



WHITE PAPER

Nest Protect Steam Check Study: Results from November 2013 to May 2014

Nest Labs, Inc.
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Introduction

In October 2013, Nest launched Nest Protect: Smoke + Carbon Monoxide™, a combination smoke and carbon monoxide (CO) alarm designed to give people the information they need to stay safe. As an Internet-connected alarm installed in hundreds of thousands of homes, Nest Protect can report detailed, anonymous data from the smoke and CO events that it detects. Nest Protect also contains many different sensors. In addition to a smoke sensor and a CO sensor, Nest Protect also has a humidity sensor and a heat sensor. This means we can understand more about the conditions near the alarm.

Using this information, Nest developed a new feature called Steam Check, which helps reduce the number of nuisance alarms caused by steam from a bath or shower - or a boiling pot of water. This is just one example of how Nest learns from real data to improve our products. Because Nest Protect has the ability to perform automatic software updates over WiFi, unlike any other on the market, this feature will be available for both new and existing devices.

In this white paper, Nest shares statistics surrounding steam-related events as well as what happens when Steam Check is turned on. Highlights from this report include:

- 14% of Nest Protect alarm events are steam-based.
- A steam-based event is approximately three times more likely to occur in the morning between 6 a.m. and 9 a.m. than in the evening between 5 p.m. and 8 p.m.
- The majority of steam-based alarms occur on devices labeled as Upstairs or Hallway.
- Steam Check is expected to reduce the rate of nuisance steam alarms by 57% - without reducing fire sensitivity.

The analysis reported is based on hundreds of thousands of aggregated units in the field. All field data is anonymous, and no information about individual users is shown or discussed. This white paper is presented for informational purposes only to describe a new feature offered by Nest.

How Nest Protect detects steam

To develop Steam Check, Nest tested and recorded steam-generated alarm incidents in the lab as well as in real home settings. We produced steam using showers, baths, running water, and cooking-related activities. For bathroom tests, the alarms were placed both inside the bathroom and immediately outside the bathroom. During kitchen tests, the alarms were placed as

recommended by the [National Fire Protection Agency](#) (NFPA) - at least 10 feet (3 m) away from any appliances such as stoves, ovens, toasters, etc.

Statistics and machine learning were used to identify the difference between steam-related events and real fire or smoke events. After quantifying the precise differences between steam-related events and fire or smoke events, we developed an algorithm to detect the events only related to steam and to suppress nuisance alarms, while keeping exactly the same level of sensitivity for fire and smoke events.

With Steam Check enabled, Nest Protect continues to meet the safety standards required for certification in the US, Canada and the UK set by:

- [Underwriters Laboratories Inc.](#) (UL)
- [California State Fire Marshal](#)
- [Canadian Standards Association](#)
- [British Standards Institution](#) (BSI)

Results of the study

Using anonymous aggregate data available from November 2013 to July 2014, we found alarm events that matched the signature recorded in our steam testing but that appeared significantly different from real fire and smoke events. A survey sent to a select group of customers to confirm the nature of their alarm event confirmed a high correlation to our expectations.

Frequency of steam-based events

During the period examined, 14% of alarm events in the field contained a steam signature. 59% of devices that had steam-based nuisance alarms had no other causes to alarm during the period of this study. Furthermore, devices that experienced at least one steam-based event often experienced additional steam-based incidents: 36% had more than one, and 9% had five or more, with a maximum number of 41 steam-based events seen by a single device. The frequency of repeated steam-based alarms is shown in Figure 1 as a percentage of the total device population.

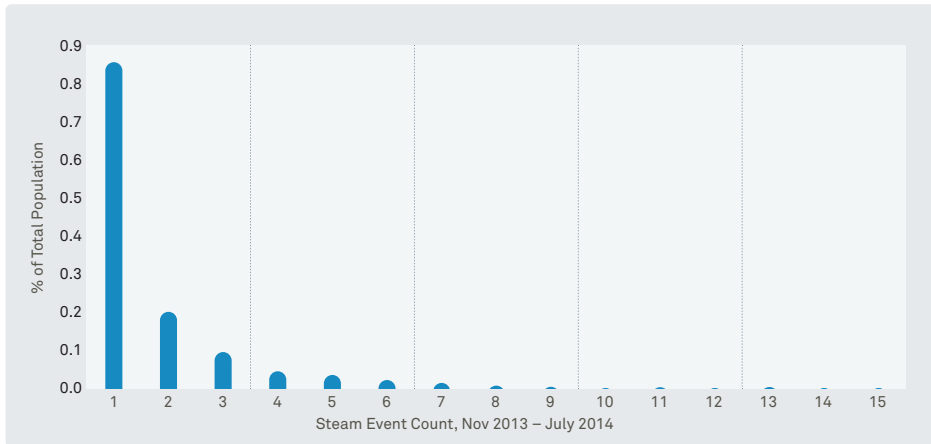


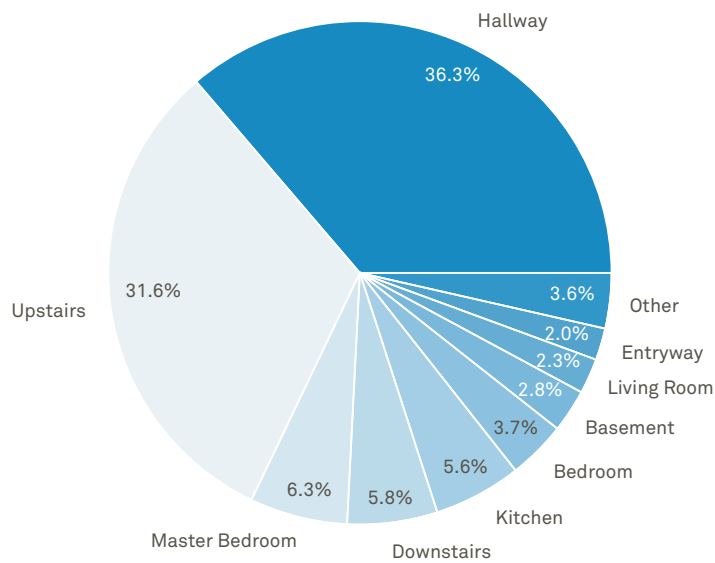
Figure 1: Repeated steam event frequency

Location of steam-based events

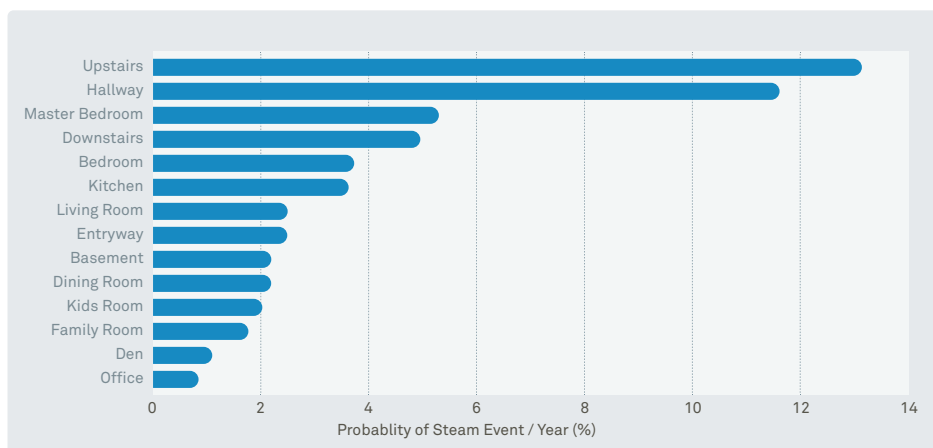
The Nest app allows customers to specify a location name for their device. Figure 2a shows the frequency of steam-related events based on the device location. Nearly 70% of events identified as having a steam signature occurred on devices named "Upstairs" or "Hallway", with a significantly lower percentage of steam based events happening elsewhere in the home. In Figure 2b, the frequency of steam events has been normalized by the total number of devices with each location label. On average over a one year period, 13.2% of devices named "Upstairs" and 11.7% of devices named "Hallway" experienced a steam-related alarm.

Time of steam-based events

There was a strong trend in the time of day steam events occurred. Figure 3a shows the frequency of all alarm events by time of day, with the majority occurring during the evening. However, the time of day at which steam-based events occurred shows a markedly different distribution, as seen in Figure 3b. Steam events occurred primarily in the morning, between 6 a.m. and 9 a.m., with a second, lower peak occurring in the evening between 7 p.m and 10 p.m. After combining the frequency of all alarm events with the frequency of steam events, Figure 3c shows the percentage of alarms each hour of the day that were steam-related. In the mornings, between 6 a.m. and 9 a.m., over 25% of all alarms were steam-based. This is in sharp contrast to the evening period between 5 p.m. and 8 p.m., when less than 8% of alarms were caused by steam.



(a) Steam event distribution by room

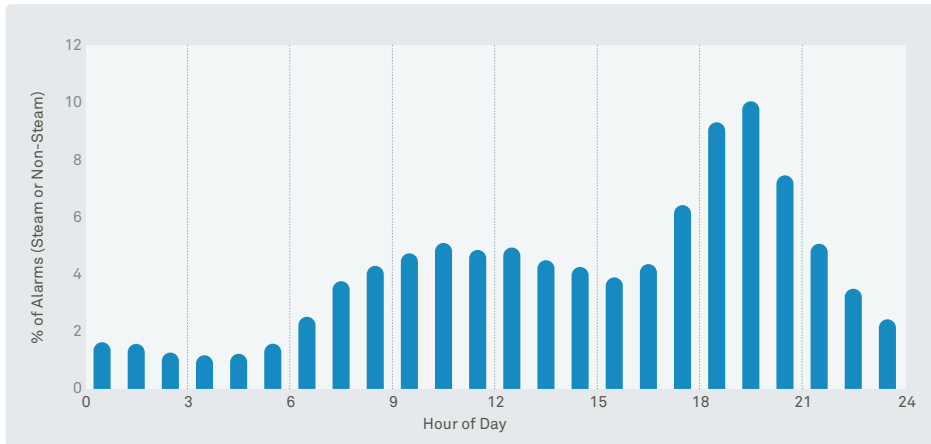


(b) Steam event distribution by room, normalized by number of installed devices

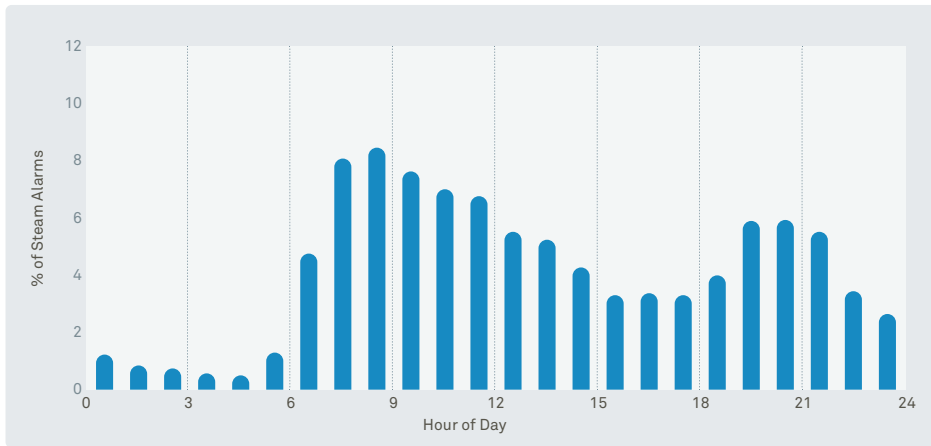
Figure 2

Evaluating Steam Check

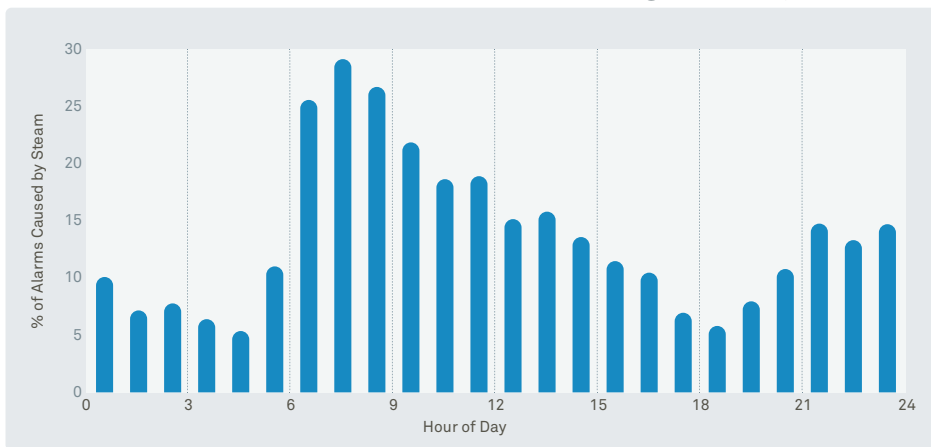
During the occasions when the smoke sensor detected an event identified as having the steam signature, Nest Protect sounded Heads-Up or Alarm 89% of the time, while the remaining 11% stayed below the required thresholds. By simulating the Steam Check algorithm on this data, we evaluated the performance of the new algorithm. With Steam Check active, only 38% of these steam-related events led to a Heads-Up or Alarm. This represents a 57% reduction in nuisance alarms. We tested the algorithm in real homes, and the performance matched our simulated results. This performance was achieved without altering the Heads-Up and Alarm rate for real smoke events, including those specified in the relevant product safety standards in the US, Canada, and the UK.



(a) Distribution of alarms throughout the day



(b) Distribution of steam-based alarms throughout the day



(c) Percentage of alarms each hour that were caused by steam

Figure 3: Alarm frequency by cause and time of day

Conclusion

Steam can trigger recurring false smoke alarms. That's why Nest developed an algorithm to tell the difference between steam-related events and real fire or smoke events.

Steam Check is a conservative feature, and it won't suppress all steam-related events. If the signature from the event appears similar to real smoke or fire, even if the event itself is caused by pure steam, the alarm will sound.

At Nest, we hope to continue improving the smoke detection experience by working with customers and taking a data-driven approach. To contact Nest about the results of this white paper, please email firesafety@nest.com.