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RESNET & Infrared Thermography

An Overview of the New IR Standard

New-housing market crashes, 110 million homes need retrofitting, and billions in stimulus money for efficiency hits the streets! Such a scene could not have been more perfectly set for drama, unless it was for a new blockbuster movie.

Against this big screen plays another less flashy scene, a classic good news/bad news story line. The good news: The price of infrared (IR) cameras has plummeted, and they are easier to use than anyone had ever imagined. The bad news: Any fool can buy an IR camera, and many do! Besides, how hard can it be to "audit" a home?

The sad reality is that what has been lost in this mad rush to market is the very high-quality work that many good auditors and raters are doing—and can do to 110 million homes—with today's truly amazing IR systems. It could be argued, in fact, that these efficiency retrofits—key to reducing CO_2, energy use, and unemployment—can't be done effectively without IR technology.

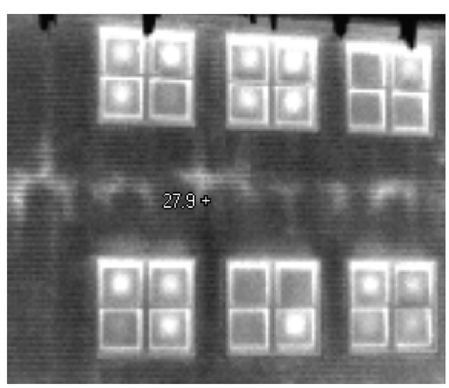
Into the scene steps the Residential Energy Services Network (RESNET)—maybe not exactly the White Knight, but a well-respected organization nevertheless—to help clarify the definition of a high-quality IR inspection and the qualifications (and certification) needed to conduct one. A committee of several dozen experts in the industry has worked for over a year on a draft document that was recently posted at the RESNET Web site for public comments.

Several standards for inspecting buildings with thermography—standards that have been in use for over 20 years—have never been widely used in the home inspection market. There was simply no demand, or in many ways, need, for these particular standards, as few thermographers conducted inspections, and those who did mostly used very powerful imaging systems. In the past several years, however, literally thousands of people have begun to conduct IR inspections. Many have little background or training in either building diagnostics or practical heat transfer. What's worse, they often are using IR systems that are inappropriate for this specialized application, because they don't have the high thermal and spatial resolution required for residential inspections. Add to the various mix a number of "certification" programs, some of which are all but advertised on the back of a matchbook, that don't really qualify someone for this challenging work.

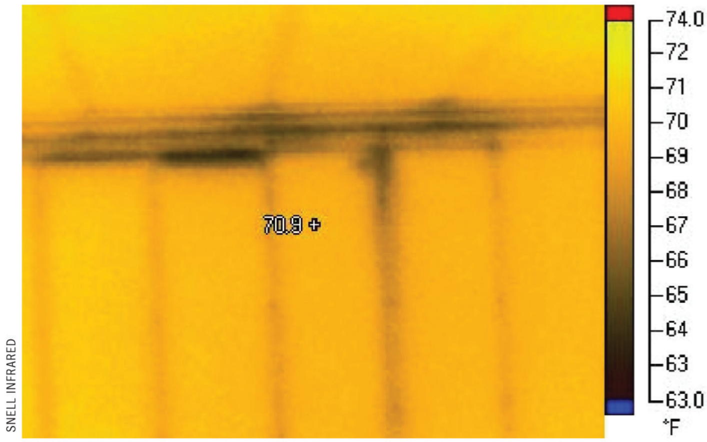
Clearly, the task RESNET took on was a tall order. As one might expect, the standard set forth in the document—still in the final stages of tweaking by the technical and administrative committees of RESNET— may not fit all the needs of the entire building industry. That said, the effort is welcome, and, I believe, will prove useful, especially in the residential market. It also may serve to draw an important line in the sand to define what is—and is not!—acceptable.

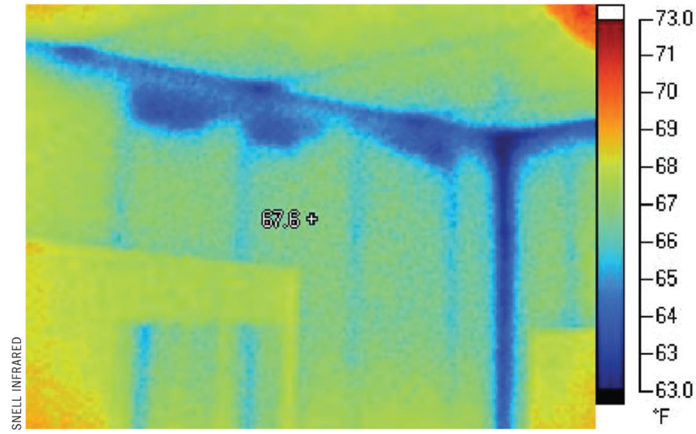
Here are some of the nitty-gritty details:

- The standard will nest within the larger context of RESNET National Home Energy Rating Standards, Chapter 8, "Performance Testing Standards"; along with Section 801, "Pressure Diagnostics"; and Section 803, "Combustion Safety Testing," both of which will be added in the near future.
- The standard describes two methods of achieving advanced RESNET certification, a credential that will be required of anyone who conducts IR inspections.
- The standard provides a clear procedure for how to conduct IR insulation and air leakage inspections of new and existing frame homes being rated under the auspices of HERS.
- The standard lists minimum IR camera specifications.



Many, but not all, infrared imaging systems in the market today comply with the minimum specifications of the new RESNET standard and, when conditions are correct, produce high quality results like this showing poorly fitted fiberglass and failing argon windows.





Blown-in cellulose, when improperly installed, can settle. These cases resulted in Grade II (left) and Grade III (right) designations under the new RESNET standard.

Certification

Under the new standard, advanced certification can be achieved in one of two ways. Both assume that the candidate has, at the minimum, Home Energy Survey Professional (HESP) certification and can demonstrate “sufficient building science knowledge.” Method 1 requires completion of a 32-hour training course that complies with the Level I standards of the American Society for Nondestructive Testing (ASNT). Whereas Method 1 covers a broader range plus buildings, Method 2 requires less training, focusing only on buildings, completion of a 24-hour course (classroom and fieldwork) approved by RESNET, and passing a RESNET online exam. In addition, the candidate must document three months of field experience and submit three reports. Both the outline for the 24-hour course and the online examination are still in development, but should be available soon. Under both methods, the Infrared Certification Committee may request additional information and documentation prior to issuing certification.

Minimum Specs for Imaging Systems

Most, but not all, thermal imagers in the marketplace will comply with the requirements of the standard. In general, the thermal imaging system must be able to distinguish the framing members from the wall cavity under prevailing conditions (defined later) and must be able to display an image showing at least two cavities and their framing members.

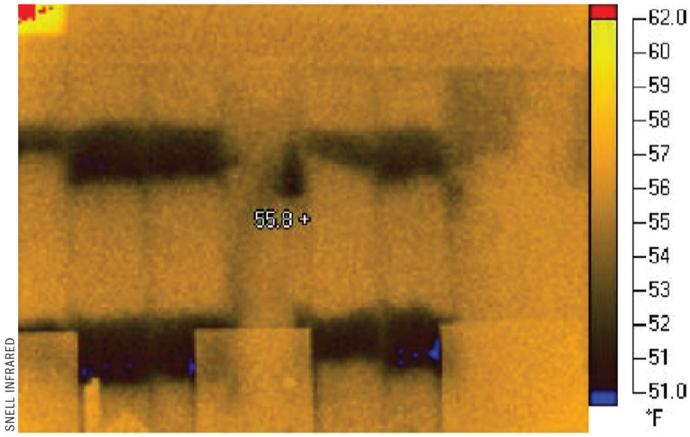
The minimum acceptable spatial resolution is defined as 3mRad or greater, and the detector array must have at least 120 x 120 pixels. A thermal sensitivity of at least 0.10°C (at 30°C) is specified. Even if the system has an automatic capability, the thermographer must be able to adjust the thermal image manually in software, or to adjust his own position relative to the envelope, to avoid saturation or poor focus. While all three of these requirements will eliminate several systems in the market—ones that are less sensitive, have too few pixels for building work, or cannot be manually adjusted—they will allow the use of any of literally dozens of excellent systems, with a wide range of features at a wide range of prices.

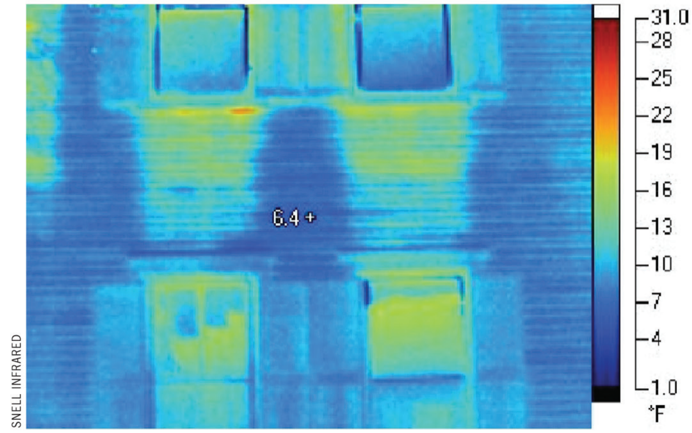
Conducting the Inspection

The process for conducting the home inspection using IR thermography is broken into two sections: the insulation inspection and the air leakage inspection. This is because although both are conducted during the same home visit, different conditions and procedures are required for each, and the insulation inspection must be conducted first.

The RESNET standard, drawing heavily on previously written standards, specifies that insulation inspections be conducted as follows:

- Make sure that the difference between the inside and outside wall temperature is 18°F for at least four hours prior to the inspection.
- Move away major obstructions in order to gain a clear view of all walls.
- Take samples of representative sections of the building, both with and without anomalies.
- Document all anomalies.
- Investigate all anomalies.
- View the exterior surfaces if there has been no direct sun (or no significant indirect sun) for the previous three hours (frame) or eight hours (masonry veneer); the wind is less than 8 mph; and surfaces are dry.
- View the interior understanding that the sun can affect interior surfaces after a lag period of approximately 2 to 6 hours; and differences in interior temperature from room to room may affect image comparisons.
- View interior partitions and all interior surfaces for potential bypasses.





Inspections are conducted on both the interior of the envelope and, when conditions allow, on the exterior. Exterior inspections are often impossible or limited by direct sun, wind and moisture.

The insulation inspections can be either qualitative or quantitative, and both must be conducted prior to using the blower door. Quantitative inspections allow the rater to grade the insulation as Grade II (0.5%–2% voids) or Grade III (2%–5% voids).

The standard defines Grade I as insulation problems that cannot be verified using the IR method. Quantification is accomplished by measuring the void areas and determining what percentage of the entire envelope area they constitute.

Inspections to check the air barrier and locate sites of leakage are conducted after insulation inspections because they involve the use of the blower door, which typically changes all the thermal images. The air leakage inspection, which is qualitative, requires less of a temperature difference—a minimum of 3¡F inside to outside. That said, cautions are included about pulling air through buffer zones, such as attics or weep spaces, that are tempered in a way that may make it difficult, or even impossible, to detect the thermal influence.

The standard calls for depressurizing the building to 20 Pa for at least ten minutes, so that the influence of air leakage can be seen. The standard emphasizes the importance of using the technology as a tool to further the understanding of the basic structure—rather than using it as an answer machine. For instance, the document states in Section 802.5.5.c that “cooling or heating an entire joist cavity between floors with air infiltration will take longer than finding an air leak around an electrical box.” Well said!

Importantly, the standard clearly states that thermography can be used for an evaluation of both thermal bypasses (air intrusion) and thermal bridging (insulation and framing issues). For situations where a visual inspection is not possible or was not completed before the envelope was closed, this ability to conduct both evaluations is crucial.

Section 802.8 and “Appendix A (Normative)” both go into detail about what should be included in the report. “Appendix B (Informative)” is a useful sample Inspection Form for Thermal Bypasses and Bridging. “Appendix C (Normative)” shows the methodology used for determining the insulation grading—an area where some subjectivity may come into play, depending on the spatial resolution of the camera being used. “Appendix D (Informative)” goes into greater detail about the types of thermal pattern that the inspector may encounter. RESNET intends to add actual thermal images to this appendix in the future. A final “Appendix E (Informative)” clarifies the special complementary role a visual inspection can play to thermography by asking a series of questions about the details of home construction, especially visual indications of thermal bypasses and problems with insulation.

The RESNET draft document is a good first cut, one that certainly will be improved as it is used and tested in the field. I don’t expect there to be many technical problems, but there will probably be refinements as this advanced certification is implemented and work is done across diverse climates and housing types. The good news is that the refinements to the document will be reviewed and compared as the results that raters produce continue to improve.

IR camera manufacturers are scrambling to package less expensive systems that are more appropriate to the needs of building inspectors, and training organizations are working hard to deliver high quality training designed to meet RESNET certification needs. And fortunately RESNET recognizes that thermographic inspections must be of the highest quality if their work and the Energy Star logo are to mean anything at all. The technology, properly used by qualified people, can have huge impact on how effectively we retrofit the 110 million existing homes in this country.

IR and Vermont's Weatherization Assistance Program

With IR camera prices tumbling and quality zooming up, the barriers to using this remarkable technology at all levels in the DOE Weatherization Assistance program are evaporating faster than warm air in a leaky house on a cold January day. Vermont has long had a very innovative program that has been used as a lab for testing new ideas. Geoff Wilcox, the Vermont program's director of field monitoring, had just such an idea: Let's push IR right down through the organization, so if all goes well, it will be used every day for audits and installation of materials by the crews.

Geoff first got the IR bug when he was conducting audits and installing materials at a local agency. He moved on from there and used thermography extensively at the state level, for monitoring all the agencies in Vermont. His thermal images very quickly showed that where auditors and crews were using IR, the work was better. Without thermography, problems were common. The difference was so profound that Geoff committed himself to a goal of having every single audit and job incorporate the technology.

These were the kinds of results he says he was seeing where thermography was not used:

- "I saw a lot of empty walls and sent the crew back. They blew 40 more bags and dropped the air leakage rate by 700 CFM.
- "The crew had supposedly blown all the walls, but my images showed about 30%–40% were still empty. The agency realized it was time to retrain on proper cellulose install techniques, and use the IR for quality control.
- "An older two-story house had fiberglass insulation in it, so the agency didn't touch the walls or band joist. Using the blower door and IR together showed the first-floor ceiling turn black when it was depressurized, so I asked them to go back and bag and blow the band joist. They dropped the home from 3,200 CFM50 to 2,200 CFM50 from that one additional measure alone!"

His (Geoff Wilcox) thermal images very quickly showed that where auditors and crews were using IR, the work was better.

Because he had seen so many of these sorts of issues over the past two years, Geoff and his boss, Jules Junker, tried to make it easy for all agencies to purchase cameras. It certainly helped matters that the less expensive systems were so powerful and user-friendly. Importantly, their availability and accessibility also ensured that home performance contractors could get the training they needed to be successful.

They found there were still some real hurdles to be dealt with, such as weather and building type. Training went a long way toward teaching thermographers to jump these hurdles. Other obstacles, however, were related more to perception than to fact. Some people objected that using IR would take too much time (in fact, it takes less time), and that these expensive cameras might get broken (they may, but it doesn't happen very often).

Initial skepticism led one auditor to ask, "Are you going to pick apart my jobs?" Now this auditor finds that many crews welcome his monitoring as a challenge to validate their good work, rather than to scrutinize their mistakes. Agencies are acting on his findings and suggestions for training crews to get better results.

While Geoff's success to date has not been perfect, it is darned good! He estimates that about 80% of all audits now incorporate thermal imaging. But while more and more crews are using IR side by side with blower doors, caulk guns, and blowing machines, it is not as widely used as he knows it might be. "I would say the crews at three of our agencies are using IR often, another agency sometimes, and the fifth not much yet," says Geoff, "but if there is good news, it is that the crews are more and more often asking for cameras."

The results Geoff is seeing from the use of thermography are real. Certainly barriers still exist, but more and more auditors and crew members are seeing this as the only way to get their work planned and completed in a timely fashion with results that will pass Geoff's "thermal eye!"

Geoff hopes that other state programs can learn from what is happening in Vermont and apply the technology to their own circumstances. He has no doubt that the investment is already paying substantial returns, and he knows those returns will only continue to increase with time.