Cooling Fan Behavior in Fringe Magnetic Fields

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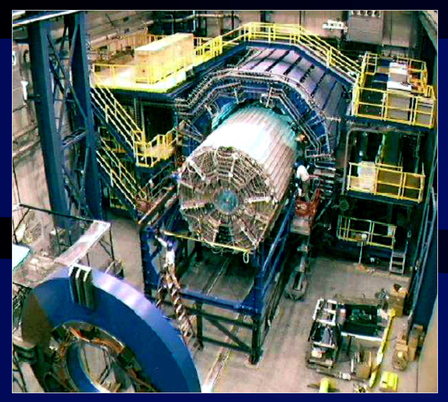
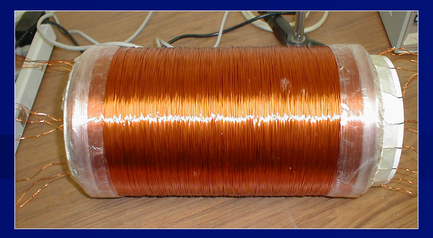
Background

It was observed that electronics were repeatedly failing in the same configuration in fringe fields of magnets (50-200 Gauss) in high energy physics experiments at Brookhaven National Laboratory. Identical electronics with different orientations did not fail. These failures may be due, in part, to the effects of magnetic fields on the cooling fans. Concerns about similar problems were voiced by the ALICE experiment CERN.



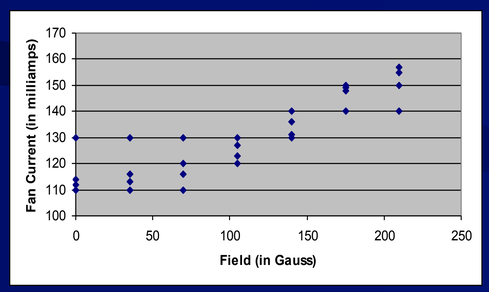
Test Solenoid

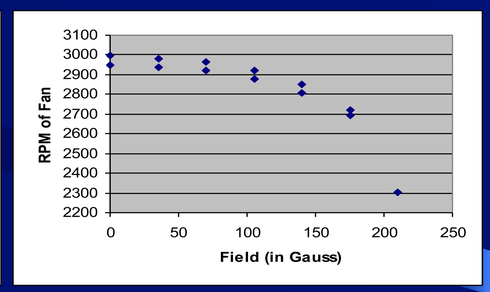
A solenoid was designed and constructed for use with available power supplies to replicate the environment of the failures.

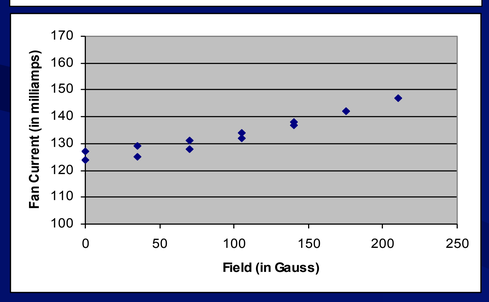


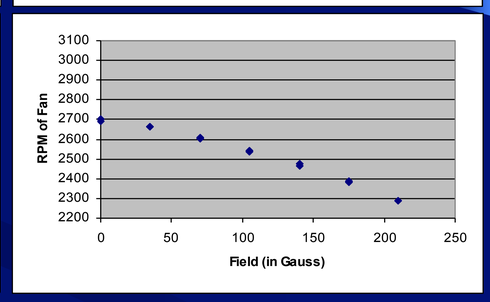
Differences in Fan Types

The response differs between 120 V AC crate fans and 12 V DC computer fans. The DC computer fans show a consistent decline in efficiency with increasing fields, while AC crate fan effectiveness drops more rapidly at higher fields.







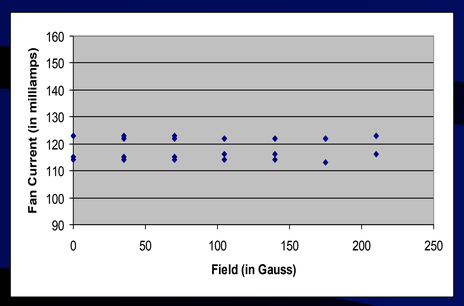


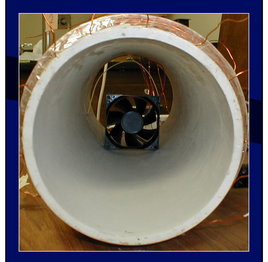
Consistency model to model:

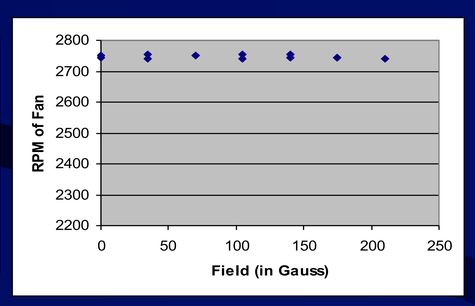
- Tests of other models of 120 V AC crate fans yielded similar results.
- Tests of other models of 12 V DC computer fans always showed orientation dependence, but the size of the effect and optimal orientation varied.
- Smaller CPU cooling fans felt drastic effects; they were brought to a complete stop at relatively low fields when oriented perpendicular to field.

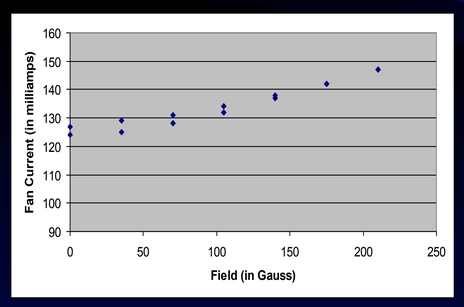
Testing and Results

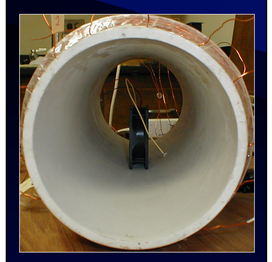
Multiple cooling fans were tested, and measurements were taken on the size of the current drawn by the fan and the speed of rotation of the motors. Each fan was tested in several orientations. Data from a 12 V DC computer fan is shown.

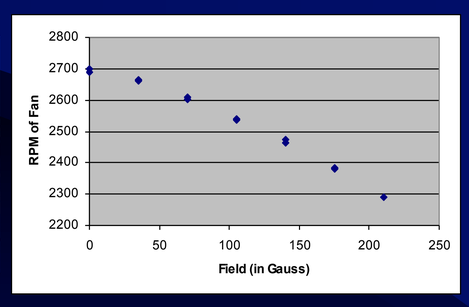


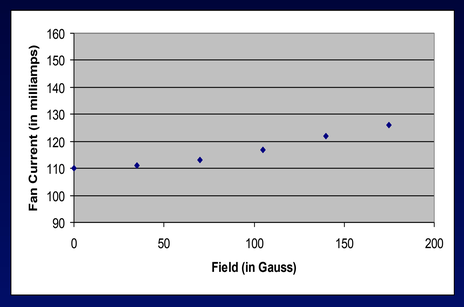


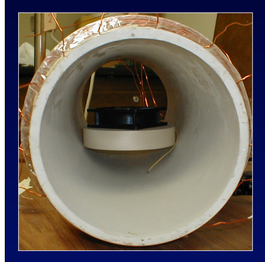












The fan response depends on its orientation.

Blowing along the field
- little effect

Blowing perpendicular to the field
- change detectable at 40 Gauss
- audible distortion appears between 70 and 100 Gauss

Likely Explanations

Induction (both AC and DC fans)
- All models of all types of fans showed some effect when the fan coils were oriented in a way such that the change in flux through the coils was increased.

Hall Effect (DC fans)
- Brushless computer fans are regulated by Hall probes. An external field alters the voltage across the sensor and compromises the switching required for DC motors. Orientation of this sensor varies by model.

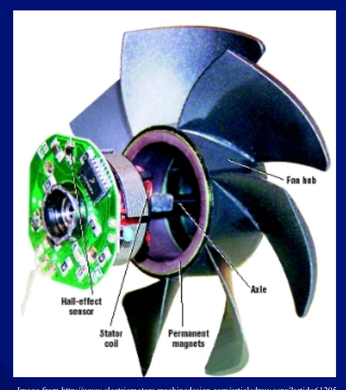


Image from http://www.electricmotors.machinedesign.com/articledraw.aspx?artid=61295

Consequences

- Electronics may be overheating because of reduced air flow.
- Fans may be failing due to increased wear on their bearings.
- If you are told that a device has been tested in a magnetic field, ask how it was tested.
- If you need to place an AC fan in a fringe field, orient the air flow in the direction of the field.

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