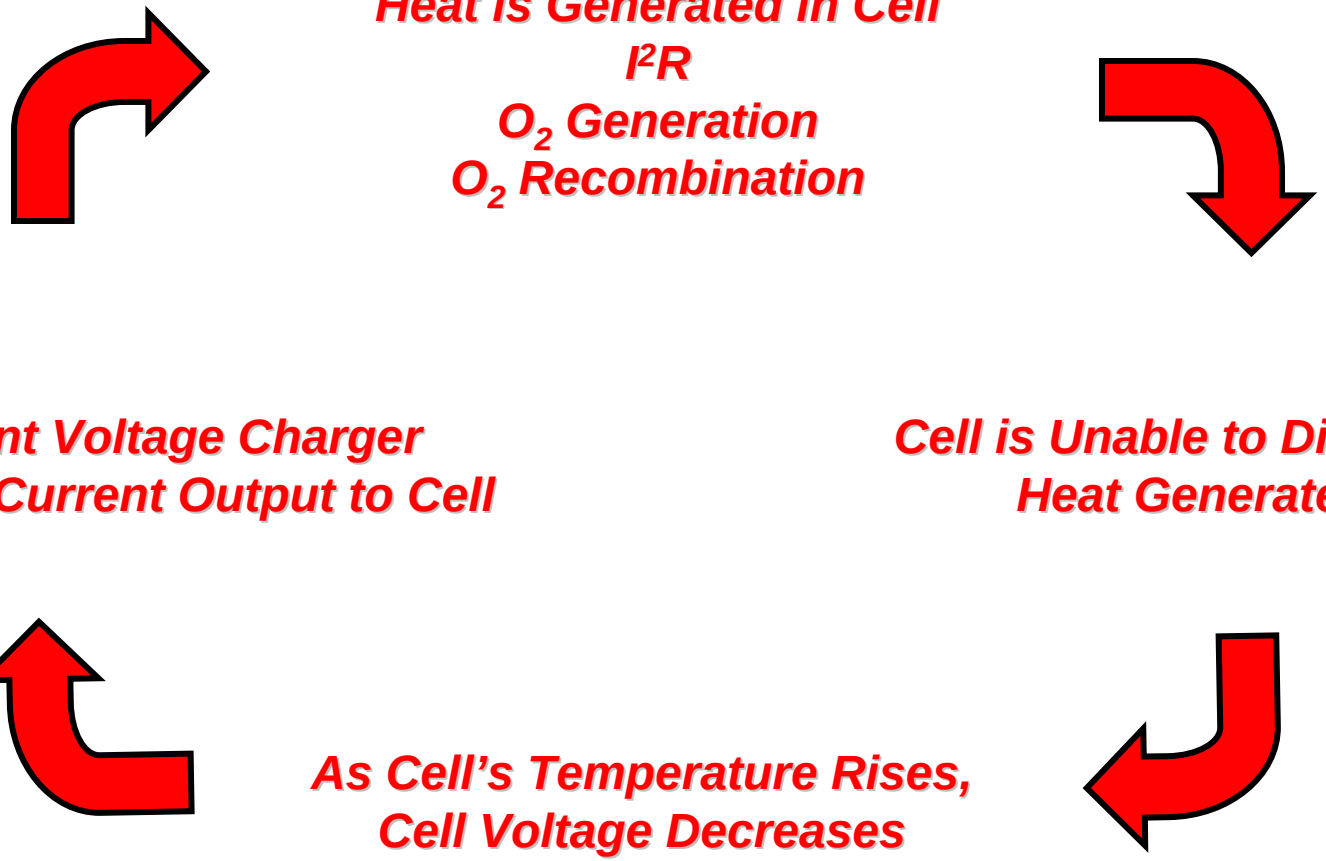
Thermal Runaway and VRLA Cells

What is Thermal Runaway?

- Thermal runaway is that phenomenon which occurs when a cell produces more heat than it can dissipate.
- The generated heat that cannot be dissipated causes the cell temperature to rise.
- This temperature rise causes the chemical reactions within the cell to take place at a faster rate.
- The increased rate of the chemical reactions produces even more heat that cannot be dissipated.
- This additional heat then causes the reactions to increase yet again, thus creating a cycle that “feeds” upon itself in an escalating manner.

Thermal Runaway Cycle



What Causes Thermal Runaway?

- ***Elevated Cell Temperature***
- ***High Cell Charge Voltage***
- **Shorted Cells**
- **Heat Conduction Characteristics of the Cell**
- **Ground Faults**

What Causes Thermal Runaway?

- **Elevated Cell Temperature**
  - ⇨Cell temperature is not typically a primary cause of thermal runaway but can contribute to the start of the phenomena by elevating the cells beginning ambient temperature.

- **High Cell Charge Voltage**
  - ⇨Typically, float voltages of greater than 2.50 vpc can lead to the onset of thermal runaway.
  - ⇨Prolonged cell voltages greater than the recommended float voltage can also lead to thermal runaway.

What Causes Thermal Runaway?

- **Shorted Cells**
  - ⇨When a cell short circuits, it's voltage approaches zero.
  - ⇨This effectively takes the cell out of the battery string and thus distributes the battery float voltage among the remaining cells.
  - ⇨This in turn causes the float voltage per cell to increase.
  - ⇨Depending upon conditions, this increase in float voltage per cell can lead to thermal runaway.

What Causes Thermal Runaway?

- **Heat Conduction Characteristics of the cell**
  - ⇨If a cell is designed such that, under normal conditions, it cannot dissipate the heat generated by its internal reactions, the cell's temperature will continue to rise during charging. Under poor thermal conditions or extended float charges, a cell of this design will pose a thermal runaway problem.

What Causes Thermal Runaway?

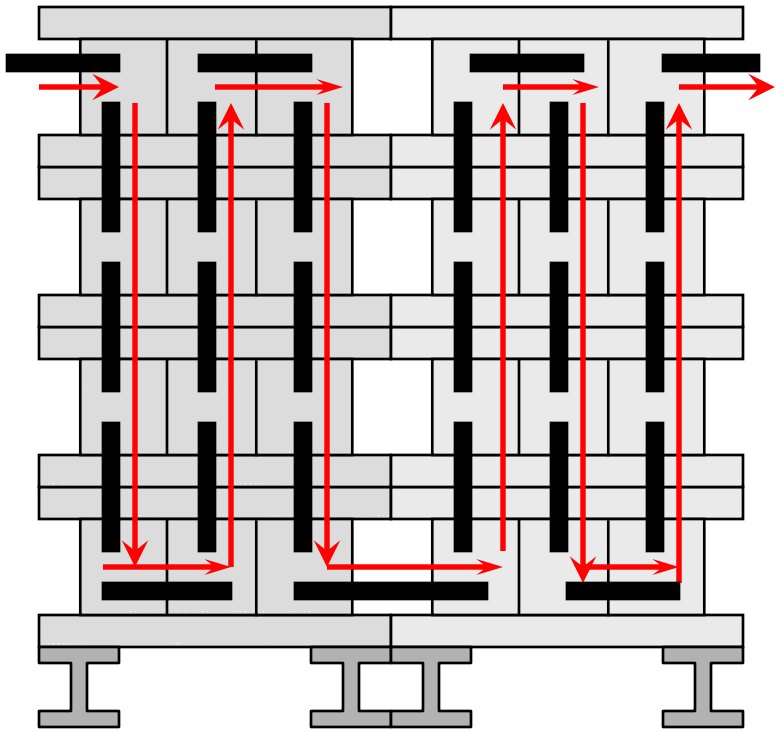
- **Ground Faults**
  - ⇨If two cells within a battery string develop ground faults, the potential for a thermal runaway situation could exist.
  - ⇨When two separate cells develop hard ground faults, a current path is established between the cells via the steel trays.
  - ⇨This current path diverts all, or a portion, of the float voltage usually absorbed by the cells between the grounded cells to the cells that are outside of the grounded loop.
  - ⇨This increases the float voltage per cell of those cells outside of the grounded loop.

What Causes Thermal Runaway?

- **Ground Faults** (a graphical representation)

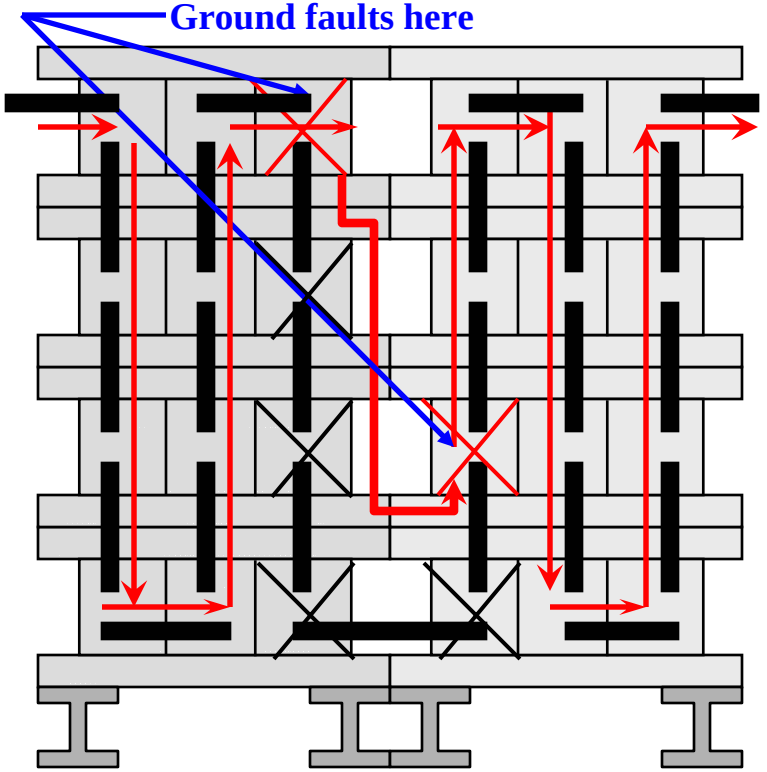
Normal current flow

Charger Setting = 54 volts
(2.25 volts per cell)



Current Flow with Ground Faults

Charger Setting = 54 volts
(2.70 volts per cell)



What Leads to High Charge Voltages?

- Improperly set Charger/Rectifier.
- Faulty Charger/Rectifier
- Voltage not corrected for elevated temperatures
- Shorted cell
- Cell removed from battery string without adjusting overall float voltage setting
- Malfunctioning Auto-Equalize

Steps to Avoid Thermal Runaway

- Product Design
  - ⇨Select materials (plastics) with good thermal properties.
  - ⇨Utilize thin wall plastic jars to minimize insulating properties.
  - ⇨Install cells in steel tray
  - ⇨Build air circulation paths into tray/module.
  - ⇨Utilize copper terminals to remove heat.

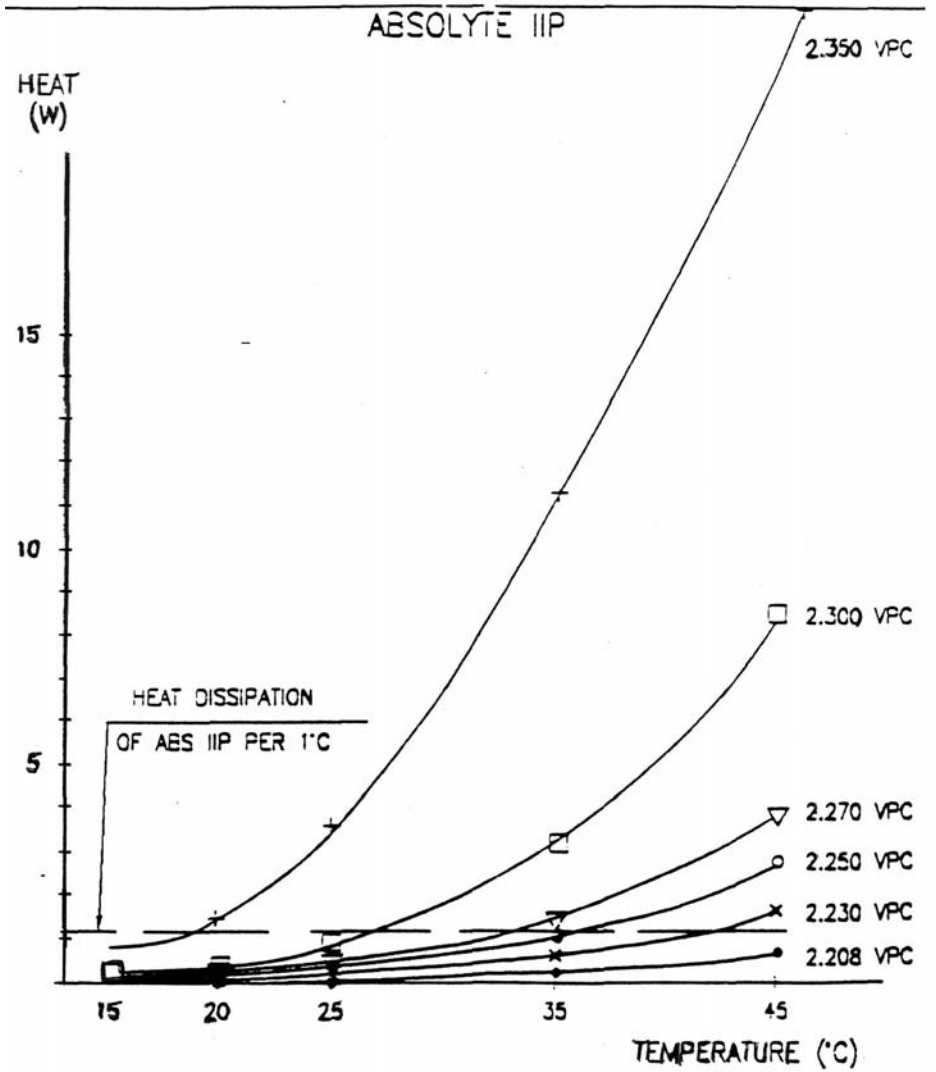
Steps to Avoid Thermal Runaway

- Battery System Operation
  - ⇨Maintain moderate battery room temperatures.
  - ⇨Avoid hot spots/thermal imbalances within battery strings.
  - ⇨Provide adequate ventilation and forced cooling if necessary.
  - ⇨Temperature adjust charge voltages.
  - ⇨Incorporate charger shut off switches.
  - ⇨Establish a regular maintenance routine.

Absolyte IIP Heat Dissipation

- Heat Generation Values for Absolyte IIP
  - ⇨C/3 Discharge 8.75 Wh/100Ah/Cell
  - ⇨8-Hr Recharge 25 Wh/100Ah/Cell
  - ⇨Float @ 2.25 vpc 0.08 Wh/100Ah/Cell
- Absolyte IIP cells can dissipate 1.05 Watts through a 1ºC Temperature Gradient.
- Heat Generation greater than 1.05 Watts continuously can lead to thermal runaway.

Absolyte IIP Thermal Stability



Thermal Runaway Indicators

- Increased cell voltages in combination with unusually low cell voltages on float.
- Continual increase in float current
- Cell temperatures greater than 15ºC above ambient under normal float conditions (25ºC ambient and recommended float voltage).
- Stressed covers

Conclusions

- Cell Charge voltage plays an important factor in inducing thermal runaway.
- Temperature can be a major contributing factor to thermal runaway.
- Always temperature compensate float voltage.
- Regular periodic maintenance plays an important role in ensuring a batteries state of health.
- Rectifiers should be equipped with high voltage cut out switches.

Conclusions - cont.

- Absolyte IIP cells have been tested by both Sandia National Laboritories and by Bellcore. Absolyte IIP cells passed both thermal runaway test regimes.
- Test results show that a typical 48 volt Absolyte IIP battery string that is being floated at 2.25 vpc and at a temperature of approximately 25ºC can lose three cells and still not go into thermal runaway.
- Tests showed that Absolyte IIP cells Floated at 2.252 vpc would not go into thermal runaway, even when floated at an ambient temperature of 80ºC (176ºF).