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Technical Data Bulletin

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H-700T Radiant Heat Temperature Testing

Description

A comfortable hard hat is especially desirable where elevated temperatures can exist, such as in metal working facilities, foundries, and other high heat manufacturing environments. Temperature sources can range from low 1000's °F (538 °C), such as in aluminum and aluminum alloy processing, to greater than 6192 °F (3422 °C), such as in tungsten processing. The energy from these heat sources can be transferred through conduction, convection, and radiation.

- Conduction heat transfer occurs via direct molecular collision, otherwise known as contact heat.
- Convection is heat transfer through the movement of fluids, such as hot air from a furnace.
- Conduction and convection burn hazards can be somewhat mitigated with proper engineering controls and worker positioning.
- Radiation is unlike convection or conduction and involves electromagnetic waves to transfer energy as thermal irradiation. Electromagnetic waves disperse in all directions, fall off very quickly with distance, and are hard to avoid when working directly or indirectly with these applications.

Notwithstanding the extreme potential levels of heat in various workplaces, most workers have been found to experience radiant temperatures below 400 °F (204 °C) while on the job in actual field observations. As a result, 3M has evaluated the performance of the 3M H-700T in radiant heat exposure in a laboratory environment comparable to observed conditions. This Technical Data Bulletin details the results of that testing.

Scope

Many of the elevated temperature hard hats on the market today range from 302 °F (150 °C) to 500 °F (260 °C). Human factors connect the hard hat temperature rating to the high heat sources through discomfort/pain, working distance, and exposure time. The distance and time at which the work is being done must be far enough away and at a short enough exposure time for the user to be able to perform with heat reflecting apparel. Exposing the human skin to hot water at 156 °F (69 °C) can cause third degree burns in 1 second.[1] Hard hats and face shields are typically among the PPE positioned between the user and the heat source, thus receiving more heat exposure. Temperatures can often be elevated quite a bit above the aforementioned hot water temperatures before the user notices the heat on the head behind the hard hat or face shield.

In these high heat applications, the main source of heat is often projected onto the user through thermal irradiation. Hard hats are tested to International Safety Equipment Association (ISEA) American Nation Standards Institute, Inc. (ANSI) Z89.1 for Industrial Head Protection standard, where it undergoes upper temperature testing at 120 °F (49 °C). As an optional High Temperature (HT) rating, hard hats are conditioned to 140 °F (60 °C) prior to testing.[2] For demanding environments exceeding 140 °F (60 °C), the standard provides no guidance or ratings. To address elevated temperatures, a modified National Fire Protection Association (NFPA) 1977 70E section 7.2.2 and 7.2.3 is used to demonstrate the integrity of a hard hat after it has been exposed to radiant temperatures.

H-700T Testing

The NFPA 1977 70E sections 7.2.2 and 7.2.3 were used to evaluate helmets comprised of GF Nylon 66 (15%) for impact/penetration after being exposed to a radiant heat transducer at an irradiance of 1.0 ± 0.1 W/cm² for a specified length of time. The impact and penetration test was modified to be mounted after conditioning, but still impacted within 15 ± 5 seconds. The impact and penetration tests were conducted per ANSI/ISEA Z89.1-2014 Standard for Industrial Head Protection. The temperature selected for this experiment was 400 °F (204 °C). The time required for the transducer to reach the specified temperature was 1 minute, +5/-0 seconds.

Under similar testing concepts, a second test was conducted to evaluate repeated exposure of hard hat material test bars to radiant heat cycling to help determine long term effects under those conditions. Using a constantly rotating belt, the test bars underwent temperature cycling in a radiant/convection heat oven at the following conditions to demonstrate the integrity of the hard hat after multiple exposures:

- 1 minute oven timing
- 375 °F (190 °C) at the point of exit
- Samples were tested every 2,500 cycles (representing 250 work days per year, with 10 exposures a day) and compared using mechanical simulation modeling.
- Materials were tested to 20,000 cycles

In addition to these laboratory tests, non-human field tests were performed in two foundry facilities. To determine effect on the hard hat in an actual working environment, samples were placed closer than any workers could be placed under workplace safety protocols to streams of molten metal for approximately 5 minutes, under normal operations. The samples had to pass inspection as indicated by the *User Instructions*.

Results/Conclusion

3M™ Hard Hat H-700T, made of GF Nylon 66 (15 percent), passed the 400 °F (204 °C) modified impact/penetration tests performed. Radiant heat temperatures can rapidly surge or decline with small changes in distance. Keeping the worker's safety and extreme work environment in mind, the hard hat was given a supplemental temperature safety window of +25 °F or +14 °C, and rated to 375 °F (190 °C), instead of the tested 400 °F (204 °C). The H-700T 20,000 heat cycle material testing and simulation also demonstrates the durability of the material in those conditions. Additionally, the hard hats subjected to the environmental conditions in the foundry sites passed the visual inspection described in the user instructions.

References

1. http://www.burnfoundation.org/programs/resource.cfm?c=1&a=3
2. ISEA/ANSI Z89.1-2014 American National Standard for Industrial Head Protection

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