# INFRARED THERMOGRAPHY PROGRAM AT DARLINGTON NGD

Prepared By: B. Speer
Production Support Dept.
Darlington NGD
Box 4000
Bowmanville, Ontario
L1C 3Z8

## ABSTRACT

Infrared Thermography is a proven predictive maintenance tool for improving equipment reliability and reducing maintenance costs. It has been identified as one of the maintenance technologies that could contribute to the reduction of OHN forced incapability factor.

At Darlington NGD a program has been established by combining OHN and Nuclear Maintenance Applications Center (NMAC) operating experience. This presentation outlines the development and implementation of this program. The main point are: Roles and Responsibilities, Equipment Selection, Software Requirements, Manpower Level, Inspection Equipment, Training and a Cost / Benefit Review.

## 1. INTRODUCTION

An Infrared Thermography Program has been established a Darlington NGD to: Improve personnel safety, minimize forced outages, prevent catastrophic failures by identifying equipment that is deteriorating before it affects station operation.

This paper will outline the key elements that went into establishing an effective program. The program established follows guidelines in the NMAC "Infrared Thermography Guide" (see Reference 1) and adds station experience. The information presented is : Responsibilities, equipment to be surveyed, conduct of work and frequency of surveys.

## 2. DEFINITIONS

Infrared Imager - A tool capable of displaying an infrared map of an object. This device is commonly known as an infrared camera.

PMEP (Preventative Maintenance Enhancement Program) - A maintenance program based on reliability centred maintenance principles to determine which equipment should be included in preventative maintenance programs.

Spot Thermography Tool - Tool that is used to determine the temperature of a spot using the emitted infrared energy.

Thermography - The use of an infrared imager to map out a temperature profile over the surface of an object.

Thermography Crew - A maintenance crew set up to perform infrared scans.

## 3. OVERVIEW OF THE MAINTENANCE PROGRAM

The program implemented can be broken down into preventive maintenance and troubleshooting.

For the preventive maintenance a technician receives a list of equipment that require an infrared scan. Typically this list will be less than one day's work. The equipment is scanned and temperature data recorded, any deviations from the normal are noted. Once the work is completed (unless the deviation requires immediate action) the technician performs an analysis on any deviations to determine the source of the problem and passes the information on to engineering and maintenance.

On the troubleshooting side a request is made to the technician to resolve a problem. The image is taken and analysis performed. Reporting is made directly to the requester of the problem.

While establishing the program outline above the following key elements were considered:

1. Determining the program responsibilities
2. Determining equipment to be included in a surveillance program
3. Establishing an qualified crew and purchasing the appropriate equipment.
4. Developing an effective data storage and reporting system
5. Establishing a system to monitor the program's effectiveness

Each of these topics will be discussed below.

## 4. PROGRAM ELEMENTS

### 4.1 RESPONSIBILITIES

The titles below are not the actual titles at Darlington. They have been made generic to indicate the level of responsibility.

**Maintenance Coordinators (Mechanical and I&C):**

Responsible for ensuring the Thermography Crew is staffed and equipped to a level that allows it to perform its duties.

**Maintenance Engineer:**

Responsible for: Supporting the equipment selection process, interfacing with outside organizations, providing technical/troubleshooting support as required, and supporting the purchase of infrared equipment.

**First Line Supervisor:**

Responsible for supervision of the IR crew. This includes review and setting of priority of work requests and scheduling the routine work load.

**Thermographers:**

Responsible for the actual infrared scans required by the program. This includes analysis and reporting of results as directed by the program. Responsible for determining which equipment will be surveyed as outlined in Section 4.2. This includes selecting, checking and adding to database.

**RCM Coordinator:**

Responsible for passing on RCM requirements to Thermography Crew.

**System Responsible Engineers (SREs):**

Responsible to act as required to the reports issued by the Thermography Crew. They will also provide technical support to RCM in identifying critical equipment.

## 4.2 EQUIPMENT SELECTION

This section identifies the equipment that will be monitored under the infrared thermography preventative maintenance program. In general, a 'piece of equipment' is identified as having Unit-System Code-Device Code. For the purposes of thermography, this has also added 'component' since some devices have more than one area to be surveyed. Listed below are the criteria that will be used. All four methods are being incorporated.

### 4.2.1 Information From RCM

It has become recognized that to be cost effective preventive maintenance has to be performed on the right equipment. One of the methods of establishing priorities is applying the principles of Reliability Centred Maintenance. To summarize this type of program: Station equipment is analyzed to determine what the effect of a component failure is on safety and production. In the simplest terms only equipment that have an impact above certain threshold will have PM performed. RCM is detailed in many other reports therefore it will not be discussed any further.

Any equipment that is identified as critical by the RCM Group will have infrared thermography performed (where applicable). As the RCM program progresses, this information will be passed on to the infrared crew for addition to their routines. This covers both electrical and mechanical equipment. The information from the RCM program will be entered into the routines developed for the Mechanical and Electrical Equipment (listed below). This will be an ongoing process until the RCM review for the station is complete.

### 4.2.2 Discussions With System Engineers

There are several areas where System Engineers (and/or Thermographers and other Maintenance Staff) have identified the need for IR scans on equipment. Some of the areas are: Generator, TRF, Standby Generator expansion joints and Fuel Handling. The process for adding this equipment to the IR program is:

1. Meet with the System Engineer to discuss the equipment required and to determine if an IR scan is possible. Have the System Engineer justify the need for IR scans. The need must follow the intent of the RCM process (prevent shutdowns and equipment damage or economic gains). Have the System Engineer prepare a list of equipment (with location).

2. Prepare a routine as detailed in 4.2.3 and 4.2.4.

### 4.2.3 Mechanical Equipment

Since determining the temperature using the infrared imager is not time consuming the number of components that can be scanned in a day is high. This means that the exact analysis derived from RCM need not be applied. Important systems are scanned but the individual components may not be highly rated by the RCM system.

The determination of which pieces of mechanical equipment are to be scanned is as follows:

1. Obtain a list from the RCM group that details the most critical systems in the station.

2. Examine the operational flowsheets for the RCM identified systems and determine which equipment can benefit from an IR inspection. Typically this will be rotating equipment and valves (that could be passing). The list is cross referenced with equipment lists already identified by RCM (to ensure nothing was missed).

3. Prepare a routine of equipment based on the system and a useable route.

4. Perform a trial inspection of the routine. This determines if the IR inspection will produce useable results and determines the approximate time for the routine. During the trial the technician would add equipment that did not belong to the system but was nearby and an infrared image easily obtained. In this manner the route becomes the most efficient use of time

#### 4.2.4 Electrical Equipment

The determination of which pieces of electrical equipment are to be scanned is as follows:

1. The Electrical Systems Group in Engineering identifies the electrical distribution equipment that should be examined.

2. Equipment identified that can be inspected is added to the electrical routine for that system. Presently 4 and 13 kV breakers cannot be inspected as they are explosion proof and the cabinets cannot be opened on power.

3. A routine of equipment based on the system is prepared.

4. A trial inspection of the routine is performed. This determines if the IR inspection could produce useable results and determines the approximate time for the routine. During the trial the technician would add equipment that did not belong to the system but was nearby and an infrared image easily obtained. In this manner the route becomes the most efficient use of time.

The information above is for electrical distribution systems. This system supplies power to individual MCC's. It has been decided that not all the MCC cells and 600 V feeder breakers will be examined. The individual MCC Cells to be examined will be identified by:

1. Examining any MCC cell or 600 V feeder breaker that appeared as critical on the RCM list.

2. Having the balance of the loads reviewed by the IR crew and the Maintenance Engineer determine if the load is important enough to be scanned. This will be a crude criticality assessment but it is felt that it will be cost effective.

A separate area of work is the inverters/rectifiers for the Class I/II systems. It has been decided that thermography will be performed approximately one month before the annual maintenance is performed. After the maintenance is performed, a follow-up scan will be performed.

#### 4.2.5 Test Frequencies

The test frequencies for the inspections were determine as follows:

Electrical: Once per year based on experience at BNPD, or as requested by SRE.

Mechanical: In general, once every three months, or as suggested by SRE.

### 4.3 EQUIPMENT, QUALIFICATION AND CREW COMPLEMENT

#### 4.3.1 Equipment

The minimum to start a program is the use of an infrared imager that has the capability of storing images on disk. The latest generation of imagers have focal plane array detectors. While this is a better technology and is recommended, the program can operate with the older scanning models.

#### 4.3.2 Qualification

The American Society of Non-destructive Testing (ASNT) has added thermography as a program they accredit. It is recommended that all thermographers achieve Level I within the first year of joining the program. Level II or other advanced study (eg, Electrical Applications) is recommended for at least 50% of the crew within the first three years.

The ASNT accreditation is required in order to control thermographers offering their service to the public. Since the Thermography Program at Darlington is not a service to the public, the qualification should not be viewed as mandatory; rather, by using the ASNT levels, the station can be assured of receiving quality training.

#### 4.3.3 Crew Complement

It is recommended that a Thermography Crew for a four unit station with the equipment to be scanned identified be, at a minimum, composed of the following:

Two I&C Technicians: To run the electrical equipment side of the program and provide insight regarding the results from the scans on electrical equipment. Two technicians are required in order to have a safety person when performing scans on HV equipment (opening panels).

Two Mechanical Maintainers: To run the mechanical equipment side of the program and provide insight regarding the results from the scans on mechanical equipment

### 4.4 SOFTWARE AND REPORTING

There are two areas that software is required to run a good program.

#### 4.4.1 Analysis Software

The first is software to analyze the IR images obtained from the IR camera. This software is purchased from the suppliers of the cameras. The main requirement is the capability to easily produce quality reports. All suppliers of infrared imagers now offer analysis programs.

#### 4.4.2 Database

The second software requirement is a database capable of listing the routines generated. This database will record IR data and be capable of trending the results. Experience at Darlington has shown that with the large number of equipment entered into routines and the large amount of data collected from these routines a database is required. With the start of the Thermography Program in 1995 work began on developing a LAN based database that met the requirements of this program. There are still some enhancements required in order for this program to meet the minimum needs of the program..

It seems best to illustrate the program by going through the steps required of a routine:

- On the LAN a routine is requested based on the preventive maintenance schedule.
- This routine is downloaded into a laptop computer.
- The computer is taken out into the field along with the infrared imager.
- The routine in the program identifies the piece of equipment (and the specific component on the equipment) where the temperature is to be determined.
- The Thermographers determines the temperature and determines if action is required. This determination is from a comparison to previous readings and experience.
- The new reading is entered into the database and the Thermographer moves onto the next component.
- Once the routine is complete the data is uploaded from the laptop back into the LAN.

#### 4.4.3 Reporting

The reporting of thermography results will depend on the type of work being performed routine or request.

##### 4.4.3.1 Routine

The results will be entered into the thermography database for each component examined in the routine. If an anomaly appears, the Thermography Crew will:

1. Initiate a work request either to a trades group to repair the problem or to the technical group to determine a course of action.

2. Issue a Thermography Report to the SRE. A copy of the report is filed in the Thermography Office.

3. Issue a second work request if a post-maintenance scan is required and/or determine the nature of the problem for future reference.

4. For issues where root cause is not determined by Thermography Crew any work reports to the work requests that have root cause information are to be printed and filed with the report.

#### 4.4.3.2 Requests

1. Enter a work report against the requesting work request detailing the results of the scan requested.

2. Issue a second work request as detailed above if follow-up work is required.

### 4.5 TRENDING

Once a year, the Maintenance Engineer will initiate an action that reviews the routine results for the past year. This will attempt to identify components on the program lists that had: Failures that should have been detected by thermography but were not, or failures that were undetected by an inspection.

For these components, the frequency will change to suit the findings or they will be dropped from the program.

The Maintenance Engineer will also implement a yearly cost/benefit analysis of the maintenance program. This will consist of reviewing the thermography reports that were issued for the for a year. A estimate will be made of the potential savings from detecting the fault based on the probability of failure x consequence of failure. The total benefit will be compared to the cost of the program (labour and equipment).

Experience at other sites which have implemented Infrared programs shows that in the first year or two numerous faults are found, especially in electrical equipment. However, when the first pass has been completed the number of faults drops dramatically. Darlington has not determined how to address this known problem.

## 5. SUMMARY

The information above outlines the program that is in place at Darlington NGD. It is hoped that the information can be used by others hoping to established their own Infrared Thermography Maintenance Program.

The program at Darlington is still in its infancy therefore the cost/ benefit and routine review have not been completed yet. They will be done after the first full year of the program. The results to date have been encouraging with both electrical and mechanical faults detected and corrected.

## 6. REFERENCES

1. Infrared Thermography Guide EPR1 Report NP-6973.
2. Darlington Procedure "Thermography Program" NK38-PROC-60051-001