How to Achieve Professional Accountability in Your Infrared Program

Establishing an Infrared PdM Inspection Program with demonstrable accountability for management buy-in, as well as methods for handling the legacy of data transition from one inspection to the next, or from one thermographer to another.

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Topics:

Abstract:

Paper/speaker to discuss concepts of periodic/repeat IR inspections versus establishing IR programs with a legacy for handling information in a professional manner. Focusing specifically on methods to automate data collection to enhance the thermographer's skill sets, reduce the amount of repetitive data entry, while increasing the quality of the information with regard to achieving demonstrable accountability for management buy-in.

Your data is your program! Today automation of data collection methods can not only ensure that the workload is reduced but at the same time improve the quality of data that is collected. Desktop / Pocket PC solutions provide improved methods of utilizing databases for the establishment of demonstrable accountability of what is to be tested, what was not, problems found, as well as historical trending of problem conditions over time. Management buy-in is greatly influenced by the ability to clearly show at a moments notice what the current condition of a facility's assets are as well as the ability to provide a legacy as personnel and equipment change. The problems that companies face with their infrared programs are not new, but today there are proven methods that can greatly improve an IR program's success. Portable computers (Pocket PC's), databases, utilization of bar codes for fast equipment identification and automated report generation are proven solutions of managing today's leading IR programs.

Introduction:

What is the recipe for successful management buy-in for an IR PdM for electrical/mechanical equipment? That depends on how you define two key points: success and a program. For management buy-in, you need to have established methodology that can easily prove that you have accountability and accuracy in the data that your program produce. You need concrete and demonstrable proof of the success of your program as well as demonstrable methods of transition in data legacy that establishes consistency in the way that the data is collected and stored, from one inspection to the next and from one thermographer to the next.

The key point here is: in the right system, data = information, information = knowledge and knowledge with action is vital to the success of your program. So to start out with, your data is your IR program, and how you choose to manage that data will establish what kind of program you have. It's that simple!

It's not the IR camera or the amount of certification that the thermographer has obtained. When the camera is broken and the thermographer has taken a different job, what is left behind? All too often that is the question that everyone faces when they are beyond the "honeymoon phase" of purchasing their shiny new IR camera with all of the gizmos, bells and whistles, and the guy that was trained to run it has moved on. The new guy comes in and finds an IR camera on his desk with a Post-it-note on it that says *"Congratulations… You're our new thermographer!"* As for the

program's data, it's in boxes over in the corner. It's in various forms of notes, memos, reports, etc. No one is sure of what the previous thermographer was actually doing. All that is left of the IR program (if you can even really call it that) is the pile of reports in whatever shape they are in.

Remember, "Your data is your IR program!" What kind of shape that data is in will define if there is an existing IR program or if at best, just a bunch of inspections that have been preformed in the past with various levels of success. The management and flow of the information in a meaningful way is your key to success. Let me emphasize meaningful. It must be meaningful to a thermographer in a manner in which he can understand it and work with it, "*in the field*" as well as back in the office!

The pivotal issue that is most overlooked is that the thermographer diagnoses the problem in the field while he is standing right in front of the equipment.

- ☑ Is it a problem, Yes or No?
- ☑ Is it a new problem?
- ☑ Is it a problem from a past inspection?
- ☑ When was the last time it was tested?
- ☑ Is it a chronic problem or an endemic one?
- ☑ How hot was it the last time it was documented?
- ☑ How long has it been a problem?
- ☑ Has it gotten worse?
- ☑ How fast is it getting worse?

To answer these questions, he needs to have quality information in the field with him to do his job in a professional manner. Quality data = quality information that is vital to making the correct decisions as to the status of problem conditions that are found during inspections. Just like a doctor needs the medical records to properly diagnose a medical condition, so does a thermographer in the filed. If the thermographer is not empowered to gather quality data and make quality diagnoses as the problems are found, how can you assure that management will buy-in to a program that is fatally flawed?

If the data can not be managed in a way that provides for accountability of the efforts that have been put forth by the thermographer, then it is of little value. However, if you put in place methods that provide in the field review and reconciliation of the information that is gained from previous inspections, you will not only allow your thermographer to do a professional job, but will also achieve the level of professionalism that will lead to the success of your program.

Case Studies:

The degree of success for an IR program can range in scale quite dramatically depending on how you measure the effectiveness of the program. To better understand this lets look at some typical ways that infrared cameras are used as well as how the data is collected. We will try to paint a picture of extremes here for the purposes of discussion only, understanding that most programs fall somewhere in between. In the following examples, arbitrary levels of success have been established to help illustrate the various levels of being able to grade a success of an infrared inspection/program.

Level 1: In-house Crisis Management

At one end of the scale you have many companies that believe a successful program is one in which they have an IR camera and a person that is at least minimally knowledgeable on how to turn it on and get a image. The operator/thermographer only uses the camera in a crisis management mode when someone thinks that they smell something burning. There are no proactive efforts made to use the camera since performing infrared inspections is only one of the many responsibilities that the operator has. There is no real commitment by the company to allow for the development and establishment of the program. They have been reasonably successful in averting severe problems just before they fail so the operator is now considered to be the company's hero in infrared since he can say that the cost of averting the problems before they failed has paid for the purchase of the IR camera.

In the above description we can say that they do not have a proactive IR PdM program. In fact we can say that they do not even have an IR Inspection survey. What they have is an IR Crisis Management tool that they take out of their tool box when a problem arises and the thermographer, like Superman, runs to the scene just in time to save the day with IR. The reality is that only a small number of problems are really averted, and there are a lot of problems waiting in the wings. The benefits of being proactive are never seen. There is no data collection since IR is only used to find the problem that is about to fail and direct someone so that it can be fixed. This is similar to search and rescue.

Level 2: Out-Sourced Consulting Services

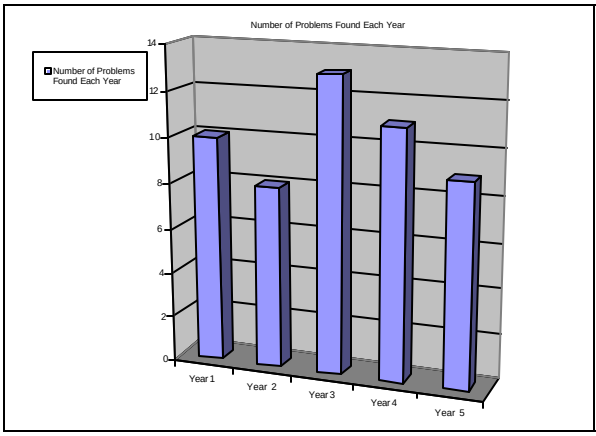
Many companies choose to outsource their infrared inspections annually to a consulting firm that can provide thermographic services. This may be at one end of the spectrum, consulting firms that specialize in providing only thermographic services to the other extreme being companies that have IR services as just an additional service that they provide. The level of professionalism can vary widely at all extremes. The contracting company will decide what will be tested at the time of the inspection and the consulting firm will inspect what it was told to test. Typically there is little or no inventory of what was actually tested and many times only the problems that were discovered at the time of the inspection are written up in the report.

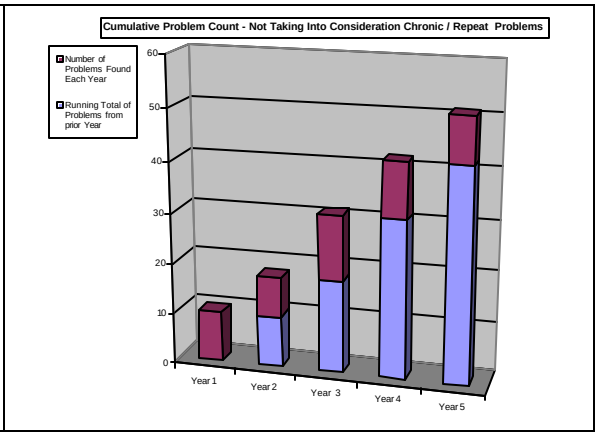
There are many outstanding consulting firms providing thermographic services today. However, one of the biggest factors in the level of quality is the fact that many companies choosing to contract out this type of "engineering / technical consulting service" see at as a commodity and therefor award the bid to the lowest bidder. Unfortunately this brings about a marketplace that provides for little margin for investment in the quality of the engineering/technical services provided by the contractor. Specifically quality test and measurement equipment, and training, because the profit margins are so low or non-existent. This method of outsourcing the company's needs for IR leads to varying levels of data collection and reports from the different companies that were awarded the contract. Usually there is little quality data of value that can be handed over to the next IR consulting firm that is coming in next. In turn the real quality of the data is also influenced and the benefits of an IR program are never realized.

Today the prices for an 8-hour day of scanning can range from $300.00 to $1,500.00. The rule of thumb for a consulting firm/department to be financially stable and afford to train its thermographers while investing in quality thermographic equipment is in the neighborhood of $1,100.00 to 1,300.00 per day. When engineering / technical consulting services are based on price alone, quality is not part of the package. (Note: in Washington State we have had 3 major bridge failures because the projects were awarded to the lowest bidders. Will we ever learn?)

Level 3: In-house Periodic Inspections

The next level on the scale of measuring an IR PdM program is one where the company makes an investment to establish their own internal program as compared to outsourcing it to a consulting firm. The in-house thermographer will be performing routine inspections on their own equipment. He may have a camera of moderate capabilities and IR image analysis and report generation software that he uses on regular occasions. The level of sophistication of selecting which equipment will be tested and tracking the test statuses is driven by priorities of having the time to do the inspections. All of the findings are written up in the reports that he creates. Although he is able to document a problem, he is not truly capable of tracking his problem over time without undo labor on his part by cross-referencing his inspections. His system only shows the total number of problems that have been found in that individual inspection.





	Year 1	Year 2	Year 3	Year 4	Year 5
Total of Problems Written-up each year	10	8	13	11	9
Plus: The Running Total of Problems from prior year	0	18	18	31	42
What is the total number of problems that have been found at this facility? **The Total Problems Found**	**10**	**18**	**31**	**42**	**51**

In Year One he found 10 problems and in Year Two he found 8 problems. The total cumulative number of problems that have been found in his plant at the end of the second year is 18. We can keep this problem count going on

through the years to see what the total cumulative number of problems that have been found at this plant by the fifth year as 51 problems. Just for the sake of discussion let's say that we associate an arbitrary number of $2,000.00 on average saved by averting an electrical problem before it failed by fixing it (Parts and labor only, not loss to production/revenue). Based on this arbitrary value of dollars saved by fixing each problem before it failed times the total cumulative number of problems found over the 5 years (51 problems x $2,000.00) years we would be saying the program has saved the company $102,000.00 on parts and labor alone.

In this case, the degree of success of this company's efforts has been in providing proactive PdM inspections on a routine basis. But the numbers are not quite right. He has not reconciled his past problems from the previous inspections to see if he has any chronic conditions from the previous inspections that he wrote up as new each year. The real answer to the total problems found in the past five years is 32 problems or a saving of $64,000.00! That is an error of $38,000.00. We will explore how this accountability error happens later in this paper under the section "True Cumulative total pf problem that have been found". At this point it is important to make a mental note of this point for referring back to when we come to that section.

Data Flow Models:

One Directional, Field to Office/Report data flow is the most common model of data flow and is the easiest to establish. It is based on the idea that the data/information that is gathered by the thermographer in the field will come back to the office and be written up into a report. The methods that are used by the thermographer in the field will govern the quality of the data that is collected at the time of the inspection and if it is feasible to be used in a Two Directional Data Flow Model.

Two Directional data flow encompasses the ability to utilize the data that is gathered in the field in both the office and then back in the field during the next inspection. Again the methods that are used by the thermographer in the field at the time of the inspection define the ability to bring back into the field the data from the previous inspections to be reviewed and reconciled in the next inspection. Two directional data flow allows for solid methodology in the data collection methods and increased accuracy and quality of the data since a thermographer can police himself or another thermographer by being able to review the quality and accuracy of the data that was collected in the previous inspections. This can lead to a feedback loop to better train your thermographers since you have established a "Peer Review" method that ensures quality in the information that is gathered. The ability to "Review and Reconcile" is the focus of establishing a two directional data flow model that works, but the defining methods that are used to collect the data in the first place as well as bring the data back out into the field will define if it is possible in the fist place or not.

Review and Reconciliation Methods

Believe it or not, an Infrared program is more than just a pretty IR image! That may be hard for some people to understand but the IR image is only the beginning. It's all of the rest of the data that makes up the program. The IR image alone would be of little value if you did not know what piece of equipment the problem was on.

The Importance of Reviewing and Reconciling Past Inspection Data in the Field

Many companies do not just rely on one of the following methods, but a combination of methods to document the inspection. It should be noted that it is not just the data collection method that is of importance here but how it assists in performing the inspection. Many people only focus on the data gathering process of the inspection but remember that there is also the "reviewing of the data" component that must be taken into consideration. The reviewing of the data takes place not only back in the office when the report is being generated but also needs to be reviewed during subsequent inspections in the field by the thermographer so that he can refer back to previous test statuses and problems that were found. The concept of "reviewing previous test statuses" and "reconciliation of the previous problems" is essential in establishing a solid IR PdM program that management can support. The methods that are used to gather the data in the field will define how you can review and reconcile the data in subsequent inspections as well as how much work will be required to do it.

The Library Cart Method of Reconciling and Reviewing

In most cases the data from the inspections is written up into a report that is distributed / published within the departments of your organization that are responsible for the repairs of the equipment. For the thermographer to have access to this data during the inspection in order to review previous test statuses on equipment and reconcile past problems requires him to have a method of having the data at hand with him in the field. Since most of the data is in the form of reports he will have to have the report with him. In the case of a large facility with lots of problems this report can be of some size. Problems can span over many inspections and he may need to have all of the reports with him to adequately perform his job. Since all of the data is in these reports it will require a system similar to having a "Library Cart" containing all of the previous reports on it, that will be pushed around at the time of the inspection. This is similar to a doctor having all of your medical records to review when you have a medical condition that needs diagnosis. The best time to analyze the problem is in the field and this is where the data is the most important to refer

back to in accurately diagnosing the problem condition.

The truth of the matter is that most IR programs do not do this because the data collection methods and the system of report generation they use would require a great deal of work to provide this level of accountability. "Why push the library cart around if no one is looking?" Just write up the problems that you find and skip the details. This approach to performing an inspection is like going to the doctor about a medical condition and finding out that he has thrown out all of your medical record. As we cover the basic methods that are used, please keep in the back of your mind - how would you review the previous inspections data easily on the next inspection.

Pen and Paper

Many have found that the pen and paper method for in the field data collection has worked out the best for them using pre-printed forms the thermographer can fill out when problems are found. This allows a certain establishment of a system since the data that is required to collect is on the form, ensuring that he does not miss anything. By taking a clipboard or 3 ring binder out with him when performing his inspections, he can also keep a list of what he has tested and what he has not. In addition he can track a list of the past problems from previous inspections to be reconciled so that they can be checked to see if they have been effectively repaired or is a reoccurring, chronic problem condition that must be documented again. Once back at the office the forms are typed up into a report.

The pen and paper method requires a lot of work in the field and office, as well as establishing sound methods for the paper / data flow to be used in a two directional data flow model. This would be the typical Library Cart method.

Voice Dictation

Another method is to use a voice dictation recorder to record your comments on to tape or digitally while you perform an inspection. You have the ability to comment on what you tested and any problems that you find. Once back at the office you can play back the tape and enter the information in your report. This type data collection will not lend itself well to a two directional data flow back out in the field on subsequent inspections since it is difficult to find all of the previous recorded notes from the previous inspections for a particular problem in a timely fashion.

Videotape

Another way is to record to videotape the entire inspection like it is a documentary or just the problems that you find. This typically requires the use of a video capture card to digitize the videotape back at the office or using a Polaroid Screen Shooter to take a Polaroid photograph of the TV screen. When all of the inspection has been put on tape, someone will have to play back the tape to transcribe it into a computer. Usually the audio track has the voice comments as to what was tested or not and the problems that were found. Many times using pen and paper to compliment the videotape so that records of what was scanned in conjunction to the tape counter is of great benefit.

Just like the voice dictation method, this type of data collection will not lend itself well to a two directional data flow in the field on subsequent inspections. With this method it is difficult to find all of the previous recorded items on the video tapes from the previous inspections for a particular problem in a timely fashion.

Using the image files as a data storage container.

Many of the cameras today offer the ability to store directly into the IR image file a memo field that you would type up in various ways on the IR camera as well as the ability of adding voice comments and even storing a complimentary visual image as well. The data collection is usually for only the problems that you would find at the time of the inspection. Once back at your desk you would compile your report using proprietary software that allows you to retrieve the data from the image files and insert it into your report.

This method is very well suited for one directional data flow, but is usually limited on the amount and quality of the data that is collected. It would be very inefficient to try to use this method in a two directional data flow. It requires the thermographer to bring with him hundreds of previous images from past problems and find some method of indexing them on large inspections so that he can find them in the field.

Traditional Method Of Data Collection	Pros	Cons
Clipboard, Pen and Paper	Easy to establish a method since there are forms used to fill in the blanks. Provides for consistency among varying thermographers and over multiple inspections.	Requires a clipboard or 3-ring notebook to be carried out into the field. If you are taking the previous inspection data with you (past problems and inventory test status) then in a large facility with many previous inspections you could be taking a library cart around with you so that you have all of the required data (Library Cart Method). Requires you to do data entry back at the office. Handwriting must be legible.
Voice Dictation	Easy to talk into a dictation machine to describe what you are testing and the problems that you find. Small voice recorders will fit into your shirt pocket, allowing you to be quite lengthy in your comments about your inspection	If you misplace the tape all of your data is lost. Requires someone to transcribe the dictated comments into the report. No form / template / fill in the blanks to make sure that you got all of the required data. Loud background noise can make it impossible to understand what is said. Can slow office data entry if not legible, requiring someone to keep replaying the tape to understand what was said. No real ability to take previous inspection data into the field in a usable way and review it, so you must take the previous reports with you. (Library Cart Method)
Videotape Recording	Allows you to record everything! From beginning to end of your inspection.	Requires a video recorder / microphone / cords and batteries so you have more equipment to take around with you. No real ability to review quickly previous inspection data. Requiring you to use the Library Cart method. Can be slow and cumbersome back in the office compiling your report using video capture cards and transcribing your comments.
IR image as data container	Allows for one place for you to enter / record your data.	Poor data entry method for typing in information. Very limited field length for comments. Limited amount of time for voice recording. Poor quality low -resolution visual images (no flash or zoom). If you lose your image file or if it is corrupted, all of your data is gone (all of your eggs were in one basket). Does not handle inventory issues of what was tested vs. what was not. No real ability to take previous inspection data into the field in a usable way and review it, so you must take the previous reports with you. (Library Cart Method)

Failure Mechanisms and Misconceptions of IR Programs based on One Directional Data Collection

Failure mechanisms of infrared programs are based on two components:

- Misconceptions about what it takes to truly have a quality IR program.
- Poor data management methodology

We must first look at the misconceptions so that we can have a clear idea of what it takes to succeed. Based on understanding the misconceptions we can ask some rather tough questions that will help us gain the perspective over our program to fine tune them into the way we will be able to guarantee that we achieve our goals. We need to understand what past mistakes/failure mechanisms lead to a program's failure.

Program vs. Inspection

There are many misconceptions about establishing infrared programs. The first is thinking that the IR camera in of itself is the program. I have seen many companies say that they have a program but no one in the company actually knows how to use the camera correctly.

Many companies perform inspections on a regular basis but the data / information can not be cross-referenced very well from one inspection to the next or from one consulting firm to another. As in the case of contracting out your inspections to the lowest bidder, you may have a different consulting firm from one year to the next. There is no synergy between the reports that you get back. There is not an IR PdM inspection program, there is only a periodic inspection that yields uncollaborating data each time.

Understanding what the focus of your intentions is and being clear as to what you are trying to achieve is the only way to reach your mark. There are many more misconceptions as to what it takes to truly establish a world class IR program

Camera – not all cameras are created the same, but focus on its IR capabilities

To many first time purchasers of infrared cameras, they may all seem to be the same. You just point it, Find it, and Report it. It has been said that even a monkey can do it! Infrared cameras are very complicated devices in and of themselves. It takes a developed understanding of what your requirements are and the capabilities of the camera to

match those needs. If the basic camera specifications (IR detector, not the other gizmos that are attached to the camera) do not meet your needs, then you are throwing good money away and your program's goals will never be met.

Personnel – Training is one of the most important aspects of a successful program
Training of the thermographer is paramount to the success of the program. The idea that all you need to do is point and shoot is one of the most detrimental misconceptions to this industry. It is this misconception that is lowering the quality and integrity of this industry. Many companies believe that an IR camera is just like a pair of binoculars. All that the operator has to do is look through the eyepiece to understand what the problem is. That's like saying that if someone has a stethoscope around his neck and a thermometer in his pocket then he is a doctor. If MRI machines became so inexpensive that you could afford to purchase one and take images with it and you found a suspicious lump in your brain. Would you have it cut out? (By the lowest bidder?) Or would you find someone that was highly trained to analyze the image first! MRI image or Thermal image, it is all the same. It takes skill to know what you are looking at.

There is a great deal of training that must go into teaching someone how to interpret the thermal images that are used in PdM. That interpretation happens in the field by the person with the camera in his hand, not by someone else at their desk. There are many excellent training organizations that provide training programs as well as in the field mentoring that can definitely help fine-tune a program. We have seen that it takes 3 to 5 months of "on the job training", 8 hours a day, 5 days a week to get an apprentice/amateur thermographer up to speed as an entry level professional that can stand on his own two feet. Even then they still need to have their work reviewed and require continued mentoring. The idea that a company can purchase an IR camera and get professional results right out of the box is a huge misconception. Its like saying that anyone that purchases a 35mm camera for the first time is an instant professional photographer and we all know that is simply not the case.

Reports – It is not the IR image that is of the most value, it is the rest of the data!
The first misconception is that the report is just a pretty IR image on a page. If that was all there was to it then we would be like photographers selling snap shots to people. The IR image is only the beginning. It's the rest of the data that is where the real value is. The data should be able to be cross referenced against previous data to allow for a clear and concise perspective of what is happing to the overall health of the program as well as what going on with any problems that are found. This can be very difficult depending on the data collection method and storage/retrieval systems that are employed. Not all reports are the same and it is important to focus on improving the quality of the data, not the image.

Using the IR image as the ultimate storage system
If you used the image file as the storage container for all of your data, the voice comments, memo notes, visual image, etc. are all stored in to the same image file (in the header). If you lose the file or it is damaged then all of your data is lost! I know of one consultant that told me that he upgraded his computer operating system and the software that he used to generate his reports would not open the image files with the new operating system. He was already three weeks behind on getting the report to his client and did not take any notes on paper as to what the problems were. To make things worse, the new operating system corrupted his image files so that they could not be opened on an older operating system so all of the data was lost. Furthermore: The camera manufacturer was not supporting that software any more so his ability to get technical help was impossible, (he did not have a back up of the image files). The moral of this story is don't place all of your eggs in one basket and keep a back up to minimize your risks.

Reviewing and Reconciling of past data in the field is not important
This misconception is one of the most basic mistakes that can be made. To have a program you must have checks and balances. To ensure that the quality of the collected data you must have some method of peer review to keep check on what is going on as well as provide for a feedback loop as to ways to improve the program. This is the basis of ISO standards and quality control. By providing your thermographers with all of the data they need, when they need it you raise the bar on the quality of information that they can collect. Otherwise its like having them bury their heads in the sand when they are out in the field performing their inspections and trying to document the problems that they find.

Professional Accountability in Data Management can be divided into three parts:

Data management can be looked upon in three different parts with regard to how you manage your IR program: pre-inspection, during inspection and post-inspection data management. How you handle these three parts plays an important roll in which type of data flow model you are using. Your answers to the following questions will define the level of success of your IR program.

NOTE: It should be remembered, should you be on the receiving end of a lawsuit, you could very easily be asked these same questions. In your own defense it is a good idea to have a sound answer. We are in a professional test and measurement business; you should be using sound data gathering and management methods that would be expected of any professional.

Part 1: Pre-inspection data management: The data flow of what goes out into the field with the thermographer to be reviewed and reconciled. Is the thermographer taking with him:

- ☑ A list of what equipment is to be tested and it's respective location in the facility so that it can be found.
- ☑ A list of all past problems that have been documented.
  - o Open problems need to be re-inspected to verify that:
    - Any repair attempts to fix the documented problem actually did fix it, so that the problem status can be set to Closed.
    - If the problem is still there, it needs the details of its current condition documented to show any changes in its chronic condition over time.
  - o Closed problems from past inspections on equipment so that the thermographer can pay particular attention in evaluating the equipment at the time of the inspection to ensure that the problem is not endemic to that piece of equipment and starting to reappear.

Part 2: During the inspection data management: The data that is reviewed and reconciled / collected in the field by the thermographer.

- ☑ How the data in the field is to be:
  - o Reviewed and Reconciled to previous findings from past inspections
    - What should be inspected?
    - What is not to be inspected?
    - What is left to inspect?
    - Was this equipment tested during the last inspection?
    - Was it not tested in the last inspection?
    - When was the last time it was tested if not in the previous inspection?
    - Is there an open problem on it from a previous inspection?
    - Does the problem have a history of being a chronic condition?
    - How much has it changed since the last time the problem was documented?
    - If the past problems on the equipment were fixed correctly, have they started to reappear/endemic condition?

Part 3: Post-inspection data management: The way the data is managed in the office to generate the reports.

- ☑ How is the data going to be compiled?
  - o Typed up into a report?
    - Is the data going to be handed to someone else to type of the problems that were found and who was not even present when the problem conditions were discovered?
      - How will you handle handwriting problems because of illegible handwriting by the thermographer?
      - Will the thermographer be the one typing up the reports after the inspection?
      - Is that the best utilization of a trained thermographer?
      - Are you using a minimum-wage data entry person to be the vital link in the chain of custody in the integrity of data that is going into the report?
      - Will the thermographer actually review the report for errors before it is published?
      - What systems are in place to account for correcting errors in the data before the report is published?
  - o Entered into a Database?
    - Is it a true database or just an index of the reports?
    - Where is the data actually stored, in a relational database or in a document?
    - How will the data be entered?
    - Is the database designed for performing infrared inspections or a CMMS or other system?
    - Can the data be turned around to go back out into the field with the thermographer on subsequent inspections so that he can review and reconcile it?

What are Databases?

The word database is one of the most misused words concerning the way that data is managed. Today everyone says that they have a database and in the most general terms, anything can be a database (a phone book, a deck of cards, etc. Unfortunately the term is misused with such frequency and people try to skirt the issue that they are not using a specific software program that is designed with the intent of storing, organizing and retrieving data that can be printed out into some form of report.

Flat File Data Management Systems:

In all of the previously mentioned descriptions of data collecting methods the data is compiled into some type of report

or document that is called a flat file in the database world. In the software world a report or document is not a real database! This report or document is typically a MS Word, MS Publisher, MS PowerPoint, or a proprietary report format (*.REP). The key point here is that the data is not in a database, it is in a document. Furthermore in some cases the real data is not really in the report it's in the IR image that's in the report. When you need to find out some information on a specific piece of equipment you must go to the report to look up the information. Typically prior findings of problem conditions are not cross-referenced so it may be a lot of work if you wish to see some information on specific problems over multiple inspections. You must look in all of the previous reports to find the information and hope that the information was entered / typed correctly every time.

Data redundancy and errors with Flat File Reports:
If a piece of equipment is found to have many problems on it or if a specific problem is found to exist on a piece of equipment over multiple inspections, the data (name of the equipment, location, etc.) needs to be entered multiple times. This leads to data redundancy problems where one data set is entered in many times and in many ways. This can lead to problems when trying to find all of the particular incidents of a specific problem if the name of the equipment has been entered in two different ways, for example: Fan-5 or Fan 5, or if the name on the equipment has changed.

Relational Databases are the backbone of building a data management system that can ensure that your IR program has the correct testing methodology to ensure program legacy.
Relational databases are nothing new. There are many on the market today, the one that we are the most familiar with is MS Access. Microsoft has basically achieved "world domination on the desktop computer" with Microsoft Access. MS Access is packaged with almost all of the office software packages including MS Word, Excel, and PowerPoint. Access is not just another type of spreadsheet program that you place the data into tables and create pretty forms with. Access is a relational database that enables you to enter a specific piece of data in one place and use it in many other places with out duplicating the record. This ability to build relationships of data means that very complex data sets can be edited, queried very easily if the architecture is built correctly with regard to the types of data and the way in which it is used. Relational databases are based on the principal of one to many relationships. In the case of a IR PdM program, we can break this down as:

One to Many Relationships

One	Many
One Site	Many Inspections
One Inspection	Many Test status on equipment
One Inspection	Many Problems on equipment
One Site	Many Locations
One Location	Many Pieces of Equipment
One Piece of Equipment During one inspection	Many Problems
One Problem	Many incidences of the problem over Many Inspections

Benefits of Using Relational Databases

Professionally Designed Databases for the thermographer:
The above table only describes a few of the one to many relationships required to build a database for Infrared PdM inspections. Professionals in building and designing databases should carry out the design of the database. In the same fashion that a structural engineer should be the one that designs the frame work of a skyscraper otherwise it will all come tumbling down like a house of cards with your data in it and everything is lost! Don't gamble with your data. It needs to be in a database that is designed for Infrared Thermography so that a thermographer can work with it in the way that thermographer needs to. There are many different types of databases that are used for facility asset management, or CMMS databases that perform very well for the way that they are to be used. Many of these databases can share information between them so that although you may have different databases they can talk to each other and trade information. CMMS database systems are not the answer to establishing Predictive Maintenance solutions. Infrared PdM is a specific type of testing that needs its own way of working with the data. Trying to make a CMMS database perform in the manner that a thermographer needs to work with the data, is like trying to stick a square peg into a round hole. All too often the match is not functional and the IR program is limited by the way the CMMS program tries to manage it. The best solution is to keep your IR testing and data flow model for you IR program in a separate database that can share the data with your CMMS program.

Reducing data entry:
One of the benefits of a relational database is that in the instance of entering data, you only enter it once and it is used in other places without the need of reentering the data. Relational databases greatly reduce the amount of data entry since you only have to enter the name of a location or piece of equipment once. This also eliminates the possibility of duplicate records for the same location, equipment or chronic problems because of spelling errors.

For example:

> You entered into the database a 2nd Floor Location. When you wish to place Mechanical Rooms on that floor, all you would do is place the Mechanical Room under the 2nd Floor without having to reenter the 2nd Floor. Consequently, if there were a piece of equipment in the Mechanical Room, you would place that under that location without the need of reentering the name of the 2nd Floor or the Mechanical Room.

Bar Codes:
Locations and equipment names can be associated with a bar code label to greatly improve the speed of finding the record in the database and improve the accuracy of the associated records that are input into the database.

Enhanced Reporting capabilities:
Since all of the data is in a database, you can run a report against the database and have it easily print out a report for you. The data can be cross-referenced to provide you with enhanced reporting. If all of the problem data is in the database then you can have the database print out a report showing you all of the problems from the hottest to the coldest. Or in the case of a chronic problem that has been documented in the past you can see a time over temperature report that shows how much the problem has changed over time.

Export to Excel, Word or CMMS programs:
Databases can easily export and share data to other software programs allowing for greater methods of data flow and analysis.

Built in Data Transition Legacy from one inspection to the next:
Since everything is in the database it is easy to understand where the program is. You can easily look up the past inspection test status on any piece of equipment and see if it has ever had any problems in the past. Or when was the last time it was tested. Having a IR PdM Database in place is like having a torch to hand over to the next runner in a marathon. It will help light the way as to what needs to be done next.

Enterprise Solutions
Relational databases allow for distributive data sharing among multiple users at the same time as well as multiple platforms and interfaces that can work together with your company's intranet/internet, directly with the database program, web browsers, other Pocket PC devices etc. The scalable solution allows for growth within your company's changing goals at a price point that won't break the bank.

Sharing / Replaced Database with Pocket PC devices

Advantages of Pocket PC Devices

Pocket PC's have numerous advantages over other types of data collection methods and equipment. Not only is the price of the technology inexpensive as compared to pen tablets. You can purchase them and accessories at any office supply store. Field / Work force automation has been significantly impacted in positive ways using Pocket PC devices in the last few years and the Pocket PC platform will continue to carve out new markets in the years to come.

Pocket PC used in the field during the inspection
Today small computers can fit into your shirt pocket and allow you to literally take your database with you wherever you go. The advantage of Field Force Automation is being seen in almost every aspect of business today, from the hardware store, to UPS and the US Post office. Using Microsoft's ActiveSync, you can synchronize the database that is on your desktop computer with your Pocket PC, allowing you to easily transfer data between the two seamlessly. The Pocket PC allows for a simple and clean system for two directional data flow between the field and the office. Past inspection data can be easily reviewed in the field and past problems can be reconciled with current conditions. Since the information is entered directly into the Pocket PC during the inspection, there is no need to have to sit down at your desk and type reports. Since all of the past data is right there with you in the field for your quick review, you can make informed decisions as to the conditions that are found.

No more library cart! Your entire IR program is in the palm of your hand.
You can actually have all of the previous inspection data with you on the Pocket PC. Since all of the data is in a database you can review the information quickly and easily. This ability will greatly improve the quality of the inspection since the thermographer has all of the previous findings for his quick review during the inspection. It all fits in the palm of his hand as compared to having to drag all of the previous reports around with him.

Bar Codes for fast identification of equipment and locations

Bar code labels can be placed on equipment for fast lookup of equipment while you are walking around a facility. These allows the thermographer to quickly review the past tests statuses and reconcile any past problems that were documented on the equipment in the past. The Pocket PC will automatically display all of the past history so the thermographer can have the complete story on any piece of equipment without the necessity of having to look for the data in the database.

Voice dictation of any length added directly into the database
If you wish to add voice comment to a problem you can easily record the voice dictation directly into the database at the time you find the problem using the voice recorder that is built-in to the Pocket PC. Comments can be of any length. The voice file is attached as a WAV file to the problem and can be reviewed at anytime, either on your desktop computer or in the field on the Pocket PC. Since the voice comment is a WAV file you can use the voice comment in other programs as well or email your remarks to others.

Instance Reports, any way you like it
By using a Pocket PC to gather the data in the field you can significantly reduce the time that is required to get a report to someone since all of the data from the inspection is being placed directly into the database at the time of the inspection. By using a database as the container that stores all of the data, to generate a report all you have to do is tell the database what information you want and it will print out the report for you. This ability to query the data in the database allows you to look at the information from many different perspectives and sort the findings. No time is needed in typing up the report since everything is in the database. All you have to do is run the query and the database will print out the reports for you automatically. A few examples of reports are:

- ☑ Detailed documentation pages (Thermograms and photos) with sub reports on time over temperature trending of chronic conditions.
- ☑ Problems cross referenced by temperature rise, providing you a prioritized list base on temperature.
- ☑ Itemized equipment inventory report showing the location and test status of each piece of equipment.
- ☑ Many other ways that you can choose to look at your data and print out reports.

Flat File systems (typing up into a report) will require that on average for every hour spent in the field that there is at least 30 minutes of report generation. That is 4 hours for every 8 hours in the field. By automating the data collection method in the field with a Pocket PC, all that is required to get the report out is to simply synchronize the Pocket PC with your computer, transfer the images over from your camera in the usual manner as supplied by your camera manufacturer and print your report. Since the thermographer is 100% responsible for the quality of the data, there are no "change of custody" problems because of someone else misinterpreting what the thermographer meant when he typed up the report. (No errors equal no finger pointing! The thermographer is responsible for the quality of his work.)

From a hard-dollar standpoint of data entry for a Flat File system (typing up a report), a company that performs inspections for four days a week, requires 16 hours for data entry per week. If a typist is used at a rate of $12.50 to type up the report since the thermographer is out in the field performing inspections, this equals $10.400.00 per year, not including benefits. To go this route means that it is costing you more and you are delivering less of a report and less accountability. In addition, you are not empowering your thermographer in the field. He is just flying blind out there.

How a Pocket PC Manages Two Directional Data Flow

Part 1: Pre-inspection data management
Pocket PC devises offer the thermographer a method of powerful "Field Force Automation" with regard to data collection and review that was not previously achievable in a form that was small enough to literally fit into the palm of your hand. With the ability to utilize the database software that will automatically synchronize with a Pocket PC, the thermographer can literally carry around in his shirt pocket all of the data in the IR program.

Part 2: During-inspection data management
Since all of the data is now in the palm of his hand, it is all readily available to him during the inspection should he have any questions concerning the equipment that he is testing. Furthermore when problem conditions are found he can quickly and easily update and input the relative data directly into the database. By utilizing a relational database, redundant data entry and duplicate records are eliminated, thereby increasing the speed and accuracy of the data collected and reducing the error associated with duplicate records.

Voice annotation can be added to any problem condition directly into the database as well if the thermographer wishes to add voice comments to the problem conditions that were discovered.

Bar codes can be used to automate the inspection process by easily identifying the equipment or locations by simply scanning the bar codes. Test statuses can be updated and past problem conditions can be reviewed.

Part 3: Post-inspection data management

After the inspection is complete the thermographer can literally drop the Pocket PC back into its docking cradle and it will automatically sync back up with the database that is on the desktop computer. All of the data is not transferred back to the desktop computer without the necessity of having to sit down and type up reports. All that is required is to transfer the IR and Photo images to the desktop computer in whatever manner the camera manufacturer provided and then print out the reports for distribution.

The chain of custody and data integrity has not be broken or compromised because the thermographer is directly responsible for the quality and accuracy of the data that he collected. The excuse of "can't read my/your handwriting" is completely removed from the equation!

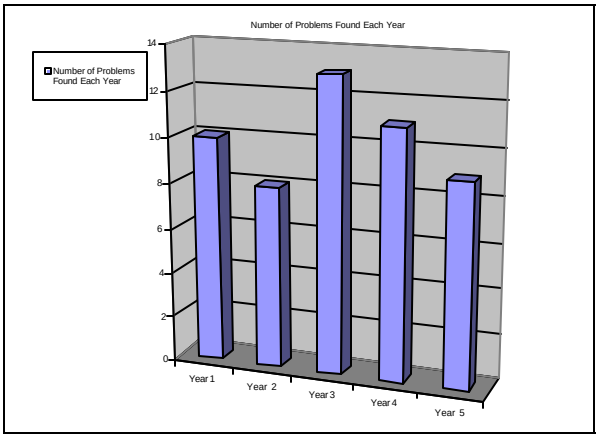
Infrared PdM Program using Relational Databases and Pocket PC devices.

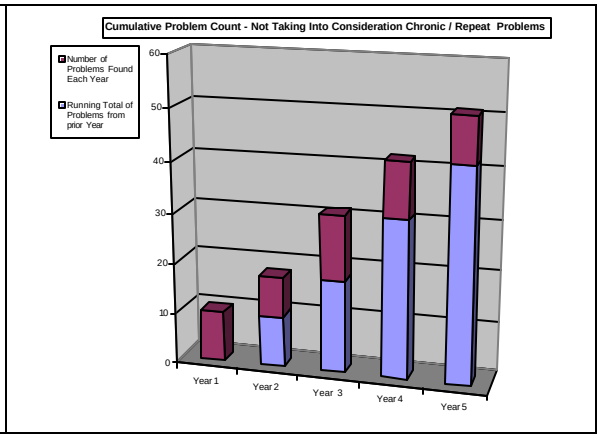
Case Study

Level 4: Relational Database with Pocket PC for Reviewing and Reconciliation of Previous Inspections

If we consider the end results of the data that is collected by using a relational database and compare the Level 3 data with what we can call a Level 4 program, we can now see what can be achieve by using a database that is designed for IR inspections that reconciles the data. The information that management can use to make informed decisions is quite dramatic as compared to the Level 3 program.

Problems with Level 3 Data

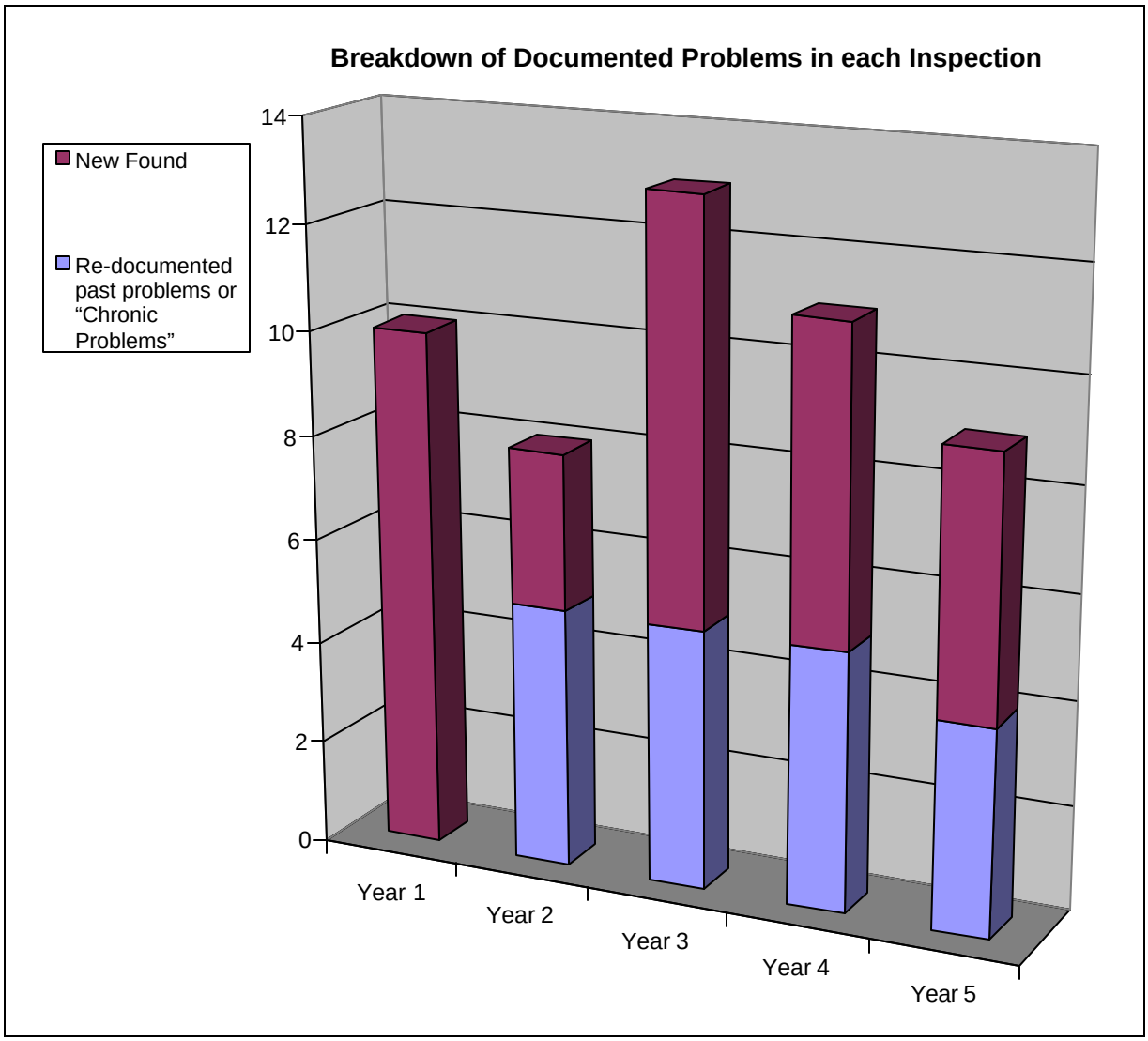




		Year 1	Year 2	Year 3	Year 4	Year 5	
Total of Problems Written-up	Report Total	**10**	**8**	**13**	**11**	**9**	
Running Total of Problems from prior Year		0	10	18	31	42	
What is the total number of problems that have been found at this facility?	Wrong Running Total	**10**	**18**	**31**	**42**	**51**	Last Years Report Total + This years Report Total

In this example of trying to find out how many problem have been documented in the past at this facility we would show 51 problems. But in reality the number is quite different if we are using a relational database that will track problem over time. If we break down the problems from the previous inspections we will find out that we have problems from the previous inspections that have been recorded as new problems in the next inspection. This will falsely distort the problem count.

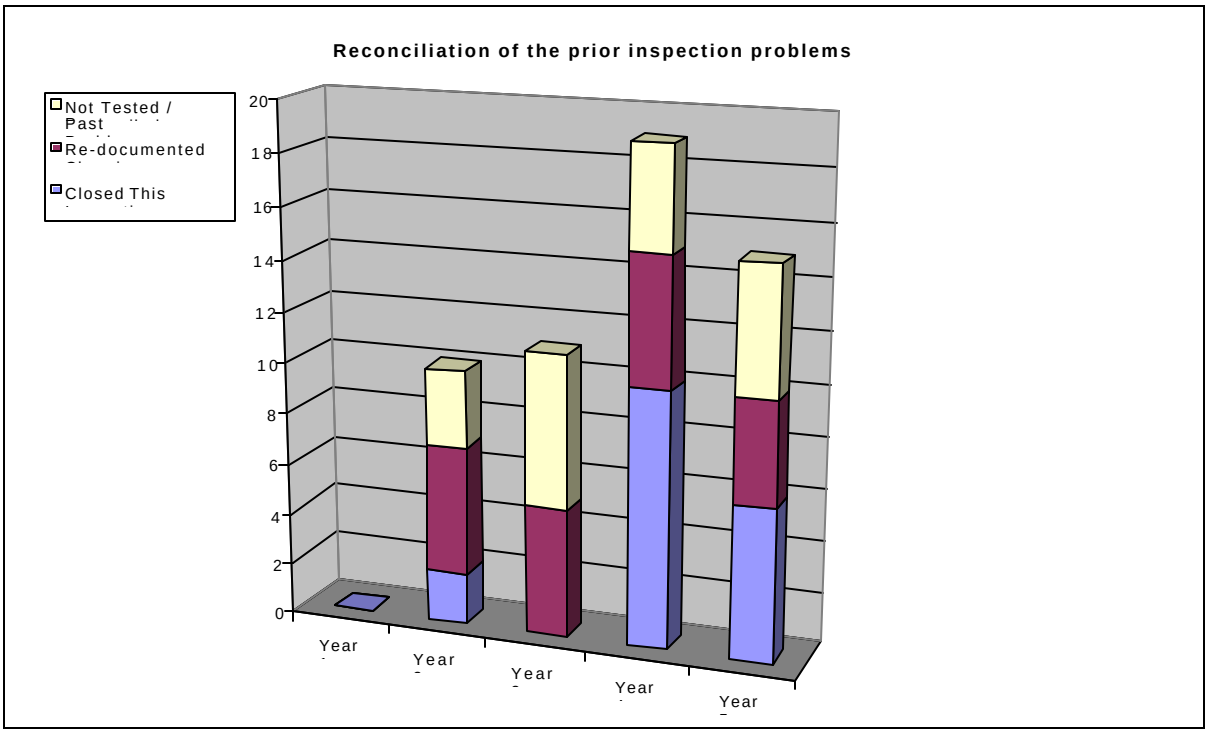
Breakdown of documented problems in each inspection.



		Year 1	Year 2	Year 3	Year 4	Year 5	
Break down of found problems							
Total of Problems Written-up	Report Total	**10**	**8**	**13**	**11**	**9**	New Found + Re-document Chronic
	Re-documented past problems or "Chronic Problems"	0	5	5	5	4	5 problems came from the prior inspection
New Problems Found	New Found	10	3	8	6	5	Of the 8 problems documented in year 2 only 3 of the problems were new problems!

In this case we see that in year two that there were only 3 new problems and 5 chronic problems documented from the previous year. This leads us to the question of reconciliation of the previous inspection's problems. What happened to them?

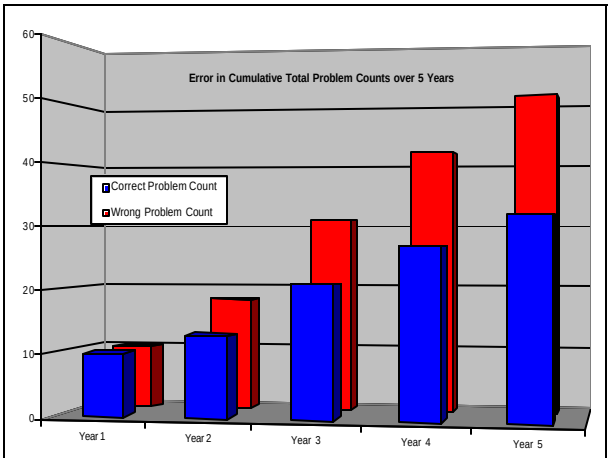
Reconciliation of the prior inspection problems

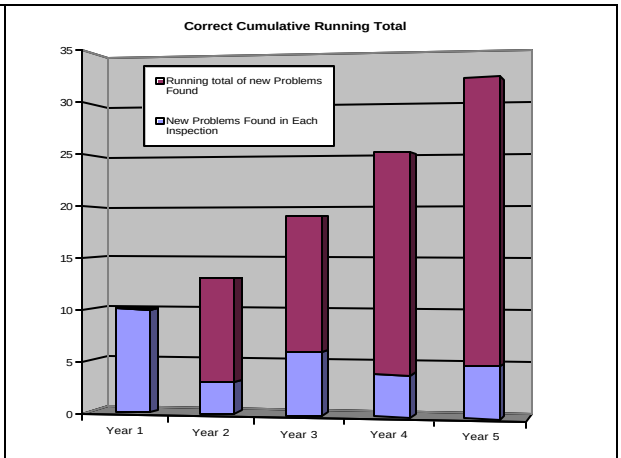


		Year 1	Year 2	Year 3	Year 4	Year 5	
Running total of open problems		0	10	11	19	15	Number of problems from the previous inspections
How many of the past problems were fixed / Closed	Closed This Inspection	0	2	0	10	6	Equal to Past years Total running open - re-documented chronic - past open not tested.
Past Problems that were still there from the previous years that where "Re-documented" as another incidence of the same problem, chronic condition	Re-documented Chronic	0	5	5	5	4	In Year 2 for example: 5 of the 8 open problems were chronic conditions or past problems from the previous year, which should be re-documented as another incident of the same problem from the previous inspection.
How many Past problems could not be re-inspected because the equipment was not running during the inspection? (Number Past Open Problems Not Tested?)	Past Open Not Tested	0	3	6	4	5	
Total Open problems from the previous inspection that have not been fixed or reconciled.		0	8	11	9	9	For example in Year 2, there are 5 Chronic open problems and 3 open not tested problems
Total Open problems from the current inspection		10	3	8	6	5	For example in Year 2, there were 3 new problems found.
Cumulative running total of all Open problems		10	11	19	15	14	For example in Year 2, the cumulative running total of open problems is equal to all of the past open problems plus any new problems found

Now that we have a way to track what is going on with the past problems we can see what is really going on with in this facility's IR program. By having a way to track the problems over time and see which ones have been repaired correctly "Closed", and tracking the past problems that were not able to be tested during the current inspection we are able to get a clear perspective of the effectiveness of the IR program.

True Cumulative Total of problems that have been found





		Year 1	Year 2	Year 3	Year 4	Year 5	
How many Past problems could not be re-inspected because the equipment was not running during the inspection? (Number Past Open Problems Not Tested?)	Past Open Problems That Were Not Tested	0	3	6	4	5	
What is the total number of problems that have really been found at this facility?	Correct Running Total of problems	10	13	21	27	32	Equal to the running total of closed + New Found

Only 32 problems have truly happened at this facility and not 51 as previously thought using the Flat File system. If we use the value of $2,000.00 as the money saved by using IR in cost avoidance of Parts and labor alone per each problem we show a true savings of 32 problems times $2,000.00 equals $64,000.00, not the $102,000.00 as thought before. That a $38,000.00 difference. Not only is the fact that by using a relational database going to improve your ability to see clearly what is happing from a problem count but you can track the effectiveness of the repair attempts and ability to close out problems my the maintenance personnel.

Cumulative Tracking of Open Problems vs. Fixed Problems

		Year 1	Year 2	Year 3	Year 4	Year 5	
Total open problems	Running Total Open	10	11	19	15	14	Equal to: New Found + Re-documented Chronic + Past Open Not Tested
How many of the past problems were fixed / Closed	Closed This Inspection	0	2	0	10	6	Equal to Past years Total running open - re-documented chronic - past open not tested.
	Running total of Closed problems	0	2	2	12	18	Equal to: Past years Running total of closed problems + Closed this inspection

By using a relational database to manage your inspection data you can easily gain control of your inspection program. It is virtually impossible to manage the program and be able to demonstrate what is going on in a Flat File system since the data is not in any way that you can look at it to show you what is really going on.

Conclusions:

The success of establishing an Infrared Program verses just some level of performing infrared inspections at your facilities is based on the how you set up the data / information flow model. One directional data flow where the information is gathered in the field and compiled into a report will not allow for the ability to clearly perceive the effectiveness of the IR program, its strengths and weaknesses. With two directional data flow, the information is easily transferred from the field to office (Pocket PC database - to – Desktop database), and in return from the office to the

field to be reviewed and reconciled. This also provides for data transition legacy, which allows everyone involved a complete perspective of the condition of a facility's equipment. Today's technology advancements in databases and portable Pocket PC allows for the infrastructure of information management that will truly bring any infrared program into the 21st century. Benefits include empowering the thermographer to be able to do his job better while at the same time providing for a reduction of redundant data collection and errors. Transitions in personnel, cameras, and time can be easily handled and the establishment of an infrared program with legacy. Management can be assured that with a two directional data flow model, their efforts in establishing an infrared PdM program with professional accountably was not in vain.

The quality of the information will increase, and quality information used correctly equals quality of the knowledge that action is taken on. Improving the quality of your knowledge is vital to the success of your program. So to start out with, your data is your IR program, and how you choose to manage that data will establish what kind of program you have. It's that simple!

Definitions of Terms:

Closed Problem Status A Problem that has been re-inspected with Infrared and that the past specific problem condition has been reconciled with the current inspection to have been repaired correctly.

Chronic Problem Condition: A problem that has been found to span more than one inspection with an open test status. For example if a problem is found on a specific circuit breaker in Year 1, and that same problem is still there in the next inspection, i.e. Year 2, then it is termed to be a Chronic Problem. It should be noted that it is not another problem in Year 2, but the same problem from Year 1 that now has a history of being a chronic problem on that specific piece of equipment. Empirical Time over temperature trending of the chronic condition can now be done to show any changes in the problems condition, helping to better evaluate the necessity to take remedial actions to correct the problem.

Database: The term can be used and misused to represent any type of collection of information, whether it is in the form of an address book, the Yellow Pages, a Report, or even a deck of playing cards.

> **Flat File Database**: Is one in which the information is contained on a computer typically in a document type of architecture in which there is little ability to query the information in a meaningful way. Typical problems that Flat File databases face is that the information is spread out over several documents, which possess data redundancy problems if the information is entered in different ways. I.E. spelling errors etc.
>
> **Relational Databases**: Are specific software programs that are designed with a specific intent to work with the information that they are meant to contain. They are not plagued by data redundancy problems since the architecture is based on the principal of "One to Many" relationships.

Endemic Problem Condition: A problem that has been documented in the past and had the problem status set to closed, and now has had the problem return. It is said that the problem condition is endemic of that specific piece of equipment.

One Directional Data Flow Model: The movement of information primarily from the field where the inspections are preformed to the office where the reports are typed up. This type of data flow model is typical of Flat File systems that do not allow for the Review and Reconciliation of data in the field on subsequent inspections by the thermographer.

Open Problem Status A Problem that has not been re-inspected with Infrared and confirmed that the specific problem condition has been repaired correctly.

Reconciling of Problems The process of reviewing previously documented problems with the current inspection to update the status of the problem a being either Open, or Closed.

Reviewing of Past Data: The process that is used in the field by the thermographer to be able to look back at any of the previous inspections and check the test statues and past problems on equipment.

Test Status of Equipment / Locations: Equipment or an entire Location can be have a status field that designates if it has been tested or not.

> **Tested**: Typically equipment that is operational and under normal load conditions is designated as Tested.
> **Not Tested**: Equipment that is not operational at the time of the inspection or is not under enough of a load to be adequately tested is designated as Not Tested.

Two Directional Data Flow Model: encompasses the sharing of information between the office and field on a revolving bases utilizing Relational databases with the ability to synchronize the data that they contain with other portable devices/databases (Pocket PCs). The resulting sharing of information allows for the Review and Reconciliation of information by the thermographer in the field while he is performing his inspections.

Bio:
Fred Colbert, President and Owner of Colbert Infrared Services, has over 25 years of experience as an infrared consultant and is a Level III Certified Thermographer and Instructor. He is a sought after speaker, having addressed many international infrared conferences and has several published white papers and articles in industry trade magazines and was featured on the cover of Maintenance Technology Magazine. He has been a Manufacturer's Representative of AGEMA INFRARED SYSTEMS and FLIR covering WA, OR, ID, MT, WY, AK, and HI, supporting new and existing PdM, R&D and Law Enforcement customers. Fred is currently the Manufacturer's Representative for Mikron Infrared, ElectroPhysics/CEDIP, and Thermal Trend. Fred's experience includes Product Development with camera manufacturers where he was able to contribute his wide range of knowledge of the industry, applications and equipment.

His background in database development started with the development of Thermal Trend in 1990 where he has been the chief architect and development director throughout its 13 years of advancements. Today Colbert Infrared Services utilizes Thermal Trend Lite in all of its PdM inspections provided to their world class customers.

Colbert Infrared Services, Inc has been providing quality infrared inspections, training and equipment sales for over 15 years. By keeping in touch with the latest technology innovations, Colbert Infrared Services has set itself apart from the competition by delivering "uncompromised quality and accuracy" to customers all over the world. The fully staffed main office is in Seattle and includes a full-time support staff to efficiently handle the often-significant needs of our corporate clients.

Evaluating Your Current Program

1. Does the person responsible for your infrared inspection have a list of what equipment is to be tested and it's respective location in the facility so that it can be found?

   Yes ☐ No ☐

2. Does the person responsible for your inspection know what problems have been documented in the past?

   Yes ☐ No ☐

3. Does the person responsible for the inspections know what pieces of equipment have been repaired?

   Yes ☐ No ☐

4. Is there a system in place for the person responsible for the inspection of equipment to know which pieces of equipment has had repairs and allows him to verify that the repairs were successful.

   Yes ☐ No ☐

5. Do you have a system that successfully tracks a problem from creation, through instances, to repair?

   Yes ☐ No ☐

6. Do you have a report of inspection data?

   Yes ☐ No ☐

7. Is that information in an electronic format in addition to a hard paper copy?

   Yes ☐ No ☐

8. Are you able to compare recent inspection results with past inspection results in an efficient manner?

   Yes ☐ No ☐

9. Does your inspection documentation include a list of equipment that was not tested?

   Yes ☐ No ☐

10. Are you able to produce a list of last inspection dates for all your pieces of equipment?

    Yes ☐ No ☐

11. Are you able to identify chronic or reoccurring problems on a piece of your equipment?

    Yes ☐ No ☐

12. Is the person responsible for collecting the data, the same person who is responsible for creating the report?

    Yes ☐ No ☐

13. Do you have a system in place to audit the documentation for errors before the report is published?

    Yes ☐ No ☐

14. Are you able to quickly view a problem's history (how many instances and how much the temperature has changed over time)?

Yes ☐ No ☐

15. Do you have a system that allows for easy review of the equipment's history (medical records) including problems and test status while in front of the piece of equipment?

Yes ☐ No ☐

16. Do you have a system that easily allows you to view where you are at in the inspection process including what has been tested, what as been not tested and what equipment remains to be tested?

Yes ☐ No ☐

17. Do you have the ability to export the data to other common forms of spreadsheets?

Yes ☐ No ☐

18. Does your current software work with multiple software platforms?

Yes ☐ No ☐

19. Does your software accurately report an actual running problem count?

Yes ☐ No ☐

20. What category does your IR program fall into?

In-house Crisis Management ☐
Out-Sourced Consulting Services ☐
In-house Periodic Inspections ☐

21. How can you improve your current process?