Heat Treatments

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Canada

Overview

- History and biology of heat treatments
- Basics of a heat treatment
- Heat treatment at Quaker Oats
- Treatment using propane heaters
- Treatment using portable steam heaters
- Spot treatments with heat
- Heat with other methods
- Heat safety

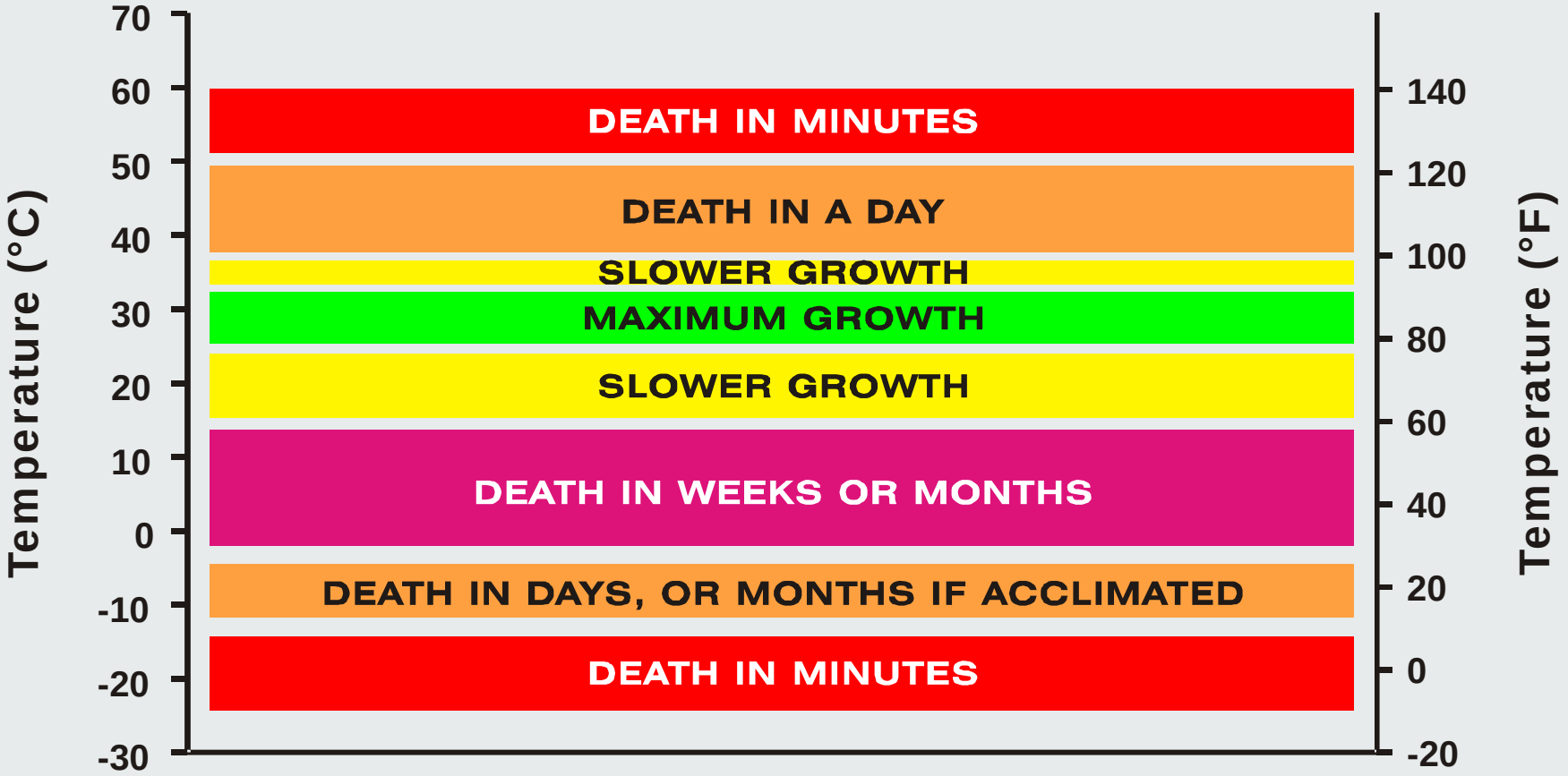
History of Heat Treatments

- 1762, France: 69^{o}C / 156 ^{o}F for 3 d, moth
- 1860, England: 57^{o}C / 135 ^{o}F for grain
- 1910, USA: heat treatment of mills
- 1920, USA: 30 mills use heat in OH, PA
- 1932, France: MB as insecticide

History of Heat Treatments

- 1950’s: Quaker Oats using heat
- 1983: EDB banned
- 1990’s: increased interest in heat
- 1992: MB found ozone unfriendly
- 1994: Dursban in Cheerios
- 2005: MB to be phased out
- 2006: MB one-year extension US, Canada

Temperature Effects



Mechanism of Heat Death

- 40-50 ^{o}C / 105 to 120 ^{o}F dehydration important
- Above 50 ^{o}C / 120 ^{o}F
  - Cell membranes “melt”
  - Damage to enzymes
  - Change in salt balance

Time/temperature to control insects

- 24 h at 38ºC / 100ºF
- 12 h at 43ºC / 110ºF
- 5 min at 50ºC / 120ºF
- 1 min at 55ºC / 130ºF
- 30 sec at 60ºC / 140ºF

Mortality of adults exposed to heat

Insect	Mortality (%)	
	50°C / 120 °F, 20 s	50°C / 135 °F, 32 s
Cigarette beetle	35	99
Flat grain beetle	45	99
Lesser grain borer	45	97
Rice weevil	60	98
Red flour beetle	**60**	**98**
Granary weevil	70	94
Merchant grain beetle	85	100
Confused flour beetle	**90**	**97**
Saw-toothed grain beetle	97	98

Kirkpatrick and Tilton 1972

Differences Between Insects

- Below 50°C / 120°F differences
- Above 50°C / 120°F all very similar

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Heat Disinfestation

- 50°C / 120°F for 24 h
- has been used in US-Canada since 1950's
- Need heat-tolerant equipment
- Can be done by plant personnel
- Need heat source

Protect unheated areas

Spray with approved contact insecticide to prevent insects from moving into cool areas

Clean-up

Remove harborages for insects

Steam Heat

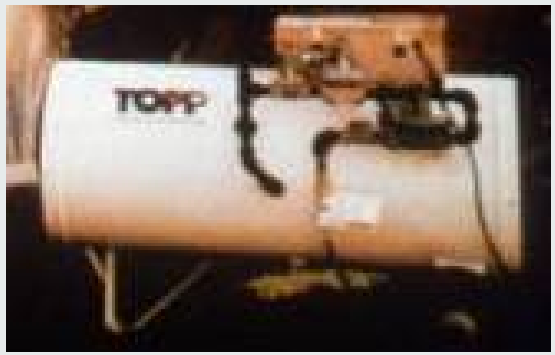
Fixed heaters

Fixed boilers

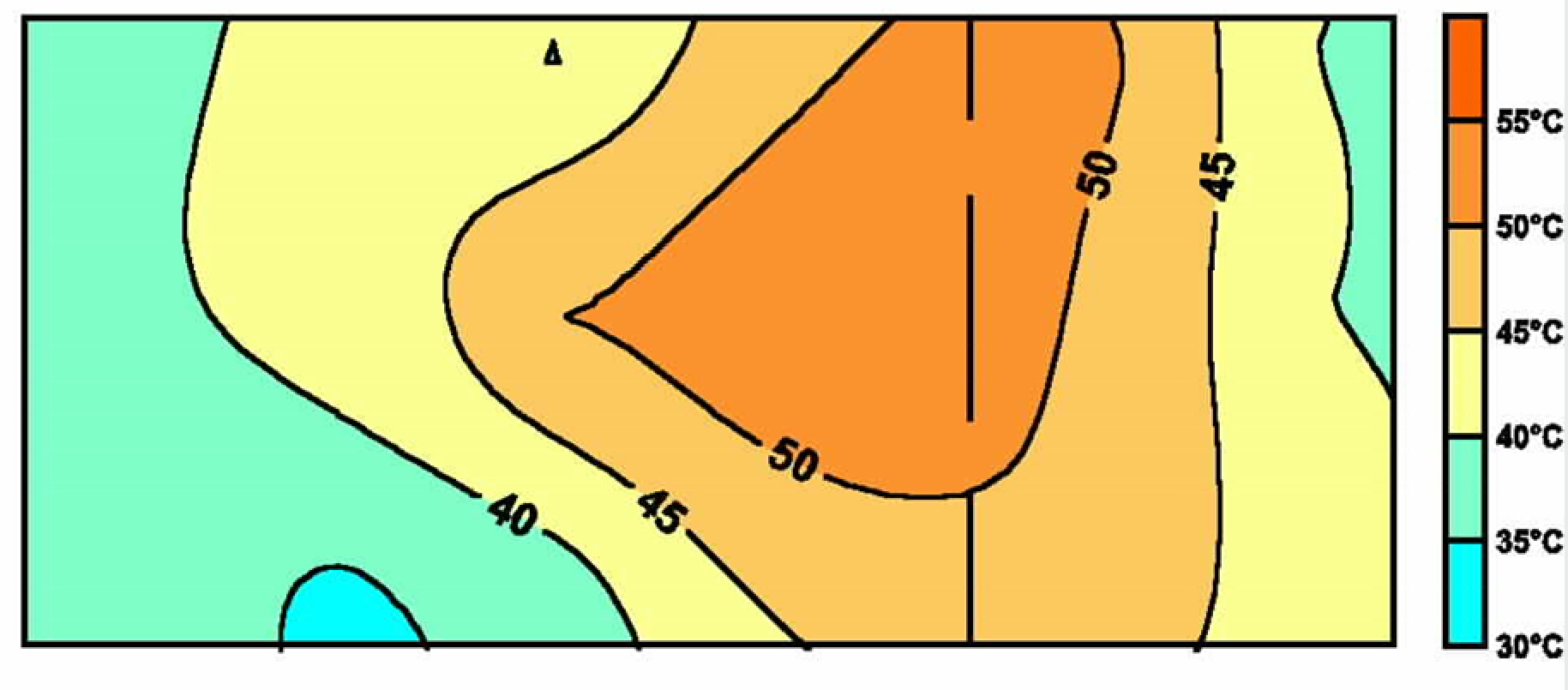
Portable heaters

Mobile boilers

Gas Heaters (propane or natural)



Electric Heaters



Variation in floor temperatures during heat-treatment of a flour mill

Dowdy 1999

Ways to move heat

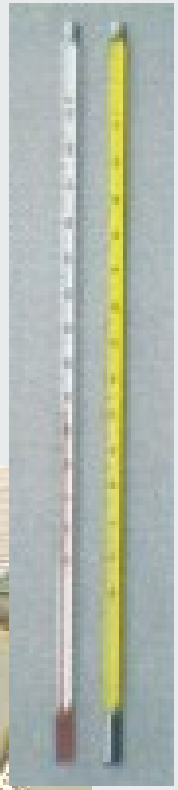
Fabric duct

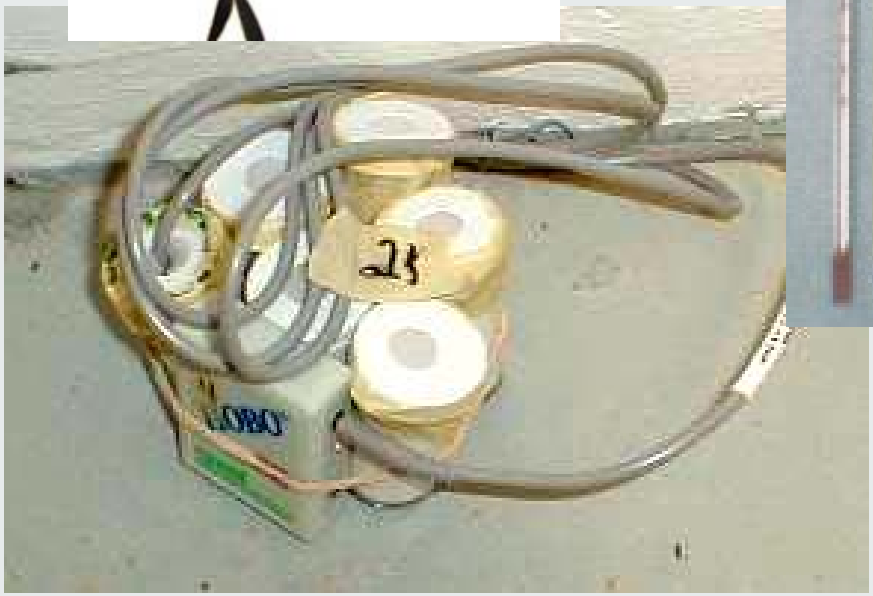
Wire and plastic duct

Air circulation important

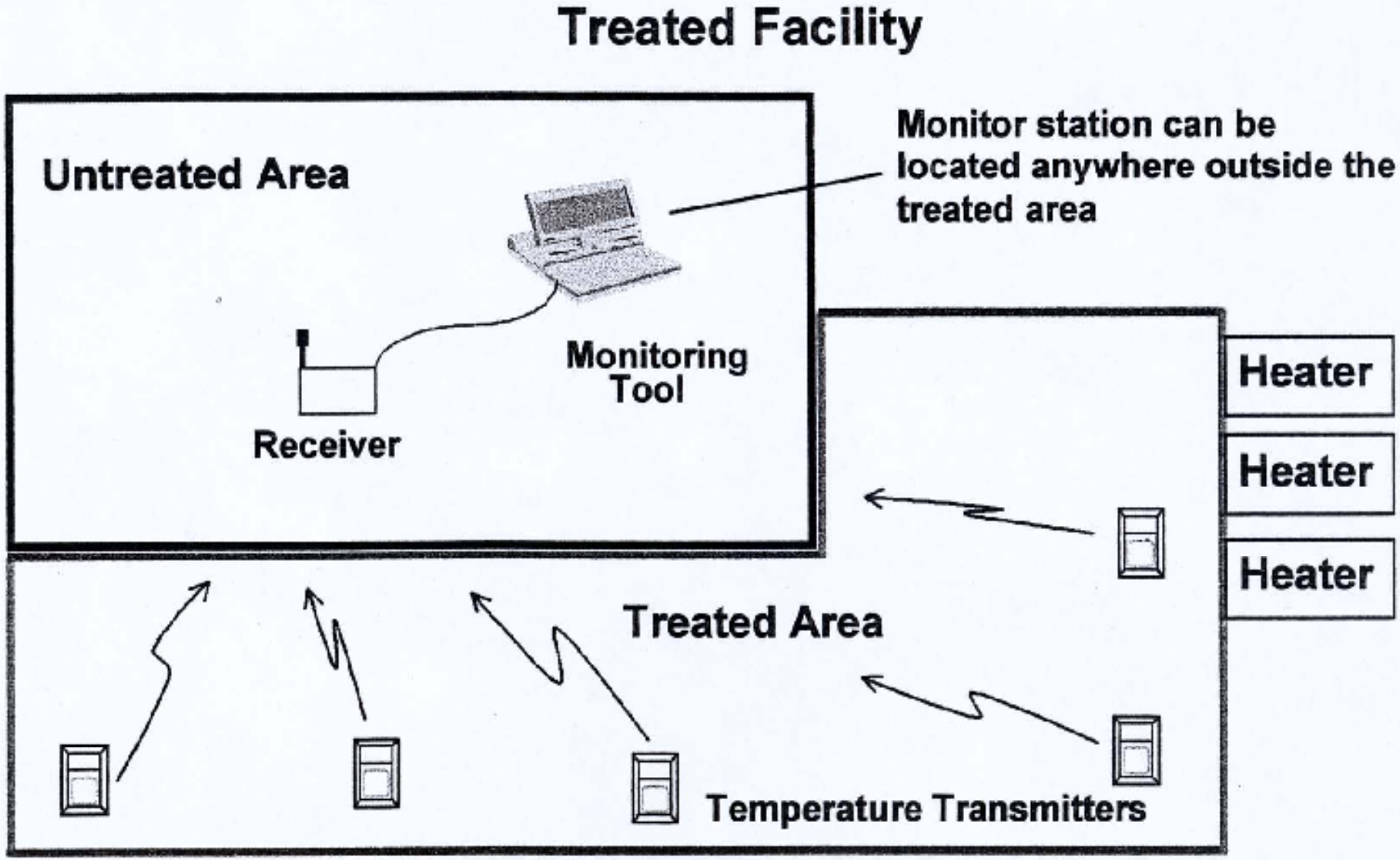
Fans or circuits
may overheat

Measuring Temperatures





WIRELESS TEMPERATURE MONITORING PROPOSAL



Measuring Temperature

- Measure hourly, several locations/floor
- Determines if too hot or too cool
- Be consistent from treatment to treatment
- Keep records
- Infra guns can lose calibration in heat
- No glass thermometers in food plants
- Have spare batteries

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Heat Treatment at Quaker Oats (Peterborough, Canada)

- Sprinklers with 85 or 100^{o}C 185 or 210 ^{o}F heads
- Buys equipment to handle heat
- Uses steam heaters
- Building mix of old and new; wood, brick and concrete

Heat Treatment at Quaker Oats

- Friday Morning
  - Shut down lines
  - Clean up
  - Leave machines open
  - Remove heat sensitive ingredients/equipment
  - Loosen belts

Heat Treatment at Quaker Oats

- Friday Afternoon
  - Close doors and windows
  - Start heaters
  - Finish cleaning, removal of materials

Steam heater with powerful fan

Heat Treatment at Quaker Oats

- Friday Evening
  - Monitor air temperature at eye level in 4 corners of each room once an hour
  - Check building during temperature monitoring

Heat Treatment at Quaker Oats

- Saturday
  - Shut off fans in areas that have obtained 50^{o}C / 120^{o}F for 24 h in all 4 corners
  - Continue to monitor temperature

Heat Treatment at Quaker Oats

- Sunday Morning
  - Open windows and doors for cool down
  - Replace heat sensitive materials
  - Tighten belts

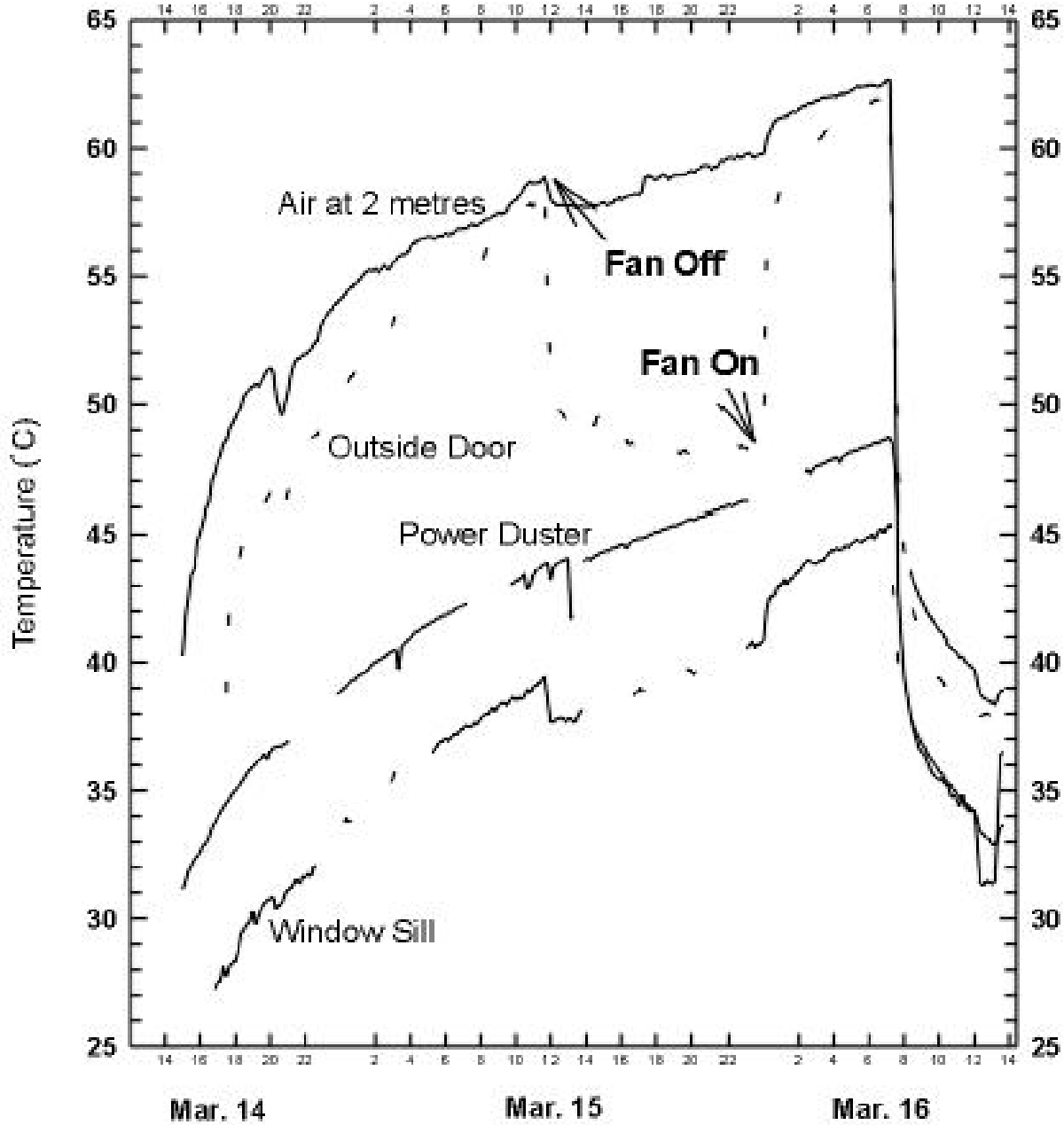

Figure 1. Temperatures at the basement, building 12-13, oat mill.

Heat Treatment at Quaker Oats

- Lines shut down for 48 h
- Treatment done by plant staff
- Need 50-55^{o}C/120-130^{o}F for 24 –30 h
- Done 4-6 times a year
- Use down-time for inventory
- Use steam heat from cooking boilers

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Temp-Air Propane Heaters: Mill 1

Propane, forced air heater

Insect Bioassay: Red Flour Beetle; eggs, larvae and adults

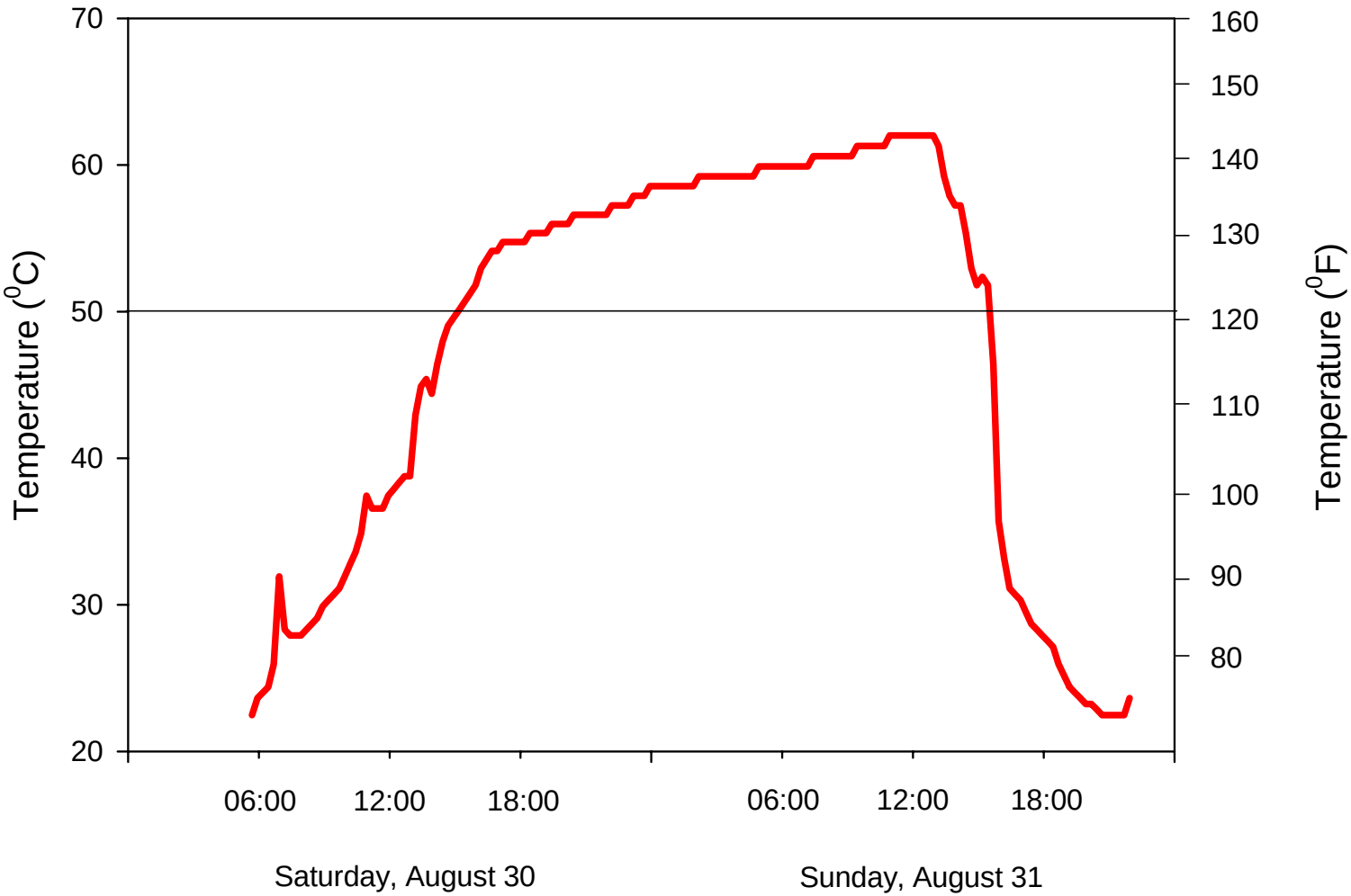
Insects pulled every
1 to 2 hours, one location

Insects pulled at end of treatment, many locations

Mill 1: Temp-Air

- Mill Shut down: 60 hours
- Heater type: propane, 7 heaters used
- Heaters On: 30.5 hours, 20 million BTU/hr
- Cost of propane: $6,000 CND
- Temperature Highs: 58-73 ^{o}C /136-163 ^{o}F
- All insects dead at one location after 8.5 h
- 100% mortality of red flour beetle adults in 20 of 20 locations

Temperature: Mill 1 with Propane



Problems Mill 1

- Fans cut-out due to circuit breaker becoming too hot (breakers in heated area, changed breakers to higher amperage during heat treatment)
- Some caking of flour in equipment (minor problem)
- One air hose line burst (air pressure should have been off during treatment)

Roo-Can Steam Heaters: Mill 2

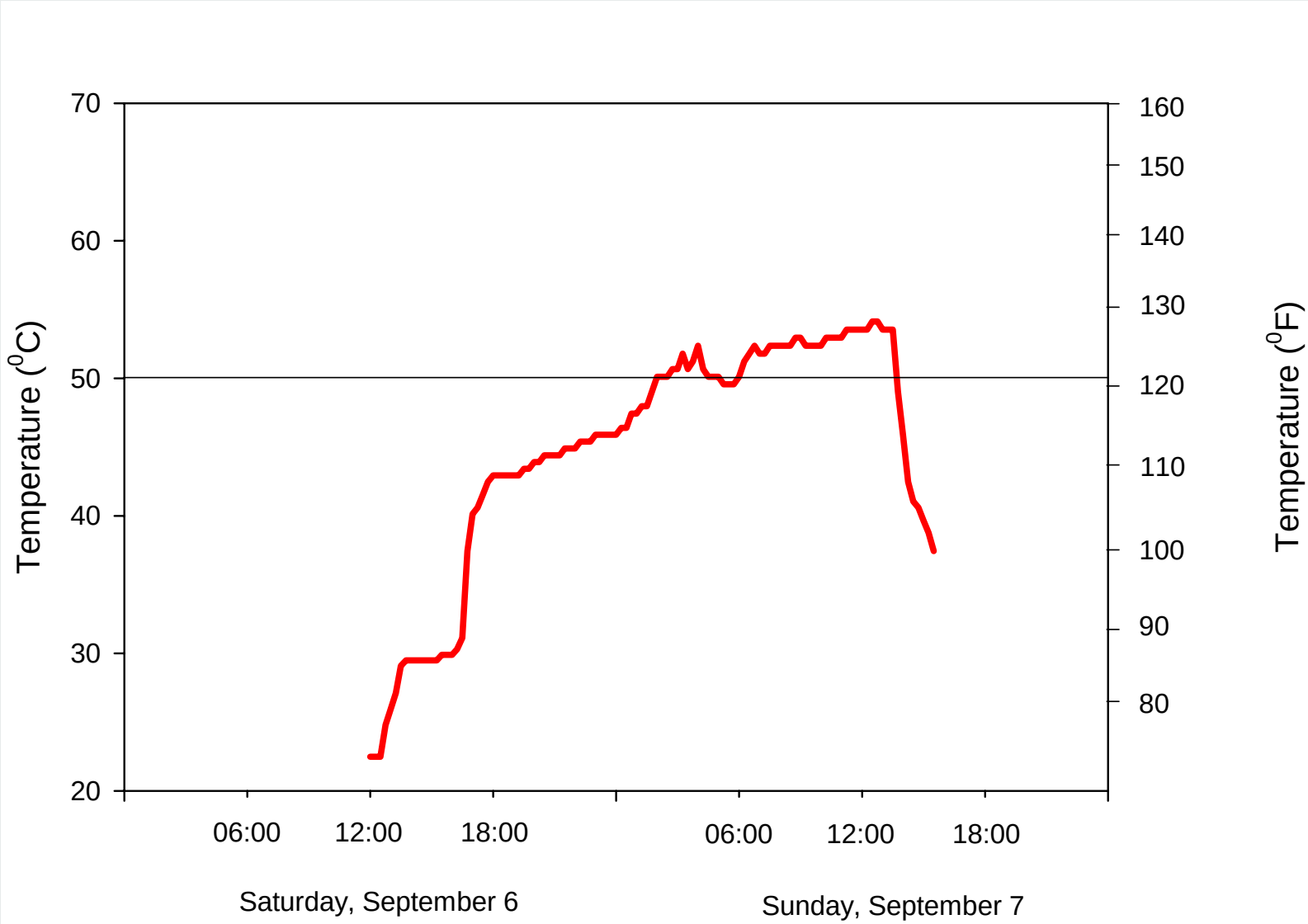
Roll heaters into mill

Steam Heating: 18 heaters used

Mill 2: Roo-Can

- Mill Shut down: 30 hours
- Heaters: steam, 18 heaters used, 3 million BTU/hr
- Heaters On: 21 hours (3h shorter than initial plan)
- Cost of Steam: $300 CDN
- Temperature Highs: 46-74 ^{o}C / 114-165 ^{o}F
- All insects dead at one location after 13 h
- 100% mortality of red flour beetle adults in 21 of 25 locations
- Mill management “More time, or more heaters would be required to get control in all locations”

Temperature: Mill 2 with Steam



Problems: Mill 2

- Some leaking of condensate on one floor (pump failure in basement)
- Some rented fans stopped working due to overheating
- Not total kill of insects in bioassays, or in mill

Flour beetles caught in dome traps.

Methyl bromide fumigation on July 26-27.

Site	Flour beetles as percent of pre-treatment (%)											
	Pre-Treatment				Post-Treatment							
	15 July	22 July	25 July	29 July	5 Aug	8 Aug	18 Aug	25 Aug	2 Sept	9 Sept	16 Sept	23 Sept
Roller Floor	136	104	60	20	1.1	4.3	2.1	1.5	0.7	0.4	0.7	2.6
Sifter Floor	134	60	106	7.5	0	0	0	1.4	0	0	0	4.3

10 Dome traps used/floor

Flour beetles in dome traps.

Mill 1: Temp-Air heat treatment took place on August 29-31.

Site	Flour beetles as percent of pre-treatment (%)											
	Pre-Treatment						Post-Treatment					
	25 Jul	1 Aug	8 Aug	18 Aug	25 Aug	29 Aug	8 Sept	15 Sept	22 Sept	29 Sept	6 Oct	17 Oct
Roller Floor	67	74	105	71	110	201	13	9	17	15	27	17
Sifter Floor	37	65	77	68	140	245	4.5	5.7	7.4	5.7	6.2	7.6

Conclusions

- Good control of insects by heat treatments
- No major damage to equipment
- Good method to locate insect problems in mill
- Mills shut down 30 to 60 hours

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Spot or Portable Heating

- Spot heating of equipment
- Heat finished product
  - Trailer
  - On production line with longwave radiation

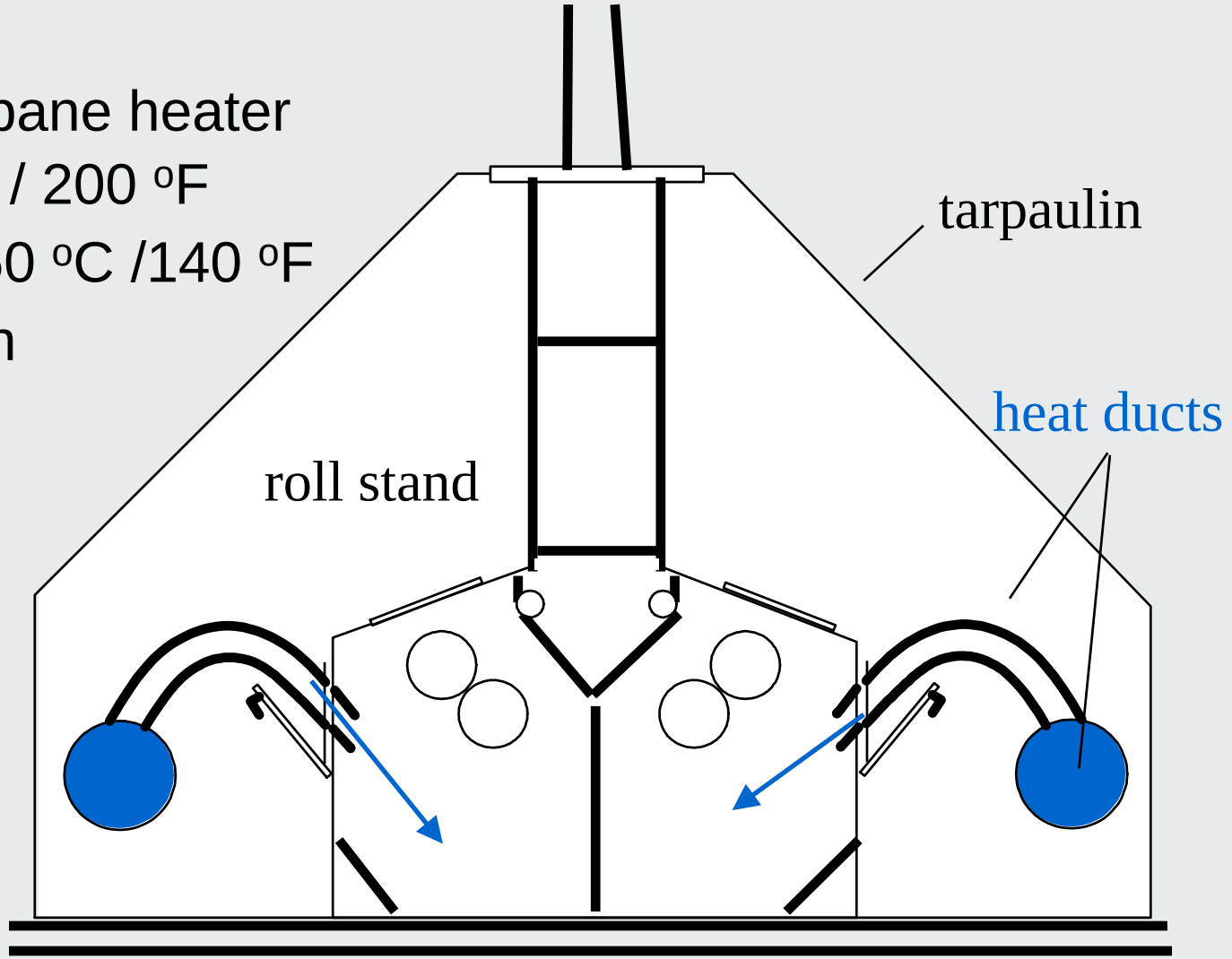
Spot Heat Treatment of Roll Stand in Swedish Flour Mill

Outside propane heater

Input: 93 °C / 200 °F

Roll stand: 60 °C /140 °F

Duration: 4 h



Long wave radiation

- 27 MHz wavelength
- penetrates 15- 20 inches (microwave only 4 inches)
- 900 lbs/hr

Heat Final Product

Heat and other control methods

- Heat and DE
- Heat, phosphine and CO2
- Heat and ProFume (sulfuryl fluoride)
- Heat increased effectiveness of Tempo
- Heat and sampling

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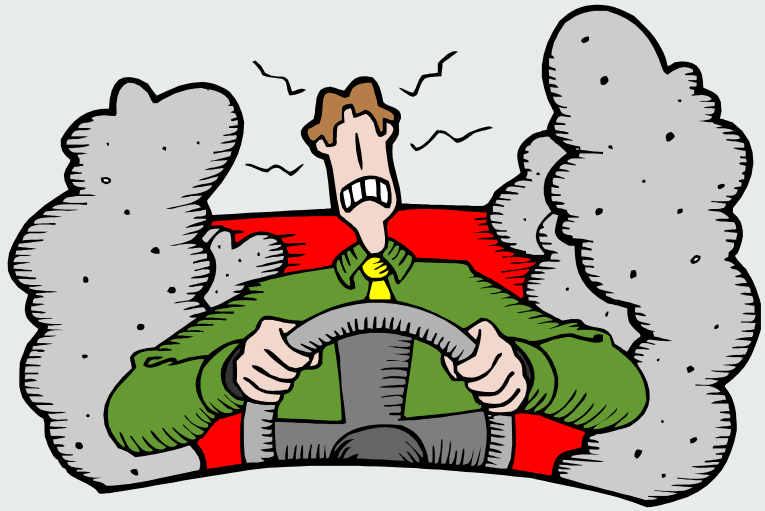
Why do insects die at 50^0C / 120^0F, and we just get hot under the collar?



Subi at work in England

Size Matters

Subi is
40,000,000 X
heavier than
a red flour beetle

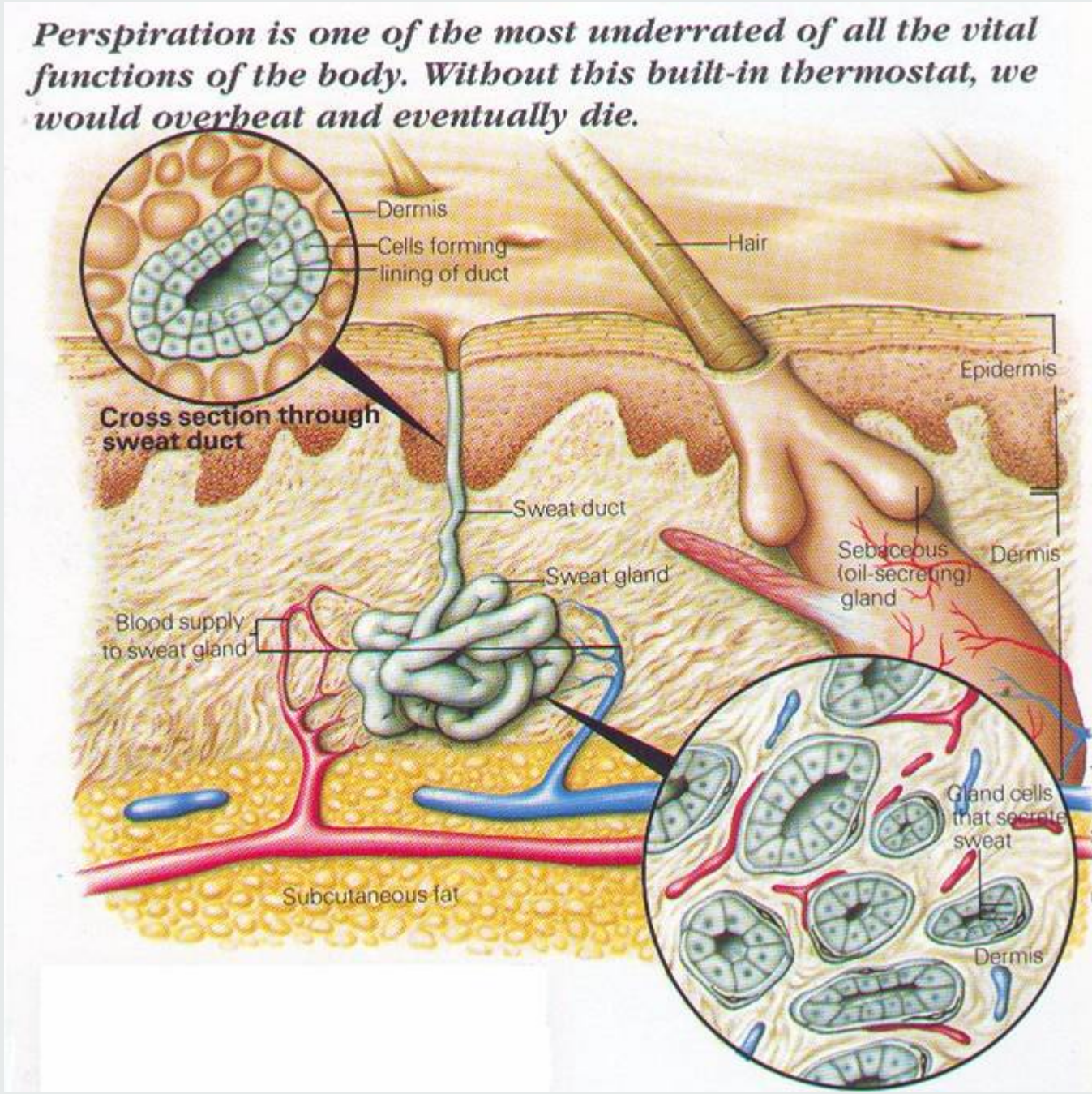
Red flour beetle

Insect body temperature = environment temperature

Sweat

- 99% water
- Salt
- Urea

2.5 M glands



Types of Heat Stress

- Heat Exhaustion
- Heat Cramps
- Heat Stroke

Tips to Avoid Heat Stress

- Drink lots of cool fluids often
- Drink even if you are not thirsty
- Wear loose clothing
- Take breaks from heat
- Elderly, heart problems, overweight low sodium diet at risk
- Avoid alcohol

Conclusions

- 50°C / 120°F for 24 h
- Has been used in US-Canada since 1950’s
- Need heat-tolerant equipment
- Can be done by plant personnel
- Various heat sources available
- No regulatory approval needed

Thank-you for your attention

Canada