2020

INTRODUCTION

360° has been retained to perform a failure investigation of a supplied medical Heating Unit, and a comparison of 120V and 240V versions. For this purpose, a failed Heating Unit and new Heating Units were supplied as pictured at right.

Failure Investigation

Upon removing the bottom base of the failed Heating Unit, the reason for non-operation was readily apparent; a terminal of the neutral fuse holder had separated from the bottom of the fuse holder.

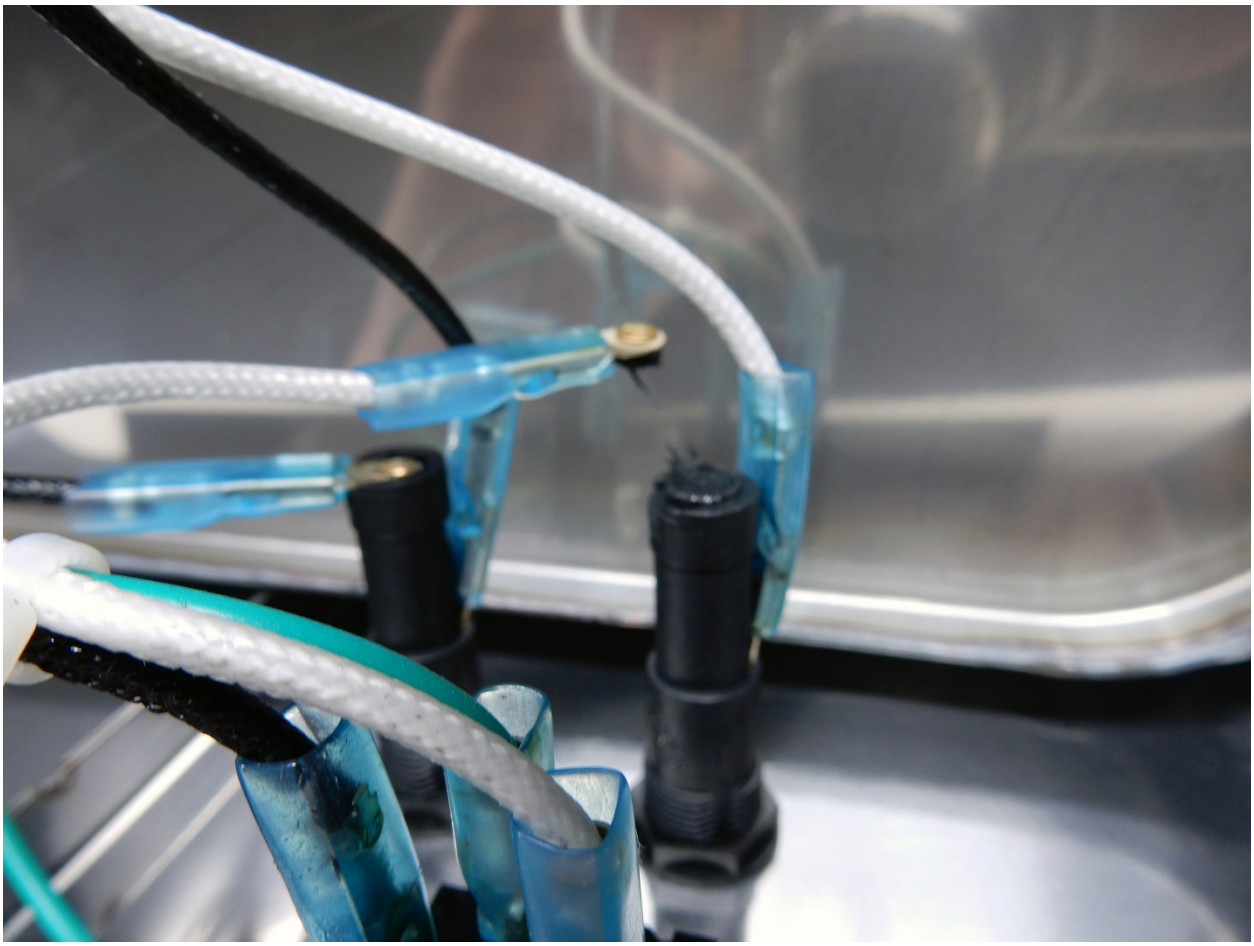

Figure 1: Terminal detached from neutral fuse holder

Upon close inspection it was noted that the fuse holder showed signs of heat damage in the immediate area where the separated terminal had been attached. The fuse holder was determined to be a Hongju Electronics and Metal Products Co., LTD part number FH201-9-P-W. The datasheet for this fuse holder specifies that it **accepts a 6x30mm fuse**, has a maximum operating temperature of 70°C, and has a current rating of 15 amps.

When attempting to remove the fuse from the neutral fuse holder it was found that the fuse was stuck in the fuse holder and the end cap detached from the fuse when eventually freed. The fuse element appeared to be intact, i.e., did not blow.

Figure 2: Embossed markings of fuse cap transferred to plastic of fuse holder (mirrored "0V 15A")

To remove the fuse cap from the fuse holder, it was necessary to cut the fuse holder. When the fuse holder was cut apart, the embossed markings of the fuse cap could clearly be seen in the fuse holder plastic, in addition plastic had flowed between the fuse cap and the contact of the separated terminal; indicating sufficient heat to melt the plastic had occurred.

Removing the fuse from the line fuse holder revealed that **installed was a 6x32mm fuse**. Whereas the fuses installed in each of the supplied new Heating Units were all 6x30mm fuses. **Fuse holders of this type are often designed to except both fuse sizes (6x30mm or 6x32mm); however, the manufacturer does not specifically state that this fuse holder can be used with both fuse sizes**. 6x32mm fuses are common in North America where 6x30mm can be more difficult to source, while the opposite is true in Asian localities.

The thermocouple of an Amprobe THWD-10W thermo meter was attached to the neutral fuse holder of a new Heating Unit, which was then filled with water and set to maximum temperature. When heating, the heating unit was found to draw 1100-1150 watts and the temperature of the fuse holder experienced a temperature rise of approximately 10°C; well below the maximum temperature and current ratings of the fuse holder.

The raw material of the fuse holder, polybutylene terephthalate (PBT), has a melting point of approximately 220°C, far above what the fuse holder would experience during normal operation. The material's thermal characteristics, combined with the highly localized melting of the fuse holder observed, indicates that an extreme temperature rise occurred at the fuse end cap / terminal contact. This temperature rise was likely due to poor contact between the fuse end cap and the terminal contact.

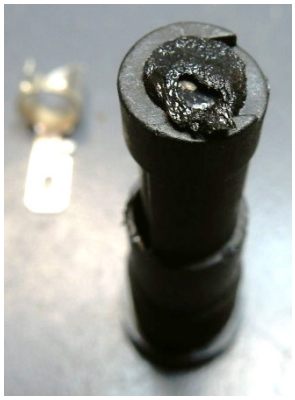

Figure 3: Localized melting of fuse holder

Two possible causes of poor contact are a poorly fitted fuse end cap, or an improperly assembled terminal contact. However, when the fuse was reassembled, the end cap appeared to fit properly. The terminal contact is a semi-tubular rivet, the head of which makes contact with the fuse. The tubular portion at the opposite end is rolled down to fasten the terminal. From side-to-side there was a measured difference between the head and rolled portion of 0.5mm at opposing points around the circumference of the rivet. This may have resulted in a canted head or a poor connection to the terminal; which would cause poor contact and excess heating.

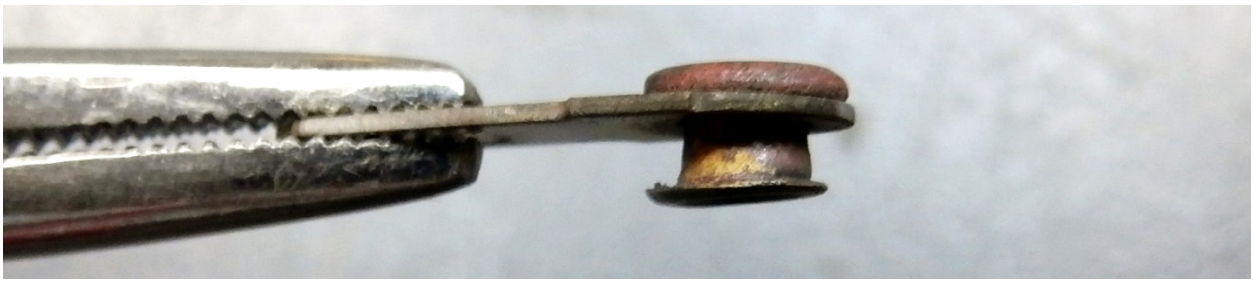

Figure 4: Fuse terminal and semi-tubular rivet

120V vs 240V Heating Unit Differences

Due to failures occurring predominately to 120V Heating Units, a comparison of 120V to 240V units was conducted. Of note, the 240V heating unit was received with a line cord fitted with a CEE 7/7 plug which would plug into the CEE 7/1 socket, the German CEE 7/3 socket (Schuko or Type F), the French CEE 7/5 socket (Type E), or the CEE 7/16 socket (Type C); plug types that are not used in the US. These plug types are used in many countries outside of North America.[1]

Within the Heating Unit, all components except for the heating element were found to be identical.

- The cause of failure of the Medical Heating Unit was likely due to poor contact at the semi-tubular rivet of the fuse holder due to a manufacturing defect. **Failure would be more likely on 120V units due to the higher (double) amperage draw required to produce comparable heating.**
- Compatibility of the fuse holder with 6x32mm fuses should be verified.
- The 120V and 240V Medical Heating Units are nearly identical; as would be expected, the power cord and heating element are different.
- The Medical Heating Units primarily consist of components that are of a generic nature and COTS substitutes for most are available.

Reviewed by: KET, CNS

[1] https://www.worldstandards.eu/electricity/plug-voltage-by-country/