Case Study: IEEE 515

How a Standard Boosted Confidence in Electrical Trace Heating ...and Changed the Processing Industry Forever

A Standards Case Study Presented by IEEE

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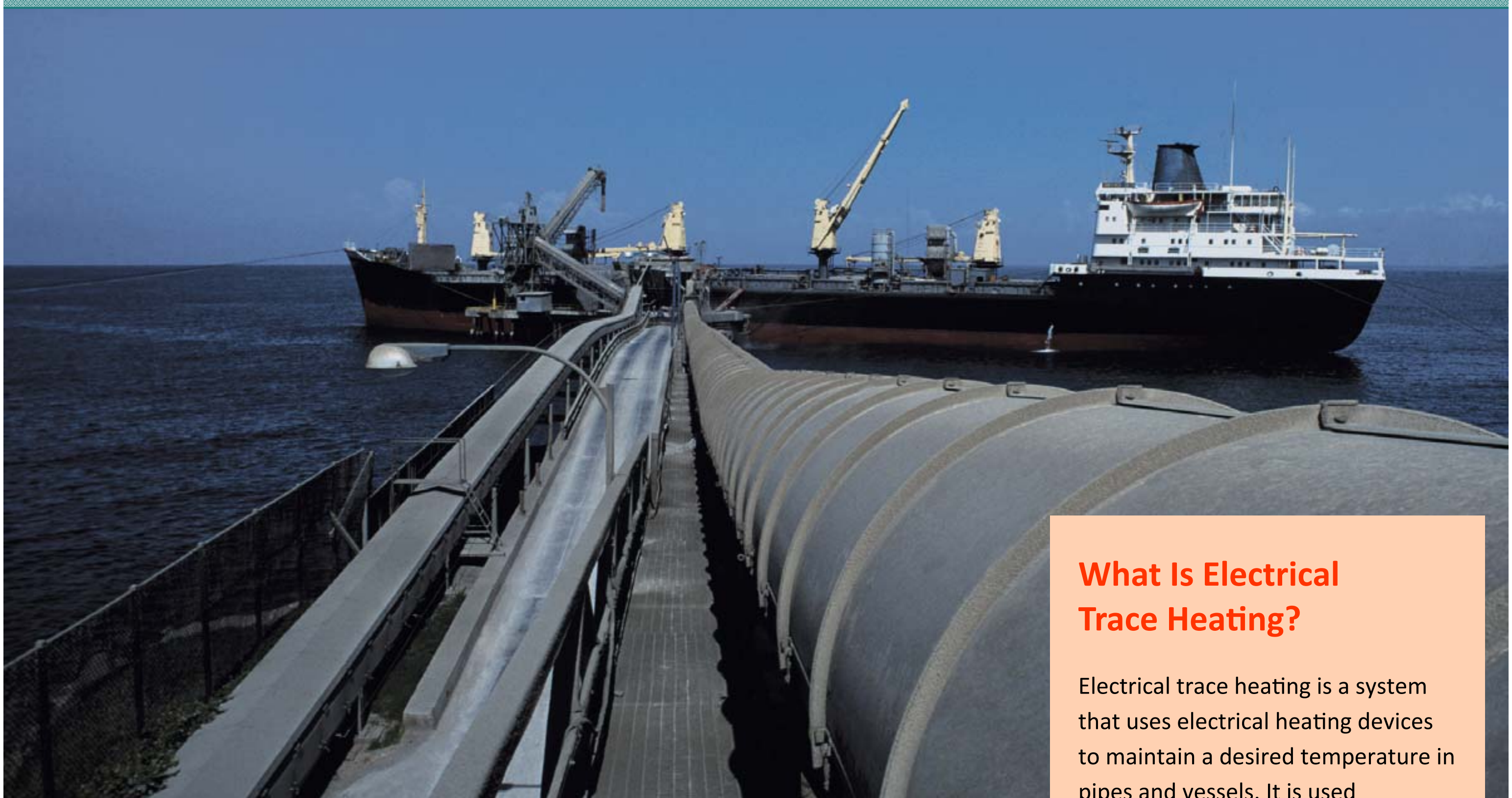


What Is Electrical Trace Heating?

Electrical trace heating is a system that uses electrical heating devices to maintain a desired temperature in pipes and vessels. It is used throughout the process industry, but also has applications in other industries. Trace heating usually consists of an electrical heating element that is run along the length of a pipe. The pipe will be covered with thermal insulation to protect against heat loss from the pipe.

Trace heating materials and systems are used to protect pipes from freezing and also to maintain a desired temperature in pipes that transport materials. Among other applications, it is used to keep snow or ice off railroad tracks, for roof and gutter de-icing, and to protect exposed antennas from accumulating ice that may fall and cause damage to property or people.

Tracing the Growth and Impact of IEEE 515

What do crude oil, lipstick, and beer have in common? They all are products of the process industry and rely on electrical trace heating as part of their manufacture and delivery.

In most process industries today -- from petroleum and chemical -- to food processing -- to pharmaceuticals and power generation -- electrical trace heating technologies help solve the problem of keeping materials flowing at an optimal viscosity regardless of ambient temperatures. Trace heating systems and equipment can be found all over the world, and part of the reason they are installed with extreme confidence and have been relied upon to solve temperature-related challenges is the IEEE 515 standard.

IEEE 515 is the IEEE standard that provides requirements for the testing, design, installation, and maintenance of electrical resistance trace heating in general industries as applied to pipelines, vessels, pretraced and thermally insulated instrument tubing and piping, and mechanical equipment. The electrical resistance trace heating is in the form of series trace heaters, parallel trace heaters, and surface heating units. In this case study we'll look at the history of this standard, how it changed over the years, the impact it has had on industry, and how the push for globalization will change it in the future.

IEEE 515: The Process and the People

We asked volunteers who helped create and revise IEEE 515 about its development and impact on global electrical trace heating applications.

IEEE 515 was developed to help ensure that process, fluid, or material temperatures are maintained and provide electrical, thermal, and mechanical durability to a trace heating system, so that in normal use, performance is reliable and poses no danger to the user or surroundings. Bottom line…if the standard is followed, electrical trace heating systems will be more reliable and safer.

First-Hand Accounts Tell the Story

Standards address economic, political, or technical challenges. In deciphering the factors that led to the development of IEEE 515, we went straight to the source and met with several key people who were instrumental in developing the initial standard and have been involved in revisions to it over the years. We spoke with Ben Johnson, who has spent the bulk of his career at Thermon Industries -- one of the main developers of electrical trace heating products and services. We also spoke with Richard Hulett, who is currently Chair of the working group charged with overseeing revisions to IEEE 515. Hulett recently retired from Thermon Industries, but when he was a member of the initial working group for IEEE 515's development, he was working for Raychem -- then a much larger competitor of Thermon's, also a main provider of electrical trace heating technology. Of course, over the years there have been hundreds of individuals who have played pivotal roles on IEEE 515. The development of a standard is truly an effort of collaboration and compromise.

Why a New Standard Was Needed

In the process industry, many fluids such as oil need to be transported via pipes from one location to another. In order to keep some fluids from thickening or becoming more viscous (which can cause slowdowns or stoppages in production) they often need to be heated to maintain an optimum temperature for flow.

Prior to electrical trace heating systems, steam was used for heating pipes in the process industry as a matter of course. There were, of course, serious drawbacks to steam -- and safety concerns were at the top of the list. In the 60s and 70s, electrical heating was not the first choice -- steam was. But a new technology, electrical trace heating, was becoming available that offered significant advantages. "Steam would certainly do the job, but it was inefficient, and not nearly as flexible and versatile as electrical trace heating -- it just didn't deliver any operating flexibility to these plants that were using it," explains Ben Johnson.

The newer electrical trace heating methods offered many advantages, but initially there wasn't high confidence among users in the process industry to adopt the method -- largely because it was a new product solution, and there were inconsistencies in testing and installation. Hence the need for IEEE 515. A strong standard was needed to help ensure that the products would more consistently and more safely meet the needs of the process industry. A strong standard would improve confidence in electrical trace heating and so improve compatibility and grow markets.

"Compared to steam, electrical trace heating is much easier to design, easier to maintain, and you can be much more precise in terms of controlling the temperature -- which leads to energy savings, too," explains Richard Hulett. "Steam can also leak, so you need water remediation solutions. In steam systems there is always a leak somewhere… so electrical is really a cleaner and better solution," he adds.

What Are Standards?

Standards are published documents that establish specifications and procedures designed to ensure the reliability of the materials, products, methods, and/or services people use every day. Standards address a range of issues, including various protocols that help ensure product functionality and compatibility, facilitate interoperability and support consumer safety and public health.

Standards form the fundamental building blocks for product development by establishing consistent protocols that can be universally understood and adopted. They help facilitate compatibility and interoperability and simplify product development, and speed time-to-market. Standards also make it easier to understand and compare competing products. As standards are globally adopted and applied in many markets, they also fuel international trade.

Standards help ensure the requirements of interconnectivity and interoperability between products and help provide confidence in new products through consistent verification of claims. In summary, standards drive the development and implementation of technologies that influence and transform the way we live, work, and communicate.

Putting Aside Differences

Establishing a New Standard: IEEE 515

Some standards are driven by government requirements, but IEEE 515 was driven primarily by economics and safety concerns. In the case of IEEE 515, the goal was to develop guidance for the safer application and installation of electrical trace heating solutions that would offer economic advantages within the process industry compared to steam heat.

That meant that manufacturers, users, and regulators had to get their arms around the technology, agree on the best testing procedures, and present a standard in a way that these systems could be more safely installed by even those with little experience in trace heating systems.

“You need to have common standards or you get a range of results,” says Ben Johnson. “The one thing the process industry can't tolerate is downtime. Uptime in these industries pushes one hundred percent all the time. So we got the industry together and worked out the standard. There was negotiation, of course, but the common goal is always to keep the industry productive and to support safety.”

Putting Aside Differences

In the development of any new standard, individuals representing many different organizations will all come to the table to address the task of creating the standard. It stands to reason that everyone who participates likely has an interest, and a way they would like to see the standard written. They might want to get an industry off the ground, to impact economics, or to meet a government requirement. But, in reality, there are rules in place so that no one position has full control.

The initial working group for IEEE 515 drew together manufacturers, users, and testing agencies. Were there conflicts during the development of IEEE 515? Of course! All standards require give and take.

"It was certainly a struggle in many ways," says Ben Johnson. "But our approach was not to worry about what the manufacturers might have wanted. Instead, we relied heavily on the input from users, especially in the early versions of IEEE 515. This set the stage for the methodology of what would be used to test the products, and to ensure products were safer and installation procedures were clearer. We wanted to minimize risk…and as a result the industry gained confidence in electrical trace heating solutions."

Forming a Working Group

Step one in standards development is forming a working group of interested individuals with technical understanding and leadership skills who can work together to develop the best consensus solution to the challenge at hand. “If one is forming a working group to do a standard, you want to get users and the major manufacturers together,” explains Richard Hulett. "You solicit their participation, and at the same

How Standards Are Developed?

The process of developing a standard is often facilitated by a Standards Development Organization (SDO), which adheres to fair and equitable processes that ensure the highest quality outputs and reinforce the market relevance of standards. SDOs such as IEEE, IEC, ISO, and others offer time-tested platforms, rules, governance, methodologies and even facilitation services that objectively address the standards development lifecycle, and help facilitate the development, distribution and maintenance of standards. While the goals of each SDO are essentially the same, each SDO applies its own rules, processes, terminology to the standards development process. Find out more about standards at www.standards.ieee.org.

Negotiating a Standard

time you also look for the national testing laboratories or agencies to participate because you want to develop a standard that pulls together what the industry really needs in terms of requirements. And while you might do it in a vacuum, it wouldn't fly… it wouldn't be universal enough. You want everyone at the table."

Negotiating Testing Guidelines in IEEE 515

It took four years to complete IEEE 515, which was first published in 1983 as a recommended practice; and published as a standard in 1997. During those early years, there were many points that needed agreement, and key technical issues that had to be hashed out by the working group.

"As a group, we had to converge on a critical issue: testing procedures," says Ben Johnson. "One of the key elements in delivering electrical trace heating to the petroleum and chemical industry is to ensure that the temperature of the trace heater is not too hot so that it would cause gas or vapor in an explosive atmosphere to ignite. That's the nut we had to crack," he explains.

"When we get our products certified, they of course have to be rugged, sturdy, and constructed of materials that can work in all sorts of atmospheres. That's a given. But a manufacturer also has to demonstrate the ability to predict -- to the satisfaction of safety groups around the world -- that their product will work consistently. You must demonstrate your ability to predict heat tracer maximum sheath temperature in a typical installation configuration -- a pipe sculpture test for example, which is in IEEE 515. It tells you how to run a test so you can verify the predicted sheath temperature ."

Sorting out the best way to test has been a challenge for the group over the decades, as different individuals wanted different testing methods to be followed. Rigorous testing is critical to ensuring that products are reliable. (See page 9 for more details on the testing methods outlined in IEEE 515.)

Confidence Surges

Once IEEE 515 was initially released, its impact was clear and immediate. Users in the process industry began using electrical trace heating systems with great confidence. "The new standard aided in the confidence in using trace heating. Industry didn't have to wonder if it would work," explains Ben Johnson.

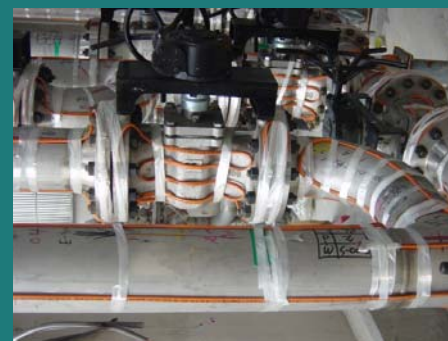
And word spread quickly as confidence in the electrical trace heating technology grew. Within the oil and petroleum industry, new applications surfaced and the results were good. "Take for example oil exploration in the north slope of Alaska," suggests Ben Johnson. "In this application, heating of the oil is key to transportation -- you just have to figure out a solution that will work. With IEEE 515 in place, industry users were able to reliably deliver oil to the world because electrical trace heating was possible, and could be safe."

What Happens When a Standard Is Not Internationalized?

What happens when there isn't an international standard? Just ask any international traveler who has to bring along any number of adapters in order to operate electrical equipment. The standards are different in France, the United Kingdom, the United States, Japan, Australia…and in many more countries.

For many industries, having international standards is important to efficient operations and to reducing costs. A company with plants in several countries might prefer to use similar equipment in similar configurations to streamline installation, training, repairs, and management functions. With a range of standards, the idea of mirror factories in different countries would be an impossible goal.

Applications Spread to Many Industries



Why IEEE 515 Matters...

"The utilization of external trace heating increased exponentially within the oil and gas industry because of the IEEE 515 standard."
-- Ben Johnson, Thermon Industries

"I think that IEEE 515 has forced electrical trace heating factory testing to be more consistent, afforded for better systems design, and assisted with training of design, installation and maintenance persons."
-- Will McBride, Consultant

"IEEE Standard 515 legitimized electrical trace heating — it helped eliminate uncertainty and allowed users to install electrical trace heating, and do it right so trace heating worked reliably and more safely."
-- Richard Hulett, Thermon Industries

"IEEE 515 provided the basis for quality and consistency for electric heat trace products as well as guidance for the design and installation of the products. With these factors confidence was greatly increased for the use of the products."
-- Robert Seitz, Artech Engineering

Confidence Spurs Application Growth

And applications soon went well beyond the oil and petroleum industry -- although this is still a principle user of the technology. Other industries, such as pharmaceuticals, food processing, and even transportation soon saw the advantages of electrical trace heating. Now, there are very few industries that don't use electrical trace heating in one form or another. It is unlikely that this would have been possible without IEEE 515 in place to help ensure that the systems worked well, and could operate more safely.

"There are so many applications of electrical trace heating," says Ben Johnson. "In the cosmetic industry, for example, lipstick has to be kept at even temperatures during production. The pharmaceutical industry uses electrical trace heating in their production facilities. In beer production, the acceptable variance in temperature is very narrow…so there are applications in this business for electrical trace heating, too. And, for the same reasons, the food process industry uses electrical trace heating in the manufacture of soup, chocolate, fats, grease -- everything."

Other examples include using electrical trace heating to prevent ice from forming on the top of skyscrapers -- to help prevent ice from falling on people or structures below. Electrical trace heating is also used to help keep ice from forming on rails in transportation systems in airports. It is used to help keep ice from forming on the wings of airplanes, and it is also used in some newer hotels to increase the efficiency of hot water distribution by heating water on demand -- instead of continually circulating to a boiler.

Manufacturers Experience Broad Growth

What was the impact on manufacturers? A huge increase in demand for electrical trace heating equipment, systems planning, and installation support. Manufacturers' revenue increased more than twentyfold over the decades since the inception of IEEE 515, as they provided their products and support services to help solve more and more problems.

"In the early years of the technology, people passed their knowledge on by apprenticeship (working with other more knowledgeable mentors)," explains Dusty Brown of Emerson General Signal and Co-Chair of the current IEEE 515 working group. "As the global economy started to industrialize, the old way of passing knowledge through direct experience was no longer viable. The development of IEEE 515 as a 'knowledge base' on heat tracing provided a vehicle for the transfer of an industry's worth of knowledge in a single place...preventing newly industrialing societies from having to suffer through the long and expensive learning curve. This results in compression of the time cycle that lifts that society's standard of living."

Globalization of Standards Is Key

Revisions, Revisions, Revisions

No standard remains stagnant. IEEE has rules with regard to revising a standard. That generally means that the minute you have a completed standard, you get to work on either reaffirming the standard or revising it again. Reviews are really an ongoing process… although frequently the individuals involved in working groups might change. Because product and technologies have changed over the years, IEEE 515 has always had a full revision, and never simply been reaffirmed. And, interestingly, many of the people who participated in the initial development of the standard are still involved decades later in subsequent revisions. A detailed timeline of the evolution of IEEE 515 is on page 8.

IEEE 515 Moves Beyond Domestic Influence

One of the major advances over the years is the drive toward globalization of IEEE 515. "IEEE 515 was adopted by industry beyond U.S. borders once it was issued," says Ben Johnson. "For example, corporations in the U.S. that used IEEE 515 in their specifications and requirements would build plants in other parts of the world and they would have these new plants meet the requirements of IEEE 515," he added. Having an international standard is really important to users, especially those with many locations that want to streamline their operations. "Imagine a company such as Shell Oil, that has plants and operations from Houston, Texas, to Alberta, Canada, to Malaysia," suggests Richard Hulett. "With one standard they can design and manage a facility that is very similar, looking to one standard for guidance. This saves on planning, supervision, and maintenance time and of course that saves money, too." Many users without U.S. bases around the globe also became exposed to IEEE 515 by manufacturers and engineering design firms that incorporated the standard into designs or product offerings.

Moving Toward True Globalization

While IEEE 515 is the clear standard for electrical trace heating in the U.S., in other parts of the world there were other electrical trace heating standards. In Europe, many countries looked to the (International Electrotechnical Commission's (IEC) trace heating standard IEC 60079-39 for guidance. And while there were differences in the two standards, there were certainly similarities, too. Over the years, and throughout the revisions to IEEE 515, there have been many changes that pushed the standard toward a more globalized approach. The next step for IEEE 515 will actually be the development of an entirely new standard, and work has already begun. Currently there is agreement that the IEC and IEEE trace heating standards will harmonize in the next few years to create a single global standard for electrical trace heating

A recent meeting of the IEC/IEEE working group in Manchester, U.K. This group is working to develop a harmonized IEC and IEEE standard for electrical trace heating. Many of the participants have been involved in the IEEE 515 standard from the beginning.

Contributing to Standards Development

applications, to be called IEC/IEEE 60079-30. “This joint standard will really benefit users of electrical trace heating,” says Richard Hulett. “We need to prepare for a global marketplace,” says Ben Johnson. “If you are interested in global markets, this is the thing to do!”

"It's fundamentally the same group of people that have already worked electrical trace heating standards before," says Ben Johnson. "But even though we are doing the work together to deliver a joint document, the process for approval from each organization is independent. So when the document is ready to go to a voting process, both the IEC and the IEEE have to approve it. We'll work on any revisions until both groups approve it -- creating a new international standard ."

Benefits of Participating in Standards

When a new standard is developed or an existing one revised, representatives from industry, government, and other groups may participate. Those involved with standards have the opportunity for significant professional growth from the experience. Working on a team with manufacturers, users, testing agencies, government officials, and others provides perspective to the work professionals do and also can lead to revolutionary changes in an industry.

"When you are involved with standards, you get to watch a company or an industry grow. And you work on a team with well respected peers," says Ben Johnson. "It really gives you an insight into the broader aspects of what you might be doing in your job. It will certainly give you a leg up on people who aren’t involved."

What skills do you need to be involved in standards development? "You have to be a great compromiser and be technically competent because those you are working with will be," adds Ben Johnson.

There isn't a particular length of time an individual needs to be working in an industry before making a contribution to standards -- but he or she really does have to be technically grounded before getting involved. A person needs the ability to sway a room, and make a point.

The bottom line is that IEEE 515 was a standard that helped grow an industry and was the result of a lot of work by dedicated individuals who worked together toward a shared goal of boosting confidence in using electrical trace heating.

There are more standards that need to be written and revised though. The door is open for others to get involved and see how their knowledge and experience can help positively impact the world.

Get Involved with Standards Development!

Participating in standards development has great rewards in terms of personal and professional growth. Those with well grounded technical expertise in a field should consider getting involved. Participation in standards development in SDOs is open to all.

A simple way to start is to identify an active project. Visit http://standards.ieee.org to review hundreds of individual and/or corporate standards projects in development. Or, explore lists of working groups that have been developed to prepare and develop standards. All who participate in working groups should have technical expertise, knowledge, and a dedicated interest in the technology being standardized in the standard.

Find out how to participate and make a difference at www.standards.ieee.org.

History and Timeline of IEEE 515

The Evolution of a Standard...

1983—IEEE 515 Published as a Recommended Practice

IEEE 515 was first published in 1983 as a recommended practice to provide guidance that helped users integrate electrical trace heating systems with confidence in results and safety.

1989—First Revision

During the first 5-year review cycle, which took place between 1984 and 1989, a major effort was made at harmonizing IEEE 515 with other North American and European standards. The use of electrical trace heating in locations where an ignitable gas or vapor can exist under normal conditions, Class I Division 1 applications, was also addressed.

1997—Second Revision

In 1997, IEEE 515 was elevated to a standard. The standard was expanded to include American classified zone heaters. A 32-week benchmark test was also added to provide a thermal shock cycling test. This test established a minimum performance criterion for new products, offered a system to validate product temperature ratings claimed by manufacturers, and provided a minimum acceptable level of quality/performance by the heating devices.

2004 – Third Revision

The 2004 revision added a 12-week temperature cycling test as an alternative to the 32-week benchmark test. This revision also aligned the tolerance on sheath temperature for T-ratings with IEC 60079-30. (IEC 60079-30-1:2007 [B15]a and IEC 60079-30-2:2007 [B16]).

2011 – Fourth Revision

The 2011 revision included subsequent harmonization with international standards and expanded the sections on maximum sheath temperature determination and design.

What's Next? A Jointly Developed International Standard: IEC/IEEE 60079-30

Over the next several years, those involved with IEEE 515 are working together with the IEC (International Electrotechnical Commission) Technical Committee 31 (TC 31) to develop a new standard that harmonizes IEEE 515 with IEC 7930. The new IEC/IEEE 60079-30 standard will take a large step closer to internationalization and open the door to increased global integration of products and systems.

Read a Standard...

One of the best ways to learn about the impact of standards is to read one!

IEEE Standard for the Testing, Design, Installation, and Maintenance of Electrical Resistance Trace Heating for Industrial Applications

IEEE Industry Applications Society

Many universities have an agreement with IEEE to access and download standards via IEEE Xplore. Explore the many standards related to the field you are studying. Download IEEE 515 to get a better grasp on the technical aspects of the standard and its key components.

A standard usually includes an overview, key definitions, and a listing of those who participated in the development of the standard. In the case of IEEE 515, it also includes sections on general product testing, marking and installation instructions, design, and maintenance.

Visit http://ieeexplore.ieee.org and search, download, and read a standard!

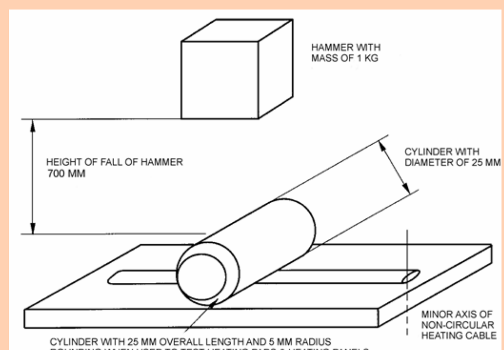
Testing Guidelines in IEEE 515

Rigorous Tests Lead to Reliable Products

The type test for electrical trace heating product certification is rigorous and is aimed a providing rugged and reliable products. The following provide details on some of the many types of tests outlined in IEEE 515.

Type Test: General Purpose

- **Dielectric test:** verifies adequate dielectric material in construction and spacing in connections. This test is performed on initial construction sample and after mechanical loading and exposure tests.
- **Insulation resistance test:** measures electrical leakage in insulation system and fittings. Increased electrical leakage may occur when moisture penetrates the electrical insulation or connections.
- **Water resistance test:** a 2-week water immersion test verifies that the trace heater dielectric jacket will not absorb moisture, weakening it to the point an electrical short can occur. Rain may leak into thermal insulation lagging and can create a moist environment for trace heaters.
- **Integral components resistance to water test:** connections/components mounted beneath the thermal insulation are subjected to thermal shock and repeated water immersion to verify that they are resistant to water entry if subjected to a moist/wet installed environment.
- **Elevated temperature exposure dielectric test:** a 4-week exposure to 20 degrees C above the highest temperature declared provides an indication of the ability of the dielectric jacket to meet its temperature ratings. If not suited for those ratings, the jacket will become brittle. That will cause cracks in the jacket, providing paths for moisture ingress and eventual electrical shorts.
- **Deformation test:** this test verifies that the trace heater has adequate strength to withstand someone stepping on the heater or a ladder being leaned against it after installation on the pipe or vessel.
- **Impact test:** this test determines if the heater can withstand the impact of a wrench or tool being dropped on it after installation without damaging the product. See diagram to the right.



- **Cold bend test:** this test verifies that a trace heater can be bent to its specified minimum bending radius at minimum installation temperature. Materials get harder and stiffer at lower temperatures; this test verifies that the product can be installed at minimum stated temperatures without damage.
- **Flammability test:** this test measures the trace heater's combustibility and ability to not propagate flame.
- **Verification of rated output test:** establishes standard protocols for measuring the power output of trace heaters.
- **Verification of start-up current:** self-regulating trace heaters and some alloy trace heaters can have high start-up currents that can cause breaker tripping if not properly addressed. This test verifies the manufacturer's stated start-up current for circuit breaker sizing for all heating products.
- **Thermal performance benchmark test:** determines power output stability at maximum temperature exposure conditions for parallel trace heaters. Poor quality zone or self-regulating trace heaters can lose significant power output when cycled at maximum rated temperatures. This test establishes benchmark parameters for maximum temperature ratings and power output performance.
- **Verification of braid or sheath conductivity:** verifies vendors' published conductance and that braid coverage is at least 70% of the surface area. The percentage of coverage determines whether a small object such as a nail or screw can penetrate the braid through the electrical jacket without creating an electrical short that would trip a ground fault breaker. Too high a coverage percentage can make the braid hard to terminate.

Type Test: Verification of Sheath Temperature

Maximum trace heater surface temperatures must be determined for products installed in classified hazardous areas to verify that auto ignition temperatures (AIT) of explosive gases or dust are not exceeded.

- **The system method test:** the "system method" is used primarily for constant wattage heat tracers to verify the manufacturer's predicted maximum sheath temperatures in a specific application.
- **Product classification test:** the "product classification method" is used primarily on self-regulating heat tracers to establish a maximum unconditional sheath temperature that can be marked on the tracer.

Some content on this page adapted from IEEE 515.