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Produced for: David Crowe, DND Fire Services

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Scientific Letter

Failed Fluorescent Ballast in Building S-89

The Dockyard Laboratory (A) was asked by DND Fire Services [1] to examine a fluorescent light ballast that had failed in service as part of a fixture in room 314 of building S-89 on CFB Halifax. There was apprehension that the ballast had burned; there were no external scorch marks, but a small quantity of potting compound appeared to have leaked out of the metal enclosure. There was added concern that this might be an early sign of a more widespread problem, since two other ballasts had burned out in nearby rooms 317 and 318 in recent months. A non-failed ballast was also submitted for comparison.

The unit was Philips model G-2S32-TPC, an obsolete electromagnetic style of ballast intended for two 32 watt tubes, and rated for a 347 volt feed, i.e., one leg vs. neutral in a 600 V 3-phase supply. It was reported [2] that the building had suffered an electrical fault in the preceding months where one phase had been lost, so there was concern that the ensuing imbalance may have caused the failure in question and damaged other ballasts in the building.

The metal casings were removed from both ballasts, revealing components embedded in a black potting compound. In the case of the failed ballast, the potting compound had evidently melted to a small extent near the magnetic core, and had become brittle (Figure 1). It also had a strong burnt odour.

The potting compound was removed by dissolution in tetrahydrofuran, revealing the internal components (Figure 2). There was no immediately obvious damage to any component, but conductivity tests revealed three anomalies that indicated internal damage: the red wire heater coil had an open circuit, the primary winding had an open circuit, and there was a short between one red wire and a blue wire, suggesting the high voltage secondary coil had shorted (see Figure 3).

Additionally, the action of the thermal protection switch was tested in an environmental chamber. The switch from the non-damaged ballast opened sharply at around 117°C, and closed again when the switch was cooled to around 60°C. This behaviour was repeatable. However, the switch from the failed unit opened intermittently over the 115–125°C range, with a less regular reset temperature hysteresis.

Aging fluorescent tubes can behave abnormally. In some cases, they exhibit rectifying behaviour: the coating on the two filaments degrade unevenly, so that electrons are emitted from only one side of the tube, and thereby permitting current to flow in one direction only. This condition can overload the ballast coils and cause them to overheat. A properly-functioning ballast should shut off as its thermal protection switch engages. In the failed ballast, the thermal protection switch appeared to be malfunctioning, therefore the coils overheated, the wires melted, and the potting compound burned. It is unclear whether the switch itself was defective, or if it had been previously damaged from too many off-on cycles; there were anecdotes of other lights in the area exhibiting chronic off-on self-switching behaviour [2]. It is also possible that one of the two bulbs failed entirely, but the net effect would be the same.

The evidence points to worn-out fluorescent tubes being the root cause of this failure. Electrical imbalance due to the loss of a power phase was likely not related, since the failure did not occur immediately after the event, and other ballasts were not affected. The imbalance of a failing or failed tube could account for the overheated ballast unit.

The Dockyard Laboratory (A) suggests that all fluorescent fixtures in the building be surveyed, and any aging fluorescent tubes be replaced promptly. Aging tubes can be identified by a heavy buildup of black deposit at the ends of the tubes. Any fixture known to have exhibited spontaneous on-off cycling should be considered damaged and should have its ballast replaced. Furthermore, it might be desirable to replace all the obsolete electromagnetic ballasts with new electronic ballasts. The newer technology is more energy-efficient, produces less flicker, and it is less susceptible to overheating and damage in the case of lamp failure.

Prepared by: **Colin G. Cameron, DRDC – Atlantic Research Centre.**

References

[1] Discussion between Dave Crowe and Colin Cameron, 2014-05-30.

[2] Discussion between Dave Crowe and Colin Cameron, 2014-06-17.

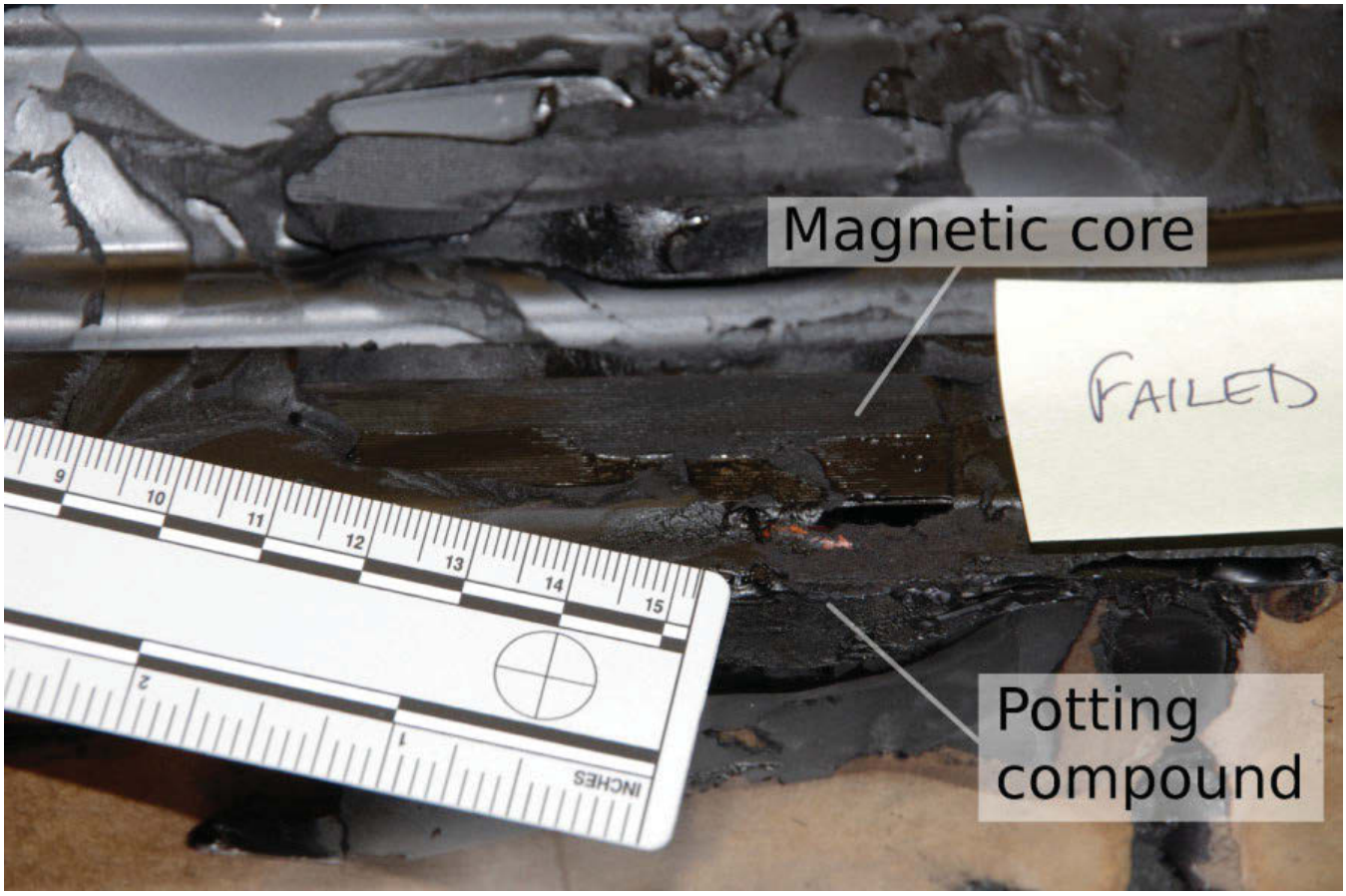


Figure 1: *Inside the metal casing of the failed ballast, where the potting compound had evidently melted and charred slightly in the vicinity of the magnetic core.*

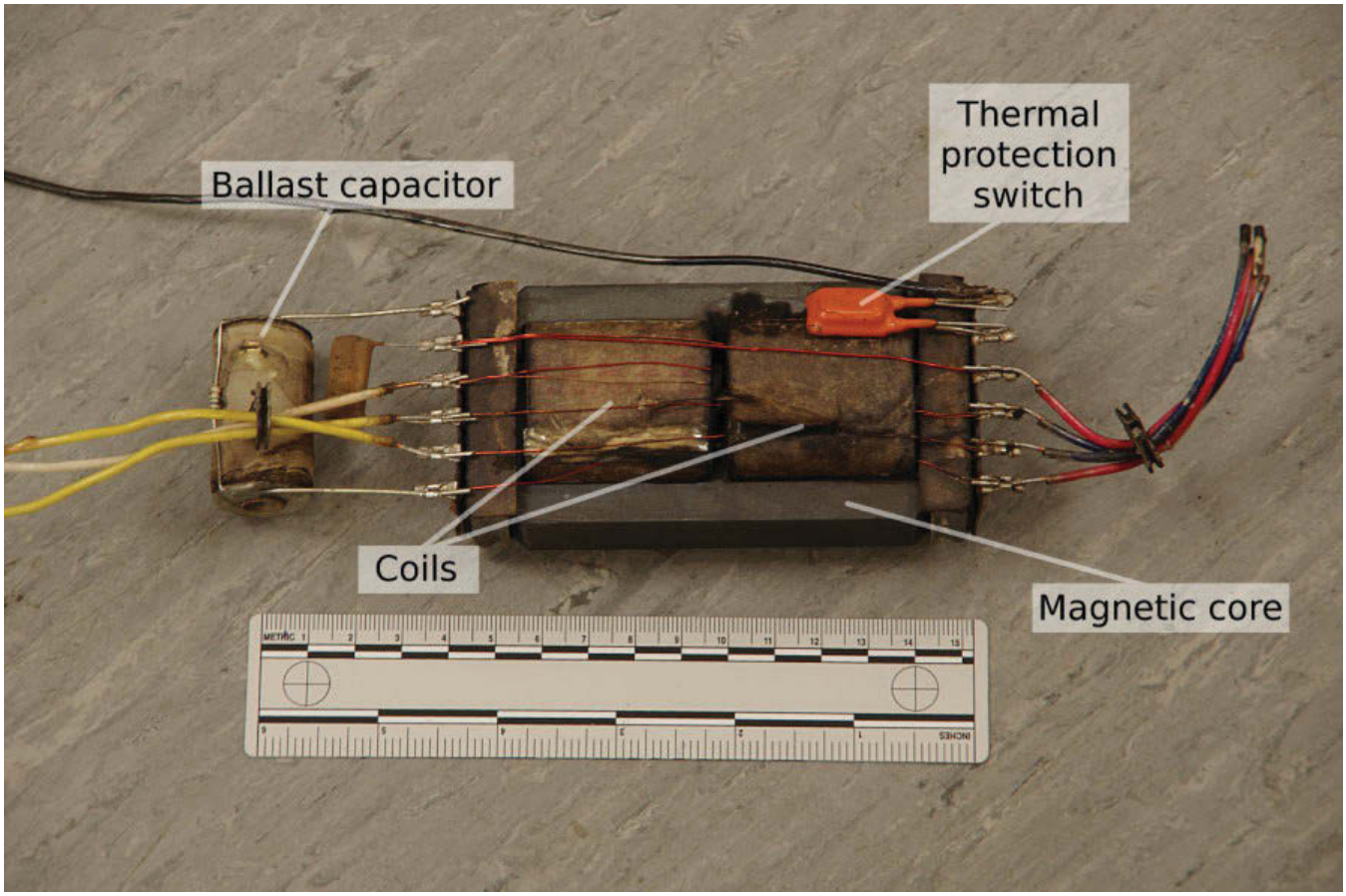
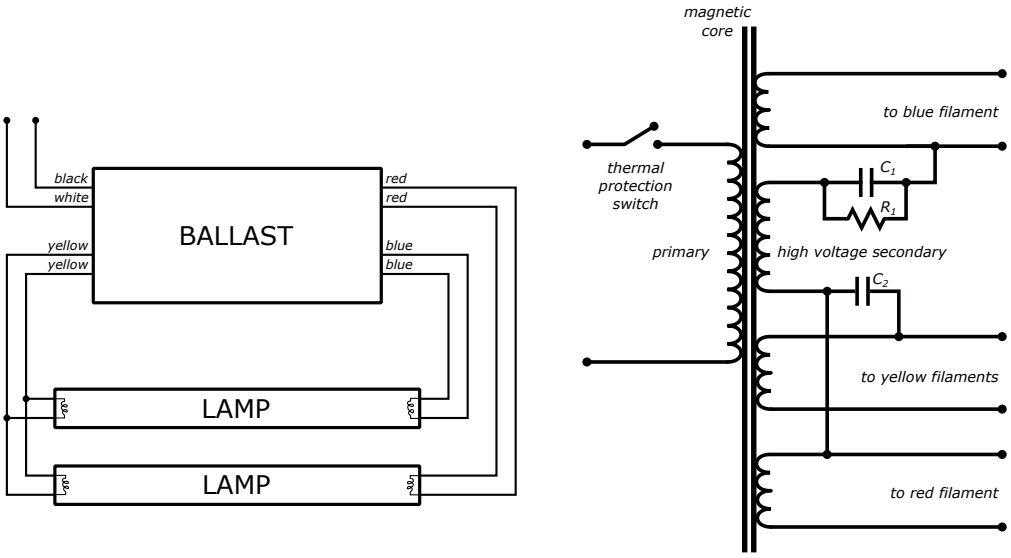


Figure 2: *The failed ballast following the removal of the potting compound.*



(a) (b)

Figure 3: *(a) Wiring diagram for a two-lamp magnetic ballast. The filaments at each tube end are heated by the application of a small current and become thermionically emissive. The emitted electrons are accelerated along the lamp tubes by the voltage difference between the filaments, impacting vaporized mercury, which emits ultraviolet light. The ultraviolet light is then converted to visible light by a phosphor coating on the inside of the tube. In such a two-lamp configuration, the lamps are driven in opposite phase to reduce perceived flickering, hence the red and blue circuits. (b) A schematic circuit diagram to illustrate the function of a magnetic ballast (some connections are omitted for clairty). Three windings provide power to the filament heaters, and the high voltage secondary drives the electron flow that ultimately produces light. The inductance of the coils and the action of capacitor C_1 contribute to the ballasting, i.e., they prevent a current runaway that would destroy the lamp. In the event of a fault, the thermal protection switch is meant to open before the coils overheat.*