Catching up with *Runaway* Hot Plates

Kimberly Brown[1], Mark Mathews[2], Joseph Pickel[3]

1- Office of Environmental Health and Radiation Safety University of Pennsylvania, Philadelphia, PA
2- Environmental Safety and Health Directorate, Oak Ridge National Laboratory, Oak Ridge TN
3- Physical Sciences Directorate, Oak Ridge National Laboratory, Oak Ridge TN

Recent Events with Malfunctioning Hot Plates

Several research institutions report safety events involving hotplates that have been left on and unattended or that have heated uncontrollably, *sometimes resulting in significant damage in the process.* Some of the known events are listed below:

- **June 29, 2005:** Lawrence Berkeley National Laboratory — A laboratory hot plate's power switch failed, resulting in a fire in the fume hood. Although the switch position, switch detent, and indicator light demonstrated that the power was off, electrical power continued to flow to the heating elements. (http://www2.lbl.gov/ehs/Lessons/pdf/FinalHotPlateLL.pdf)
- **April 2007:** University of California — Following a March 2007 report of a malfunctioning hot plate that heats while in the 'off' position, UC EHS personnel send out a system wide message concerning the issue citing "several explosions or fire events involving defective hot plates that resulted in injuries to laboratory employees or damage to laboratories" over the previous five years. (http://ehs.ucr.edu/laboratory/hotplatesafetyadvisory20110715.pdf)
- **March 31, 2011:** University of Pennsylvania — A fire in Clinical Research Building occurred when the heating function of the hot plate was turned on instead of the stirrer, causing a fire in a fume hood (details at http://www.ehrs.upenn.edu/programs/labsafety/alerts/)
- **May 12, 2012:** University of Pennsylvania — A fire occurred in Chemistry 1958 when a hot plate was left on and ignited combustible materials in the laboratory
- **April 20, 2014:** Oak Ridge National Laboratory — A runaway hot plate leads to hood fire and significant damage to a chemical research laboratory.
- **July 2014:** University of Pennsylvania — A Chemistry graduate student entered the lab in the morning and found that his fume hood was on fire. The fire originated from a hot plate that was left plugged in overnight but was reportedly not turned on or being used for any experiment at the time. The suspected cause was a malfunction of the Corning model PC-320 hot plate, which may have spontaneously heated to maximum temperature
- **January 2015**: Oak Ridge National Laboratory — A hot plate in a glove box was observed with the "Hot Surface" light on while the hot plate controls were in the "off" position.
- **March 2015:** University of Pennsylvania — A graduate student in the Chemistry Department reported that her Corning PC-420D hot plate unexpectedly heated to high temperature while the heat dial was in the 'off' position.
- **January 2016:** University of Pennsylvania — A graduate student reported that her Corning PC-420D hot plate unexpectedly heated to high temperature during an attended operation. The temperature was being monitored by both a thermocouple probe connected to the hot plate and an analog thermometer. The temperature of the hot plate spontaneously spiked beyond the target temperature of 80 C, causing a small fire, which was quickly extinguished.

These are just a few of the reports we have heard— events have also been reported by University of Delaware, MIT, Northwestern, UC Santa Cruz.

Abstract

In recent years, there have been numerous reports of runaway hot plates — hot plates that heat uncontrolled despite the setting or the fact that the controls are in the off position. Some of these events have resulted in damage to research facilities. The Division of Chemical Health and Safety has investigated this issue using all available information and soliciting additional information via a survey conducted in April 2017 to determine the cause of these issues and to develop strategies to prevent future "runaways". Results of this survey and best practices are described herein.

Survey Information

A survey to collect information from research institutions that have experienced electrical and electronic hot plate malfunctions that may or may not have resulted in equipment and facility damages.

Survey was:
- Sent to DCHAS and CSHEMA mailing lists
- Conducted from April 12 through 21, 2017
- Survey designed in Google forms and distributed by email

Questions: The survey contained questions concerning:
- Three different kinds of malfunctions
  - Spontaneous hot plate heating with the heat-control knob in the "off" position ("spontaneous heating")
  - Runaway heating event during normal operation at a lower intended temperature ("runaway heating")
  - Any other heating malfunction not otherwise specified above
- Details equipment or materials involved
- Best practices and policies in place to prevent future recurrences

Responses:
- Total = 25
- Total number of events reported = 32 (multiple events noted in several surveys)
- Types of events noted:
  - No events noted: 4
  - Spontaneous heating events: 6
  - Runaway heating events: 14
  - Other faults: 8
- Age of hot plates involved in events?
  - Greater than 5 years: 4
  - Between 3 months and 5 years: 3
  - Less than 3 months: 3
  - Unknown age: 3

Types of Hot Plates involved in events
- Spontaneous-heating events:
  - Corning PC 420 D
  - Corning PC 320
  - Corning (model not specified)
  - Corning PC 35
  - Corning PC 351
  - Fisher brand (model not specified)
  - VWR 7x7 with Aluminum Top
  - Thermolyne SP46925
  - Other reports with unknown hot plate make/model
- Runaway-heating events:
  - Cimarec H-4954.xx
  - Cimarec (two incidents, model not specified)
  - Corning PC 220
  - Corning PC 420
  - Corning PC 420 D
  - Thermo Fisher (model not specified)
  - Commercial hot plate intended for home use

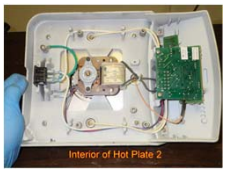
Policies and Best Practices in place
- Unattended use of hot plates?
  - Common: 18
  - Rare: 5
  - Never: 2
- Policy for unattended operations:
  - Allowed with additional controls: 11
  - Policy does not address hot plates: 9
  - Never allowed: 3 (2 allow stirring only)
- Policy for unplugging of hot plates:
  - Policy does not address unplugging: 17
  - Unplugging required:
    - Immediately after use: 6
    - At end of day: 2

Cause of Fire identified as Runaway Hotplate

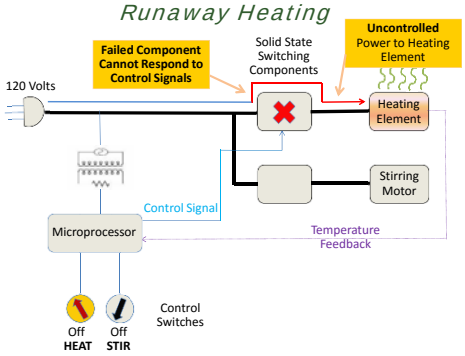
Hot plate temperature running away in the OFF position

Faulty Printed Circuit Board (PCB)
NOTE: No heat or fire damage evident in forensics inspection

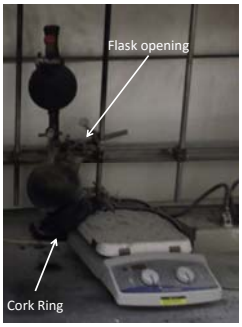
Valid NRTL listing



Switching Component Failure leads to Runaway Heating



Sequence of Events, April 2014



- Stir/hot plate plugged in and switches are off
- Printed circuit board fails such that hot plate goes to full power
- Cork ring smolders and blackens the still
- Hexane contents superheated
- Ground glass stopper ejects – still contents expelled
- Sudden expulsion enables an explosive hexane/air mixture (≥1.2%)
- Auto-ignition (433°F) or hot surface (glass, hot plate, cork) ignites mixture causing a deflagration
- Burning hexane expelled to right side of hood initiates a fire involving hood contents
- Burning hexane migrates below to the pump cabinet

Aftermath of 2014 Event

Best Practices to avoid Runaways

There are several things that users of hot plates can do to prevent overheating events involving their equipment and laboratories

- Engineering control: Utilize Intrinsically Safer Technologies
  - Utilize Hot Plate or heating device with feedback loop and/or overtemperature protection
  - Avoid combination plates if possible. If only stirring is needed — purchase plate with stirring function only
- Administrative Controls:
  - Disable hotplate when not in use — Unplug or install switch on power cord or power supply
  - Perform heating functions only when personnel are present and are monitoring heating
  - Replace hot plates manufactured prior to 1984. Cut the cord off of the equipment before discarding it to prevent reuse.
  - Keep hot plates in good condition.

Fixing the Problem

- Greater awareness of hot plate issues is needed
  - Many institutions that have had issues have imposed internal controls and communication campaigns to prevent future recurrence
  - Information needs to be shared beyond individual institutions to benefit collective awareness
- Institutions should promulgate best practices (see previous column) and policies to address risks
  - Process should include guidelines for selecting, operating and maintaining (or disposing of old) hot plates
  - Policies should consider requirements for unattended operations and disconnecting requirements when not in use
  - Other factors such as keeping hoods free of extraneous combustibles should be considered
- Industries manufacturing hot plates should consider moving to safer technologies. Most hot plates conform to the product standard IEC 61010.1 (US version is UL 61010-1)
  - Standard assumes that hot plates will be unplugged when not in use (I.e. Power plug — *Not the temperature control* — serves as the power "disconnecting means")
  - Manufacturers should consider using a mechanically opened switch (with a switch/contactor, etc.) as a safer technology
  - Revision of the current standard could drive this process

Conclusions

- Many hot plates currently in use are built with technology that could lead to spontaneous or runaway heating events
- Users can avoid common issues be proper selection of heating and stirring plates and unplugging these when not in use or attended
- Awareness of spontaneous and runaway heating causes and results needs to be better communicated across the chemistry enterprise
- Development or revision of standards to eliminate this hazard are needed to prevent future recurrence of these issues.

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