How I Complete a Days Work In One Day

by Greg Stockton

Reprinted from:
"The Proceedings Infraspection Institute Symposium IR/INFO 1995" (New Orleans, LA) January, 1995 ALL RIGHTS RESERVED.

ABSTRACT
The purpose of infrared thermographic imaging of electro-mechanical equipment, in the area of predictive maintenance applications, is to inspect that equipment and determine if a potential problem exists, that could cause a failure which could result in human or monetary loss. When an infrared thermographer finds a potential problem, that information needs to be reported to the person or persons that can act to remedy the problem, prior to equipment failure. Since we cannot tell if, or at what moment, failure could occur, the shortening of time between discovery and reporting becomes all important. Therefore the infrared thermographer must be efficient and effective with inspection and reporting time. This paper discusses the methods I employ & the equipment I use, to be more efficient and effective with time.

1.0 INTRODUCTION

This paper is about how I complete a "day" of surveying and present a complete, quality, competent report to the people who need the information that same day. Throughout this paper I will use the example of a qualitative infrared thermographic survey of electrical switchgear, although the methods and equipment that I use, could apply to many other types of infrared thermographic surveying.

The words "complete", quality", and "competent" bring up a myriad of issues, which are not discussed, such as; "qualified", "certified", "too much or not enough detail in reporting", "how hot is too hot", "what's the payback", etc. Let us just say for the sake of this paper, that these are the methods and equipment that I use to produce what I consider to be a quality report.

If I am working for a client for the first time, he probably expects me to come to his plant, spend 8 hours collecting data, and then send him a report in the mail, say within two weeks or so. This is not good for him or me! He misses the benefit of having the data right away and I miss the benefits which are also discussed in this paper.

2.0 8 HOURS - 8 HOURS = O HOURS

The way I see it, the goal of an infrared thermographer is to leave the job site:

- A) alive and unhurt.
- B) with a content client.
- C) with at least most of his electrical problems (related to heat), reported to him.

IN THAT ORDER.

Safety (A) is of course priority #1. If my client is not pleased (B) with what I have accomplished, I will not be back to find other (C) electrical problems.

To reach this goal, I need cooperation from the client, the right tools, know-how and enough time. This means I must gain access to equipment under load, inspect, prioritize, collect data, evaluate, classify and report my findings to the right people. To do all this and complete it in one day, seems an impossible task. That is, 8hrs-8hrs= 0.

Well to start with, there are 24 hours in a day of which 12 should be dedicated to sleeping, eating, and pursuits other than work. This leaves 12 hours. Subtract the 8 hours that I am billing the client, and I am left with 4 hours to travel to and from the job site, eat lunch, prepare and present the report. This is ample time, since I have planned and prepared for the day.

I have written several sets of specification data sheets for performing different types of infrared surveys. Before I do any work for a company, I make sure that there is not going to be any misunderstanding as to the following:

- What I am going to do
- What I expect them to do
- What we are trying to accomplish
- What type of equipment I will use
- What type of report I will furnish, and when I will furnish it to them
- When I expect to be paid

Before I arrive, all these issues have been settled!

Let us take a typical work day of surveying a plant 25 miles from my office for an example:

5:30 AM - Leave for the job site.

6:00 AM - Arrive at the job site, calibrate, start surveying utility lines utility transformers, any equipment that will be effected by sun loading.

7:00 AM - Meet electrician at main switchgear room, continue surveying.

11:00 AM - Lunch.

11:30 AM - Continue surveying.

2:30 PM - Surveying ends.

2:30 PM - Return to van "office" & prepare report.

4:30 PM - Report presentation at the exit conference.

5:00 PM - Leave job site.

5:30 PM - Arrive home or at the next project.

Driving Time = 1 hour
Lunch = .5 hour
Report preparation = 2 hours
Report presentation = .5 hour

Of course, there are situations where this scenario does not play out. Problems such as these will ruin the best laid plans:

- The scanning equipment fails
- The plant starts up at 8:00 AM
- The client end user leaves at 3:00 PM
- Thirty-five problems are found in the plant that day
- A utility power failure ends the survey

I could go on.

But most of the time, I have found this example to be a typical day. In fact, things could be better. For example, on multiple-day, and on open-ended contracts, the schedule can be controlled so that surveying ends in time for an exit conference at 5:00 PM on the last day. One could also contract for 7.5 hours of surveying & .5 hour presentation.

Back to the numbers. Only two hours to prepare the report? Herein lies the key to success. In order to make the day happen, I must prepare a quality report in just two hours.

Below is a laundry list of everything that I carry with me to every job:

1) VAN & POWER SPECIFICATIONS

- a) Full size van, large wheelbase
- b) V-8 engine (5.0 liters or more)
- c) 3/4 ton rear end
- d) Towing or heavy-duty package
- e) Heavy-duty gas shocks/springs
- f) Transmission cooler package
- g) Large capacity gas tank
- h) Power steering
- i) Power brakes
- j) Gauges (water temp / battery volts / engine press)
- k) Heavy-duty air conditioner/heater
- 1) Heavy duty alternator (90amp minimum)

2) VAN OFFICE & DRIVING EXTRAS

- a) Large driver's and passenger side captain's chairs
- b) Extra high roof and/or sunroof
- c) Cruise control
- d) Windows
- e) Electric door latches
- f) Console
- g) Hand-held CB radio
- h) Hand-held cellular phone

- i) Remote control stereo system
- j) Cooler
- k) Clothes rack

3) SECURITY CONSIDERATIONS

- a) No lettering on the van
- b) Stereo hidden from outside view
- c) Curtains between cab & office
- d) Shades/blinds in office
- e) Elaborate alarm system

4) MISCELLANEOUS VAN ACCESSORIES/TOOLS **(See Figure 2)**

- a) Tool box
- b) Jumper cables
- c) Small air compressor
- d) LN2 Dewar with MSDS
- e) Small vacuum cleaner & attachments
- f) 1 million candlepower spotlight with 24amp hr battery in handled canvas carrying bag

B) OFFICE

1) DESK SYSTEM **(See Figure 3)**

- a) Desk system built into van framing
- b) Framed certification
- c) Cabinetry with supplies
- d) Comfortable swivel chair
- e) Ample lighting

2) POWER SUPPLY **(See Figures 4,5)**

- a) APS1250GFI power supply
- b) Power supply accessories (DC breaker/Remote)
- c) Extension cord-100' 10/3 wire
- d) 2-deep cycle marine batteries
- e) Hydrogen gas vent
- f) Isolator diode (130Amp or larger)
- g) #2 Welding cable (or larger) from isolator
- h) Power strips/llOV protected distribution

3) VIDEO EQUIPMENT **(See Figures 6,7,8)**

- a) 8mm Rewinder
- b) 8mm VCR
- c) VHS VCR
- d) Thermal printer
- e) Monitor, wall-mounted on swivel
- f) Thermal paper

4) REPORT GENERATION EQUIPMENT (See Figures 9 and 11)

- a) Notebook computer w/UPS
- b) Hewlett Packard 200LX
- c) Software including:
  - Lotus 123 (report spreadsheet)
  - Microsoft Works 5.0 (letters, word processing)
  - Invoice program (printing Invoice)
  - 200LX Connectivity Pack (to download Spreadsheet)
- d) Bubble-jet printer
- e) Supplies
  - Notebooks
  - Vinyl "stick-on" letters
  - Computer disc pockets
  - Glue sticks
  - 3.5" computer discs
  - Scissors/razor-knife
  - File folders
  - Sheet protectors
  - Letterhead/blank paper

C) SURVEYING EQUIPMENT

1) SCANNER & CART (See Figure 12)

- a) Cart & custom design
- b) 600 Inframetrics
- c) Scanner-24amp/hr valve-regulated battery
- d) 8mm VCR-12amp/hr valve-regulated battery
- e) 8mm VCR
- f) Detachable scannerhead/monopod w/3-position swivel
- g) Detachable 8mm camcorder
- h) Camcorder batteries
- i) Diffused high-intensity lights
- j) Ambient temperature digital thermometer

2) SCANNER SURVEY CASE (See Figure 13)

- a) 1-Liter LN2 Dewar
- b) 3X scanner telescope
- c) Spot radiometer
- d) Fluke 33 clamp-on true RMS ammeter
- e) Cordless drill/bits
- f) 4-in-1 screwdriver
- g) Adjustable wrench
- h) Safety glasses
- i) Ear plugs
- j) Steel toe boots
- k) dusk mask

D) OTHER EQUIPMENT

1) BATTERY CHARGING EQUIPMENT (See Figure 14)

- a) 4-Stage, 10amp Interactor battery charger
- b) Cordless drill battery charger
- c) High-intensity light charger
- d) 2-camcorder battery charger
- e) 1 million candlepower spotlight battery charger

2) MISCELLANEOUS EQUIPMENT

- a) Soldering gun kit
- b) Miscellaneous hand tools
- c) Spare wires and connectors
- d) AC adapters, etc.

3.O WHAT IT TAKES
In order to have a quality report ready for delivery in two hours, I must:

3.1 -have a mobile, fully self-contained office set up.

3.2 -have all written survey information already prepared for downloading and printing.

3.3 -be able to print infrared and visual images quickly.

3.4 -have everything else ready for the report, that can be prepared ahead of time.

3.1 MOBILE OFFICE
There are many reasons for having a fully self-contained mobile office **(See Figure 1)**. I never arrive at a job site without a critical piece of equipment, because everything necessary to do the job and produce the report is in the van. On out-of town jobs, I no longer arrive the day before, unload my "office" into a motel room, do the survey and prepare the report the second day, load the "office" back into the vehicle, and deliver the report on the third day. Billing 1 day, for a 2 or 3 day job is for me, a thing of the past.

3.2 ALL WRITTEN INFORMATION MUST BE READY TO PRINT

All written information has to be ready for downloading and printing prior to returning to the van to prepare the report.

Before coming up with the office-in-a-van system described in this paper, my clients never saw me typing, printing, going to drop off and picking up 35mm film, gluing, pasting or pulling my hair out at 2 o'clock in the morning trying to decipher what I had written or reviewing videotape to retrieve my reference or high temperatures which had been inadvertently smudged, lost or left out of my hand written lists. In fact, in the first year or so of infrared scanning, I calculated that I spent more time writing the reports, than doing the surveying. Enter the Hewlett Packard 95LX palmtop computer. With a Lotus 1-2-3 spreadsheet file stored in the HP 95LX, I could collect data in the field without "double-handling" the information. All editing, descriptions, amperage readings, notes and other information, could be entered while standing in front of the piece of equipment being inspected. Some strategically placed macros eliminate the need to add, subtract, multiply or divide, set printing parameters, etc. This all saves me precious time. I am currently using the latest Hewlett Packard palmtop offering, the HP 200LX.

3.3 INFRARED AND VISUAL IMAGES MUST BE PRINTED QUICKLY

I must be able to print infrared and visual images quickly after returning to the van to prepare the report.

This is the most time-consuming task of report preparation. I may be an infrared thermographer, but I am in the imaging business; the color imaging business. Of course I prefer B&W, but my clients all have color TV's, they expect color images, which is exactly what they get. The perceived quality of an IR report, by most clients, is directly linked to the quality of the imagery in that report. This perception and high print costs, eliminate Polaroids as a possibility. At present, I think that 35mm photos, shot at 1/30th of a second speed from an RGB monitor, produce the best quality image **(See Figure 15)**, but a mobile dark-room does not work. Although pricey now, I like digital still cameras for visual images. I believe that the future of IR imaging lies with the development of video-captured digital imaging. So, I am left with a dye sublimation printer from a recorded video signal, printed onto blank printing paper. This type of video printing also lends itself well to my report generation methods, since I supply a VHS format videotape copy of IR and (anomaly) visuals to all of my clients.

3.4 I PREPARE AS MUCH AS POSSIBLE AHEAD OF TIME

Everything in the report, that can be prepared ahead of time, is prepared before I reach the job site. There are many of these report items. For instance, the notebook, the summary letter (leaving out what is not yet known), section dividing pages, invoices, videotape labels and computer disk pouch and labels. Now, let me say here, that I am not counting the time it takes to get office supplies, talk on the phone, do some pre-job report preparation, clean the van, etc. or to run the business, into my 12-hour formula.

4.0 DOING THE JOB AND COLLECTING THE DATA

Being efficient is only half of the equation. As stated earlier I must also be effective. My task is to find electrical problems. To do this, the equipment must be accessible and loaded. Let us consider some problems and solutions.

4.1 SCHEDULING

The old adage "know before you go" certainly applies to effective infrared thermography. All operations are not loaded 24 hours a day. The type of operation must be considered, when different loads and the highest loads occur; what time of the day, day of the week and what season of the year they occur. The time to find out about loading is while on the phone scheduling the survey, not when I get there.

Case in point. I arrived at a daily newspaper at 7:00 AM on a Monday morning to inspect the presses and switchgear to find a couple hundred ampere lighting and computer load. I was back that next Saturday night at 10:00 PM to do the survey. The fall and spring of the year are not the time to check switchgear in office buildings as they are not using chillers or electric heating. In the case of hospitals, computer centers or other operations that have back-up generators or UPS systems, I want to perform the survey on days when this equipment is being load-tested.

The point here is, I try to get as much information about the operation as possible before I get there.

After scheduling a time and date, I find out who I will meet and when, how many electricians will be required and what, if anything, the utility needs to be aware of.

4.2 UPON ARRIVAL
Upon arrival, I meet with whomever has been assigned to meet me, check calibration on the scanner and check any outside utility equipment or any other equipment that will be affected by sun-loading. At any time during the day, "critical" problems, are reported immediately to the end user. The next area of concern is outside lighting and any equipment that may be de-energized in the next few hours. With these items checked, depending on the operation, I will proceed to the main switchgear room where I meet the electrician that I will be working with for the rest of the day. I always spend a few minutes with this person as he can make or break my day. I talk with him in general about infrared radiometry, in general about the plant's operation, the maintenance department's past problems and what he can expect from the surveying day. I make sure he understands exactly how I feel about safety and let him know that his expertise and opinions are important to me. Mutual respect results and his apprehensions toward IR thermography and the day ahead, will disappear. Next, I usually proceed to the main switchgear itself and down the line to the smaller and less important circuits. I must keep in mind the time that I have been given to check the equipment. I do take the time to be cordial to everyone. I also ask the electrician to find, dust off and put some batteries in the company's forsaken spot radiometer. We will bring new life to this instrument, or if not, I will get mine, and I will show him how to use it; what it will do and will not do, and the technique for re-checking equipment after the repairs have been made.

4.3 DON'T SHOOT OR I'LL MOVE
To me, the most enjoyable and rewarding part of infrared thermography is discovery, not data collection. When I discover a problem, I must stop and document all the information then and there. The urge to move on and find more at this moment is hard to resist and is augmented by the electrician's inevitable new-found excitement in the realization that this IR really works, and his (and my) desire to go on discovering more and more problems. He will not like waiting around while I punch on this miniature keyboard, not unlike so many a kid playing portable video games. I do resist, by remembering that my client does not see me working into the wee hours, entering and reviewing data that was not entered during the day. Also, it is very easy to want to help electrician(s) R & R the panel covers. This temptation must also be resisted. My time is better spent entering data on the next piece of equipment to be inspected. Remembering my insurance liability and what my responsibility is, is helpful here. I do not want to be responsible for tripping a main or getting someone hurt.

4.4 DATA COLLECTING - THE VIDEO DATA
My scanner cart is set-up so that my hands are free to enter data (See Figure 12). I trade off portability to have my hands free. Also this allows others to see what I am seeing on the screen real-time. I record IR and visual images via video signal outputs from the scanner and camcorder, through an ABC video switch to the 8mm VCR this way:

- A Scanner - B & W IR video-through-switch-to-8mm VCR
- B Scanner - COLOR IR video-through-switch-to-8mm VCR
- C Camcorder - VISUALS video-through-switch-to-8mm VCR

This allows me to record in a set order: (See Figure 16)

- 1) Miscellaneous imaging of the entire panel, panning throughout the panel with different center temperature & temperature spreads, in B & W enhance palette and from different FOV's.
- 2) Same as above only in data acquire mode.
- 3) Anomaly image frozen in B & W enhance palette.
- 4) Same image frozen in a color palette.

- 5) Visual image in matching FOV. (Switch aligning w/IR FOV)
- 6) Visual image from distance.
- 7) Visual close-up.

This does not take long and brings consistency to the printed report and videotape. Also, I know just what to expect when I start printing thermograms. The time is recorded for reference to a particular piece of equipment.

5.0 PREPARING THE REPORT

I am now finished with the survey. I have talked with the end user and we have agreed on a 4:30 PM exit conference. I am returning to the van with two tools in which to complete the report in two hours.

- 1) The written word stored in a spreadsheet file, and
- 2) IR and visual images stored on 8mm NTSC format videotape. The job is still fresh on my mind!

Here is the usual procedure:

- Save the file on the Lotus 1-2-3 spreadsheet in the 200LX.
- Turn on power supply.
- Put scanner in it's rack.
- Take videotape out of scanner-8mm VCR.
- Put tape in office-8mm VCR and rewind.
- Put all batteries on charge.
- Install blank VHS videotape in VHS VCR mode, Record-Pause.
- After 8mm videotape is rewound, playback and record VHS.

* From this point on, I print thermograms while doing other things by keeping an eye on the time and images on the videotape.

- Download file from 200LX via connectivity pack to notebook computer.
- Pull up file, edit, review, print draft copy of data log.
- Review draft hard copy of data log. Print final draft.
- Print thermographic reports.
- Enter data in repair guide and print.
- Put data log, thermographic reports and repair guide in report notebook (prepared ahead of time).
- Save the Lotus 1-2-3 spreadsheet file.
- Type, print, save Works files and install these into notebook; the letter, table of contents, recap & summary.
- Copy Lotus 1-2-3 spreadsheet file onto my floppy disk and client's floppy disk, and put into notebook pouch.
- Cut, paste and affix red arrows, etc. to thermograms that have so far been printed, and paste to thermographic report pages.
- By this time, the tape should be copied to VHS, I rewind VHS to some point on the tape that I want to show client.
- Rewind 8mm to the first thermogram that was not printed.
- Print the remainder of the thermograms.
- Cut, paste and affix red arrows, etc. to the remainder of thermograms and put into report notebook.
- Review the entire notebook.

- Rewind 8mm videotape, put into pocket file along with my floppy disk and paperwork related to the job.
- Put invoice (already printed) in report notebook sleeve.
- Lock truck, set the alarm, take completed report to the exit conference.

6.0 THE ALL-IMPORTANT EXIT CONFERENCE
The most important part of the day, is the exit conference. All issues will be addressed and settled. It is a chance for the infrared thermographer to meet with the end user, that is; the person that hired him, the person that will make sure the repairs are made, and the person that will determine whether or not he will return to do more work.

This is my golden opportunity to sell (that's right to sell) myself, my service, infrared thermography, and predictive maintenance in general, to the end user and anyone else in attendance.

6.1 WHO SHOULD ATTEND
Almost everyone likes learning about the latest technology. If I have peaked the end user's interest during the survey day, he will round up his colleagues to see what this IR is all about. If possible, I will convince him to assemble a group for the presentation. Some personnel that should attend are:

- End user
- Corporate officers
- Chief Engineer/Staff
- Department heads
- Electricians
- Maintenance schedulers

These and others may be directly or indirectly affected by the results of the survey. Now everyone necessary to make a decision about repair scheduling is present. Also, I never know what other uses for IR that they could come up with. A quiet conference room with TV/VCR works best.

6.2 PRESENTING THE DATA
At this point, I keep in mind that it is close to quitting time and I really only have half an hour to present the results of the surveying day.

After the introductions, I pass out a copy of my repair guide (a list of all equipment that I have a thermographic report for) on my letterhead to each person in attendance. I then playback the VHS videotape and explain very briefly how IR works, and how someone can view a piece of equipment on the videotape. Then I show them what they are getting for their money, namely; the hard copy report notebook, videotape, and computer disk. Generally, I flip though the report from front to back, so that as many as possible can see it, reviewing summary, data log notes, repair guide, and thermographic reports, in that order.

I go over each thermographic report separately, but stress the importance of following types of thermographic reports:

- A) Equipment that is in "critical" need of repair.
- B) Equipment that may only show a slight rise but I think deserves special attention.

- C) Equipment that I either know, or have been told, is critical to the plant's operation.
- D) Equipment that I did not inspect, for whatever reason, or inspected under an extremely low load.

Sometime during the exit conference, I will point out that what I did not find, is as important as what I did find, and then I will explain that statement.

Because I have archived the 8mm videotape of the surveyed equipment, I can now trend and compare, at any time in the future, any piece of that equipment that was recorded. This is the reason for using the data acquire mode step. (See 4.4)

I furnish the end user with a disk copy of the spreadsheet. Almost every engineering and maintenance department has Lotus 1-2-3. He now has a place to enter all repair activity information into the spreadsheet file in the repair guide section, without picking up a pencil.

I respectfully make the suggestion that he send the original (not copy), individual thermographic report pages out in the plant, in a small notebook that I provide, so that the repairmen have the thermograms, work orders, etc. in one place. That way they can mark their repair info directly on the thermographic report pages. This helps me tremendously, because I want to take all the repair information with me on reinspections.

6.3 REINSPECTION / NEXT SURVEY / INVOICING

When I am finished reporting my findings, the end user will have already given me overtones as to how he feels about the work I did for them, IR and predictive maintenance. These overtones and the survey results themselves, will dictate whether or not I bring up scheduling a reinspection, or the next survey. In either case, I hand him the bill.

6.4 PERCEPTION VS. REALITY

Almost without fail, plant management personnel are surprised that I did not find more problems. I think this is attributable to the fact that unfortunately, they regard plant maintenance itself as a necessary evil; a non producing, dead expense of doing business. Since many maintenance activities are, again unfortunately, carried out while "under the gun" of lost production time (a direct result of re-active and not pro-active maintenance), plant maintenance evokes thoughts of impending disaster. They usually "notice" maintenance people "working" when something is wrong with the operation.

Indeed, the perception of most plant maintenance personnel themselves, is that they have more problems. They know for a fact, that they have more problems! Maybe these are problems that cannot be detected by the use of infrared thermography or ones that we have not yet learned to detect.

7.0 CONCLUSIONS

My current method of collecting data is not the important point of this paper. Indeed, I have no doubt that by next year, my methodology will be changed and improved from that which has been discussed above. What I think is important, is the idea of getting this extremely important information in the report to the client end user in a timely manner, at the least real cost.

Figure 1.

Figure 2.

Figure 3.

Figure 4.

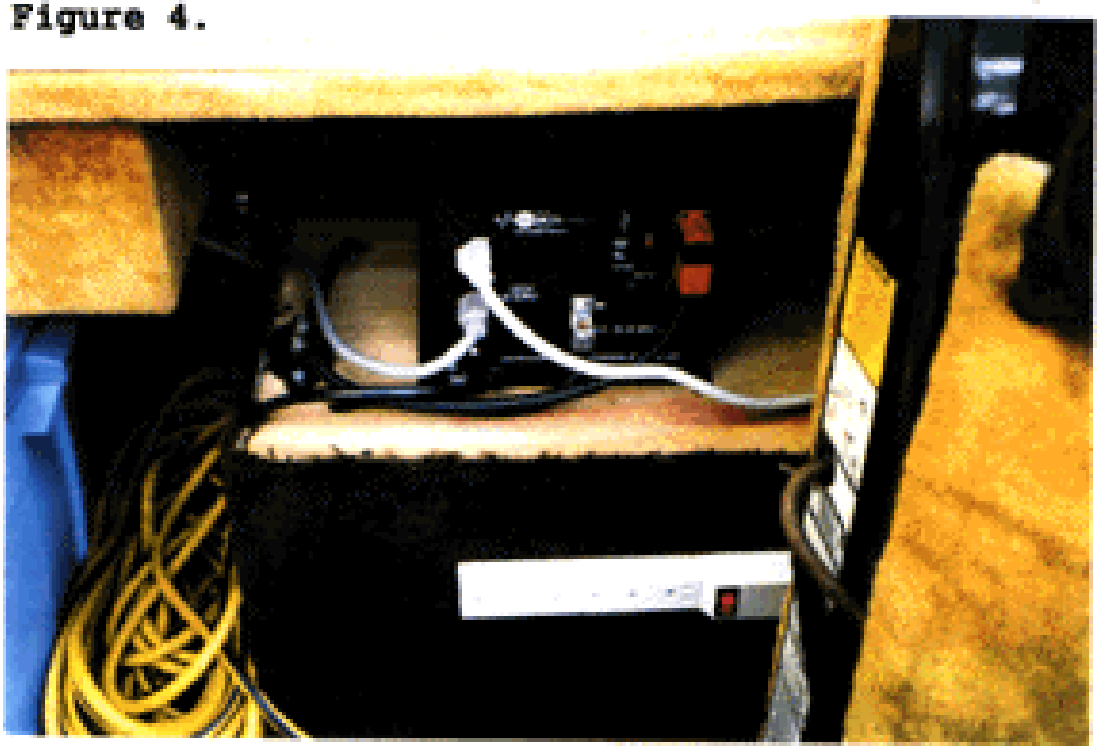


Figure 5.

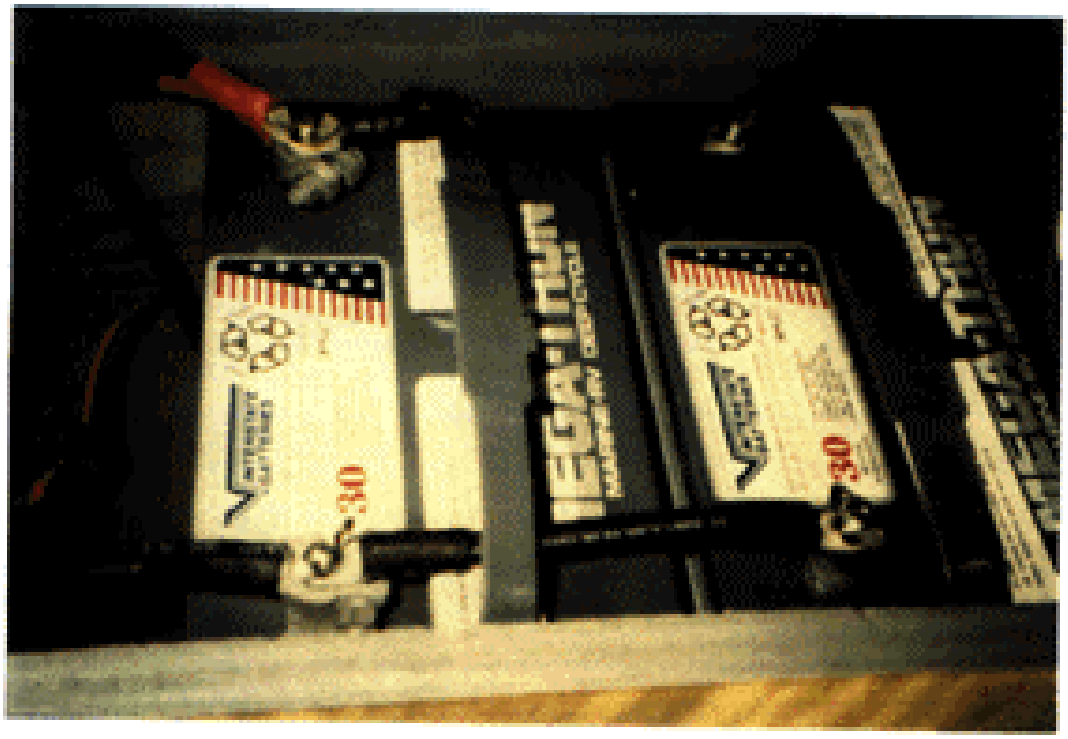


Figure 6.

Figure 7.

Figure 8.

Figure 9.

Figure 11.

Figure 15. 35mm IR image from RGB screen.

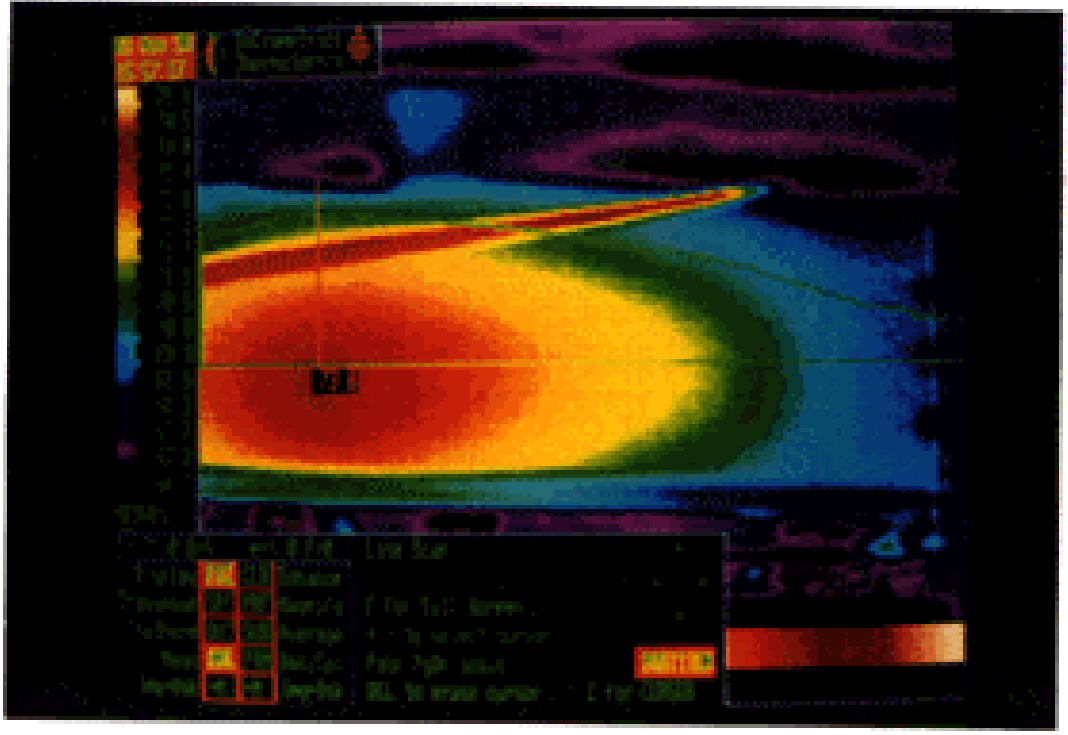
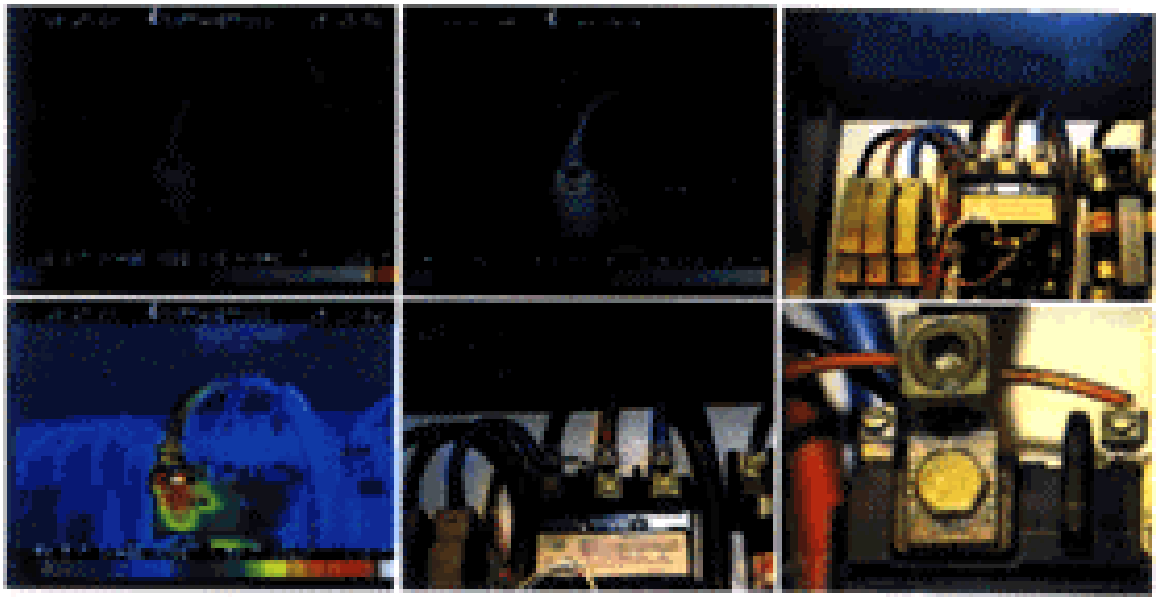


Figure 16. Images[reduced]recorded in order, to be printed.



4.5 DATA COLLECTING - THE SPREADSHEET FILE

Figure 17. This is what the spreadsheet looks like.