canyon Drum Remediation Facility in February 2010. To date, F-Canyon operators have been successful in locating Pu-238 with the infrared camera, and F-Canyon management is very pleased with the success of this tool. Figure 4 shows a screen shot from the IR camera; note that the hot areas show up in red.

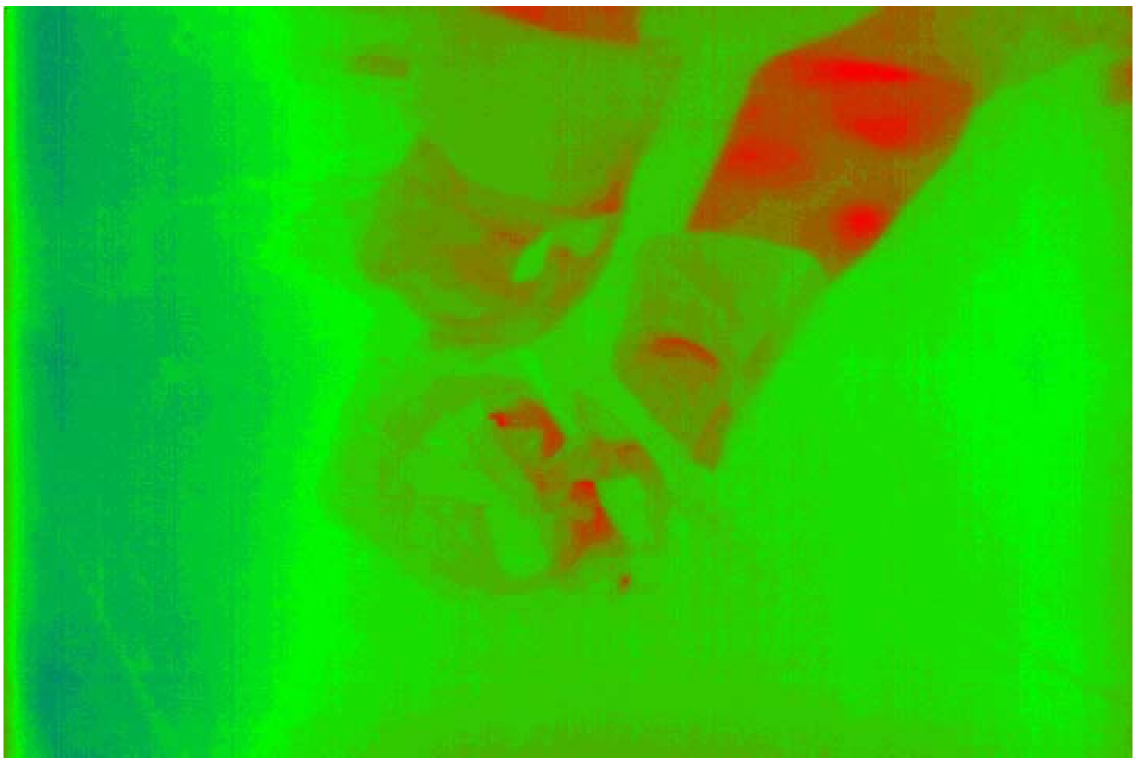

Figure 4 - Image from IR Camera Showing Operators Arms and "Hot" Package

CONCLUSION

Infrared technology has proven to be a useful tool in identifying Pu-238 in waste. Because the Pu-238 is a heat source, it is detectable with a thermal (IR) camera. This project was initiated to develop a tool to assist operators in identifying and splitting the Pu-238 waste before shipment to WIPP. The Savannah River National Laboratory developed a system consisting of commercial off-the-shelf components and combined them with custom software developed with LabVIEW. This system is currently installed in the drum remediation area in F-Canyon at the Savannah River Site.