PREFACE

Traditionally there are two types of heat detectors: fixed temperature and rate-of-rise. There may be circumstances where neither of these methods is optimal and another method is needed. The Fenwal Controls rate-compensated heat detector has unique characteristics that may make it ideal in your situation. This document explains the principles of the Detect-A-Fire ® (D-A-F) rate compensated heat detector.

Fixed Temperature

Fixed temperature devices activate when the entire detector unit is completely heated to the operating temperature. Under fast rate fire conditions and sudden temperature rise, there could be a lag in response time before some types of fixed temperature detectors have fully heated and activate.

Rate-of-Rise

Rate-of-Rise devices activate when ambient temperature increases at a predetermined rate (typically 15°F per minute). False alarms can happen when there is a sudden rush of heated air such as the rush of warm air from process ovens when doors open. These types of devices may also fail to activate if there is steady but slow rise in heat below the 15°F per minute rate, such as in a smoldering fire.

Combination Fixed & Rate-of-Rise

A combination of both technologies can also be unreliable. An example of this would be if you had a temperature increase of 10°F per minute. This would be slow enough to not trigger the rate of rise activation and still be fast enough to cause a lag in activation.

Rate Compensated

Rate compensated devices such as the D-A-F act as a fixed temperature device that compensates for both ambient temperature changes and fast rate-of-rise situations. This design allows the detector to “anticipate” fire conditions and thus activate before the fixed temperature is reached in a fast fire. The functionality of the detector is generally not affected by transient temperature changes when being installed in typical outdoors environments where the temperature can vary from extreme cold to warm and will reliably activate at it’s designed fixed temperature.

PRINCIPLES of OPERATION

Design

The D-A-F's inner assembly has silver electrical contacts that are mounted on, but electrically insulated from, two curved struts which have a low coefficient of expansion. This assembly is mounted under compression inside an outer stainless-steel shell which has higher coefficient of expansion than the inner struts. The unit is then calibrated and hermetically sealed at the factory.

Figure 1 – Cutaway of Typical D-A-F

Operation

The inner struts and the outer shell expand at different rates, this creates two variables that affect when the contacts will mate and activate the detector. An increase in temperature causes the shell to expand decreasing compression on the struts bringing the contact closer together. That same increase in temperature on the inner struts causes them to expand and become farther apart.

In a very slow rate of rise condition, about 1°F per minute, the unit heats up evenly throughout. This results in both the shell and internal strut assembly expanding to the point where the unit operates close to its set point temperature.

In faster rate of rise conditions, the outer shell expands faster than the internal strut assembly. This causes the anticipation or rate-compensation effect allowing the detector to activate even though the temperature may be below the set point.

The D-A-F detectors are optimized to work in situations where the rate of rise is between 10°F and 40°F per minute. An increase in heat greater the 40°F per minute is usually classified as explosive.

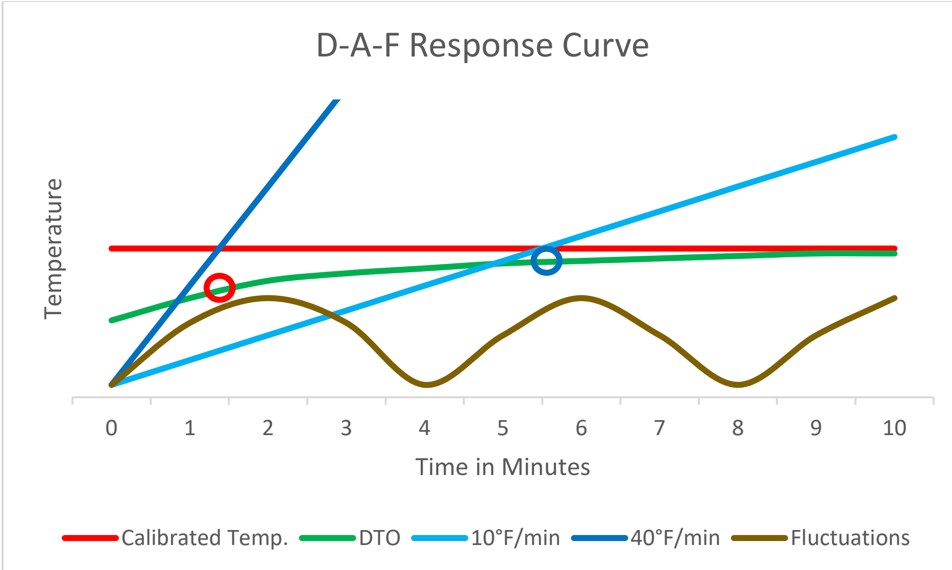

Figure 2 – Response Curve

D-A-F Response

In figure 2, the red line represents the calibrated temperature of the D-A-F. The dark blue line is a temperature rise of 40°F/min while the light blue line is a rise of 10°F/min, most typical fires fall within this range. The green line represents the device temperature at operation (DTO) which you can see is lower than the calibrated temperature as part of the rate compensated design. The faster the rate of rise, the lower the temperature the D-A-F activates.

In reviewing figure 2, you can see that in a rate of rise condition of 40°F/min, that the D-A-F is activating approximately 10% below the calibrated activation temperature (noted by the red circle). The D-A-F activates in anticipation of the activation temperature because the surrounding air heats faster than the internal strut assembly of the D-A-F.

Additionally, in reviewing figure 2, you can see that in a rate of rise condition of 10°F/min, that the D-A-F is still activating below the calibrated activation temperature (noted by the blue circle). The D-A-F is still anticipating the activation temperature but by a smaller percentage because the internal strut assembly of the DAF more closely matches the air temperature.

The brown line in figure 2 represents fluctuations in air temperature that can be caused by exposure to the sun or heat from an oven door being opened. A typical rate of rise detector may activate due to the sudden change of temperature, but the D-A-F will not activate if the temperature is safely below the calibrated activation temperature. Fenwal Controls recommends the activation temperature to be 100°F above the normal maximum ambient temperature.

Calibration, Verification, and Testing
At the factory, calibration of the D-A-F starts by placing the uncalibrated units into a temperature controlled heat block and preheating them at the calibration set temperature for 45 minutes. The system then performs an initial setting to the calibration temperature. The units are then “burned-off” by sending a 10A current at 24VAC through the electrical contacts for 6 cycles of open and close of the circuit, this cleans the electrical contacts inside the D-A-F. The units are then calibrated to the set temperature of the heat block and allowed to cool off to room temperature.

Verification of the D-A-F calibration is completed in a separate automated test system that utilizes a single station aluminum heat block for each unit. The power to the heater internal to the heat block is controlled by the switch contacts of the unit itself and monitored electronically though the automated test system. The power to the heater is set dependent on the unit’s set temperature in order to achieve the ideal “50% on - 50% off duty cycle”. This means that the block’s heat and cool cycle is measured to be the same time with the unit heating up and cooling down at roughly the same time interval. This process is repeated 10 times to stabilize the product and then another 5 times for the official verification of calibration. The final 5 actuation temperatures are then recorded and the average of the 5 readings is then compared to the set temperature and required tolerance. If the unit is outside the required tolerance, the D-A-F is rejected. The final 5 actuation temperatures are also compared from cycle to cycle for repeatability. If the cycle temp varies by more than 3 degrees from one cycle to the next cycle, the D-A-F is rejected.

Note: It is important to know that heat transfer varies by medium and using air or oil will provide different results then the aluminum block used at our factory.

Since it is difficult to test in a manner similar to the factory, we recommend when testing to always ensure that you are heating slower than the 1°F per minute or your results will be affected by the anticipation factor of the D-A-F.

FENWAL CONTROLS

Fenwal Controls, Kidde-Fenwal Inc.
400 Main Street
Ashland, MA 01721
Tel: 800-FENWAL-1
Fax:508-881-7619
fenwalcontrols.com