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Foreword

In the 1980s, ASTM published two standards, ASTM C1055 and ASTM C1057, that outlined a process to determine acceptable surface temperatures for heated systems in relation to personnel protection. These standards defined the hazards for burns to human skin, provided certain criteria to be used in these determinations of acceptable surface temperatures, and provided maximum allowable skin temperatures for defined burn risks.

For purposes of personnel protection, the generally accepted temperature limit for metallic surfaces on piping and equipment is 60 °C (140 °F) for a maximum touch time of 5 seconds. Hot surfaces with temperatures greater than 60 °C (140 °F) in areas accessible to workers are typically insulated or personnel protection is provided. This criterion often cited by field personnel regardless of the type of material of which the hot object is made. However, these limits generally only apply to metals. Materials with lower thermal conducting properties such as insulation coatings can be touched at higher temperatures without burning the skin (ASTM C1055, ASTM C1057, NACE TM21431, ISO 13732-1, and Reference 1). The method for determining surface temperature limits of any material is established in ASTM C1057 Method B, using a thermesthesiometer (TM).

In this standard, several types of temperatures are mentioned and are explained here to prevent confusion. There are three types: the substrate metal temperature of a heated test panel, the outer surface temperature of an insulation coating on top of the hot test panel and the skin temperature simulation as determined with the TM probe in contact with the surface of the insulative coating.

A summary of this test method is as follows: Test panels with various thicknesses of insulative coating are heated to various metal substrate temperatures. After equilibration, the TM probe is placed onto the surface of the insulative coating to determine the simulated skin temperature for each combination of thickness and substrate temperature. From the skin temperature readings, the maximum substrate temperatures can be determined for that insulative coating at various thicknesses. The maximum substrate temperatures can then be graphed to determine the minimum insulative coating thickness required, in the range of substrate temperatures tested, to be in compliance with personnel protection requirements.

The TM is an electrical instrument used to simulate the touch temperature response of the human skin when it comes into contact with a heated surface. The TM instrument uses a special thermal probe that simulates the human skin. The probe is placed onto a hot surface to determine the “skin temperature” after a given contact time, which in this standard is specified as 5 seconds. The TM is a relatively simple and inexpensive instrument and consists of a data logger, thermesthesiometer and thermal probe. The readings taken by the TM should not be confused with the surface temperature of the object being tested. The TM does not determine surface temperatures. It only simulates what the skin temperature will be after contacting a hot object for a given duration of time. Hot metallic objects with very high thermal conductivities, densities and specific heat capacity will conduct heat to the skin very quickly, thereby raising the temperature of the skin rapidly. Objects with low thermal conductivities, densities and specific heat capacity (as for insulative coatings) will conduct heat to the skin at much slower rates, reducing the potential to burn the skin.

ASTM C1057 states that users must make two choices when determining temperature limits of materials for personnel protection requirements: the maximum acceptable injury level and the duration of the contact time of the skin in contact with a hot object in question. The maximum acceptable injury level typically used in industry and specified in this standard is a first-degree burn. The contact time typically used in industry and also specified in this standard is 5 seconds. The temperature limit recommended in ASTM C1057 for a simulated skin temperature reading with a thermesthesiometer is 58 °C (137 °F) for a contact time of 5 seconds. At a skin temperature of 58 °C (137 °F), the skin is just beginning to experience a first-degree burn. To put this in perspective, a metal surface at a temperature of 60 °C (140 °F) will give a thermesthesiometer reading of about 58 °C (137 °F) after a contact time of 5 seconds. Depending on the insulation value of an insulative coating, its surface temperature can go significantly higher than 60 °C (140 °F) before the skin temperature simulation reaches 58 °C (137 °F) after a 5 second contact time.

As stated in the Scope of this standard, the temperature limits of insulative coatings used for personnel protection depend primarily on the coating thickness and the substrate metal temperature. But this temperature limit also depends, to a lesser extent, on the wind speed over a hot surface and the ambient temperature that the hot object is exposed to. It is the intent of ASTM C1057 to use worst-case conditions when evaluating skin contact temperatures from heated surfaces. With decreasing wind speeds, the surface temperature of a hot object is increased, resulting in a lower substrate

temperature limit. Therefore, a near-zero wind speed is a worst-case scenario and this standard specifies a near-zero wind condition during the TM testing.

Increasing ambient air temperature has the effect of increasing the surface temperature of the insulative coating. Increasing ambient temperatures results in higher minimum coating thickness requirements for personnel protection. The worst-case scenario for ambient temperature might be considered to be 38 °C (100 °F), but this will depend on the climate and temperatures of surrounding equipment. Therefore, it is difficult to standardize a temperature for ambient temperature conditions to be specified in this standard. In addition, this standard would become burdened by a much greater number of tests if different ambient temperature conditions were added to the test matrix.

With that in mind, a single temperature (21 °C, 70 °F) was chosen as the ambient temperature test condition. To cover worst-case situations where equipment is exposed to ambient temperatures at 38 °C (100 °F), users of this standard may specify additional testing at this ambient temperature. As an alternative, recent anecdotal testing on acrylic-based insulative coatings has shown that a simple addition of approximately 10% more coating thickness can be specified to keep the coating's ability to provide the necessary degree of personnel protection for ambient temperatures at 38 °C (100 °F), as set forth in ASTM C1055 and C1057.

Insulative coatings are often used to provide effective burn protection when applied to hot equipment or piping. As part of an anti-corrosion system that uses a corrosion protective primer, these coatings also provide corrosion protection and eliminate corrosion under insulation (CUI) because the primer and insulative coating combination bonds directly to the steel substrate. Other insulation materials (e.g., block and fiber insulation) have air gaps between the metal and the insulation where water can ingress. The hot/moist condition in these gaps is a common cause of CUI.

Insulative coatings can be made of organic, inorganic or hybrid binders. The maximum service temperature limit for the organic-based coatings is approximately 177 °C (350 °F) with thicknesses that range from 1 to 5 mm (40 – 200 mils). For inorganic and hybrid coatings, the temperature limit is significantly higher and may be significantly thicker.

Scope

The purpose of this AMPP test method is to standardize the testing methods and conditions used to determine the substrate and surface temperature limits for different thicknesses of insulative coatings used for personnel protection to be in compliance with ASTM C1055. The temperature limits determined when using this test method are specific for each coating tested at a particular thickness and substrate temperature. A standardized test method can validate the temperature limits of a coating used for personnel protection and enable direct comparison of its performance to other commercially available coatings. This test method is intended for use by facility owners, engineers, health and safety specialists, coatings manufacturers, and other interested parties.

Rationale

This document standardizes the test procedures to determine the substrate and surface temperature limits of insulative coatings. From these temperature limits, the minimum coating thickness can be determined for the coating to be in compliance with requirements for personnel protection. In this latest version of this revised standard, there are numerous grammatical revisions to the text and revisions to the text to make the procedures more clearly stated. Certain paragraphs were reordered to show more clarity as to when certain procedures are performed. There were also minor modifications to a few procedures to make them more accurate or to simplify the procedure.