Calculation can identify where specific improvements can be made to an infrared predictive maintenance program.

The world was changed when Albert Einstein introduced the equation $E = mc^2$, not so much for the fact that it led to the understanding of atomic energy, but that for the first time it united the physics of energy and matter.

In the same manner, to be able to truly evaluate the effectiveness of an infrared predictive maintenance program there must be an understanding of the relationship between the equipment that is to be inspected and the problems that are found and repaired. Too often the focus is on only the infrared images that the camera produces while the solutions that the data produced from the program can provide get lost.

It all boils down to a simple but fundamental law that is expressed by the equation $E = IR\infty$ which focuses on measuring the effectiveness of the overall infrared program as well as on each of the individual components that contribute to its success. Both components help answer critical questions as to where specific improvements can be made that will lead to a world class infrared predictive maintenance inspection program.

I = the effectiveness ratio of the ability to test all of the equipment/inventory that has been or should be inspected (for a specific inspection)

I is the ratio of the number of pieces of equipment in inventory that actually have been tested divided by the total inventory of what was supposed to be tested (total inventory tested, plus what was not able to be tested at the time of the inspection because of various reasons, i.e., not running, not accessible, under repair at the time of the inspection, etc.).

$I = i_{\text{tested}} / i_{\text{total inventory: tested + not tested}}$

Example: Suppose that there are 100 pieces of equipment in inventory that need to be tested. On the day of the inspection, only 75 pieces of equipment are available for testing because the other 25 pieces of equipment are not running. To solve for I, divide the number of pieces of equipment that were actually tested by the total number of pieces of equipment that were to be tested in inventory.

i_{tested} = 75

$i_{total\ inventory:\ tested\ +\ not\ tested}$ = 100

I = 75/100 = 0.75 or 75 percent

This represents the effectiveness of being able to test everything in the facility that should have been tested. A low percentage indicates a program that is not very effective at actually testing the equipment that has been selected to be inspected. A high percentage indicates a program that is very effective because the majority of the equipment is actually being tested.

A low tested inventory ratio indicates that only a few pieces of equipment were actually tested. This can be for reasons that may or may not be influenced by the thermographers' efforts. A high ratio indicates that the majority of the equipment was actually tested, and since the purpose of having an infrared inspection program is to test equipment, the more equipment tested that is part of the infrared predictive inspection program, the better.

R = the effectiveness ratio of the ability to repair the problems that have been found (covering all inspections)

R is the ratio of the number of successfully repaired problems (closed, spanning all inspections) divided by the total number of problems that have been found (all open and closed problems, spanning all inspections).

$R = r_{total\ problems\ repaired} / r_{total\ problems\ found\ spanning\ all\ inspections}$

It is important to understand that a problem can span multiple inspections and still be the same problem (a chronic problem). It is not uncommon for 15-25 percent of problems that are written up in an inspection to be chronic problems. A chronic problem is not a new problem (acute problem written up only once), but the same problem on a specific piece of equipment that spans multiple inspections (chronic problems). This is an important point when considering what the true number of problems is at a specific facility.

If a method of tracking chronic problems vs acute problems is not established in a program, then total problem counts will be greatly distorted, greatly increasing the number of problems and falsely showing more problems than actually exist.

Take a look at the total effectiveness of repairs. Suppose that 10 problems were found during equipment inspection. Of the 10 problems that have been found, how many of them have been actually repaired correctly (rescanned, reconciled, and found to be correctly repaired)?

Example: Assume that five of the 10 problems have been repaired correctly and verified with infrared. From this the effectiveness ratio of the repairs can be established compared to the total number of problems that have been found during the life of the infrared program.

$r_{\text{total problems repaired to date}} = 5$

$r_{\text{total problems found to date}} = 10$

R = 5/10 = 0.50 or 50 percent

This represents the closed effectiveness ratio of being able to repair all problems that have been found.

A low closed repair ratio indicates that only a few problems have been actually repaired correctly. The reasons for this may go beyond the responsibility of the repair personnel’s efforts to effectively fix the problems such as not being able to take the piece of equipment out of service to repair it correctly. A high ratio indicates that the majority of problems have actually been repaired correctly.

** the number of inspections that have been done over time**

∞ represents the goal that there will be many inspections running on to infinity (understanding that that will not likely happen but it represents the life of the infrared program in perpetuity).

E = total effectiveness of the infrared program

From this, the individual components that comprise the success of an infrared predictive program can be used to evaluate its success.

E = IR∞

where:
I = 0.75
R = 0.5
0.75 x 0.5 = 0.375 or 37.5 percent program effectiveness

If 100 percent of the equipment had been tested that was selected to be tested (100/100 = 1) then the effectiveness ratio would equal 1 x 0.5 = 0.50 or 50 percent.

If everything was tested (100/100 = 1) and fixed (10/10 = 1), then the effectiveness ratio would be 1 x 1 = 1 or 100 percent successful.

Although a 100 percent success rating is unlikely for any infrared program, it is the trends that these numbers reflect that show the real picture of what is going on within a program, or from one program/site/facility to another. Careful monitoring of these ratios will provide a clear perspective as to the health of a facility's infrared predictive maintenance program and the total effect it has on the bottom line.

Indicators to watch

If the *I* ratio is usually high and then starts to drop, this could be an indicator of poor scheduling of equipment to be tested when in reality it is not running or thermographers are not completing their inspection routes.

If the *R* ratio is low, then most likely there is no ability to take the equipment out of service to fix it, there is a poor quality of workmanship on the repairs that are being made, or a poor quality of replacement parts are being used.

Effective programs

The benefits of a successful infrared predictive maintenance inspection program are tremendous. Some forethought and a solid foundation in managing the data of what is to be tested, what was not, what problems were found, and whether they were fixed, will provide the expected return on investment over time.

Using a mobile database for developing the infrastructure to handle the data for tracking what is and is not tested, as well as reconciling open chronic and acute problems over time, is the key for the effective use of the $E = IR\infty$ formula. The database can easily be queried to provide the necessary reports to evaluate the effectiveness of each of the contributing components as well as the overall program. Keeping it simple and remembering that it all boils down to the formula will be the guide to a world class infrared predictive maintenance program. **MT**

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