U.S. CONSUMER PRODUCT SAFETY COMMISSION
5 RESEARCH PLACE
ROCKVILLE, MD 20850

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March 7, 2022

Mr. Joe Musso, Chair for STPs 1042
Mr. Bob Pollack, Director, Market and Surveillance
Underwriters Laboratories Inc.
333 Pfingsten Road
Northbrook, IL 60062

Dear Mr. Musso and Mr. Pollack:

While investigating heaters with thermally damaged plugs from different manufacturers, U.S. Consumer Product Safety Commission (CPSC) technical staff[1] found inconsistent crimping, welding and/or soldering on the crimp connectors of the heater plug blades (see attachment). The plugs were from certified electric heaters with UL-listed power supply cords.[2] Staff's evaluations included x-rays and CT scans of incident and exemplar heater power cord attachment plugs, which showed inconsistencies on the crimps of the plug crimp barrels to the power cord conductors and/or welding or soldering of the plug connections. Welding and soldering of heater plugs is required, as cited in Table 16.2 of UL 1278.

Additional evaluation included temperature measurements of the plug during normal operation. Staff connected cords from incident and exemplar heaters to a 120 VAC and a 11.5 A load, as appropriately rated for these power cords. Staff recorded the temperatures of the plugs using a thermocouple located between the plug blades and within the plugs overmolding. The temperature tests indicated elevated temperatures (5.5° to 19.8°C) between the incident and exemplar plugs.

Staff requests UL to review our findings and investigate if these plugs exhibit unacceptable construction deviations and the impact of these deviations on the safe operation of the cords during the life of these products.

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[1] The views expressed in this letter are those of CPSC staff, and they have not been reviewed or approved by, and may not necessarily reflect, the views of the Commission.
[2] Under Section 6(b) of the Consumer Product Safety Act, staff cannot at this time disclose the markings on the cord samples that would reveal the manufacturer.

CPSC's technical staff is committed to continuing to address the safety of electric heaters and other consumer products. The preliminary analysis that staff conducted identifies an area that may warrant additional investigation.

We look forward to an open dialogue on this topic with UL and all interested stakeholders.

Sincerely,

Arthur Lee
Electrical Engineer
Division of Electrical Engineering and Fire Sciences

CC: Jacqueline Campbell, CPSC Voluntary Standards Coordinator
Randy Cooper, Vice President, Technical Operations & Standards, Association of Home Appliance Manufacturers

ATTACHMENT

STAFF'S EXAMINATION OF HEATER POWER CORD PLUGS

MARCH 7, 2022

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Examination of Heater Power Cord Plugs

Staff conducted examinations of incident and exemplar heater power cord plugs. The power cords were from heaters certified to Underwriters Laboratories (UL) 1278 – Movable and Wall- or Ceiling-Hung Electric Room Heaters. The incident heaters were portable, floor-standing room heaters and not more than 5 years old.

The power cords examined in this report were listed by UL to UL 817 – Cord Sets and Power-Supply Cords.

X-ray inspection and computed tomography (CT) scanning were conducted on the samples. The scanning took 5,200 two-dimensional (2D) digital radiography projections around a 360-degree rotation of each sample and then the 2D projections were reconstructed into a three-dimensional (3D) CT volume, which allowed staff to view and slice the part at any angle.

Also, the temperatures for selected incident and exemplar plugs were measured by inserting a thermocouple through a drilled hole within the molded plug between the crimp barrels. The power cords were energized with 120 VAC and a 11.5 A load. A temperature logger recorded the temperatures of every 10 seconds by a temperature logger.

This report only provides staff's examination of the sampled heater plugs.

The views expressed in this report are those of CPSC staff, and they have not been reviewed or approved by, and may not necessarily reflect, the views of the Commission.

Illustrated Wire Crimp Cross-Section Examples

Best practice is that the crimp barrel is closed, wings support each other and that there is a sufficient gap between wings and bottom of the crimp. All strands needs to be deformed to create maximum surface contact between wire strands and barrel.

[1] Crimp barrel fully closed. Crimp wings touching and even.

[2] Wings even and support each other.

[3] Burrs/extrusions are even on both sides of the crimp barrel.

[4] No voids in the crimp barrel and all wire strands are deformed.

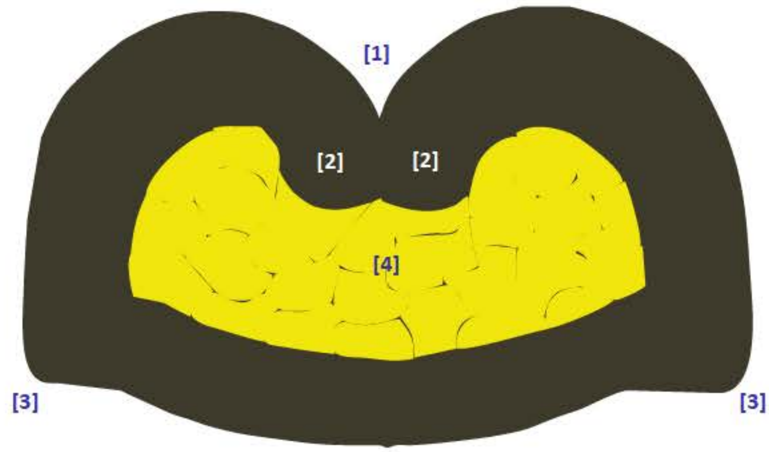
[5] Asymmetric crimp barrel closure. Uneven wing closure.

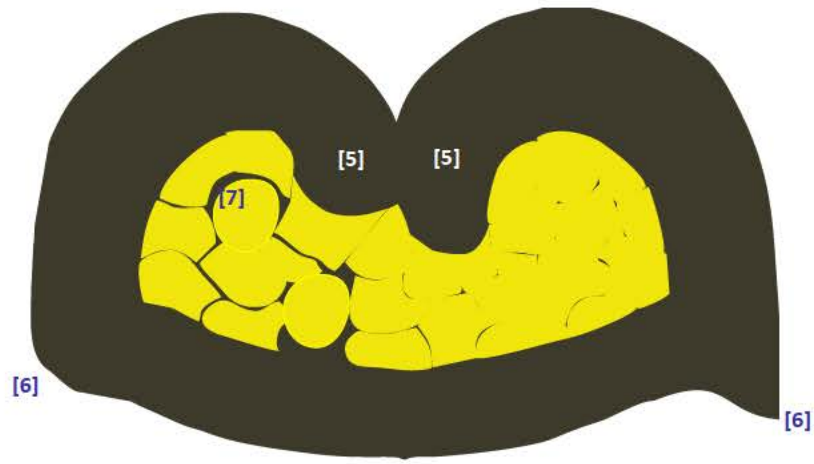
[6] Asymmetric crimp. Uneven burrs/extrusions on the crimp barrel.

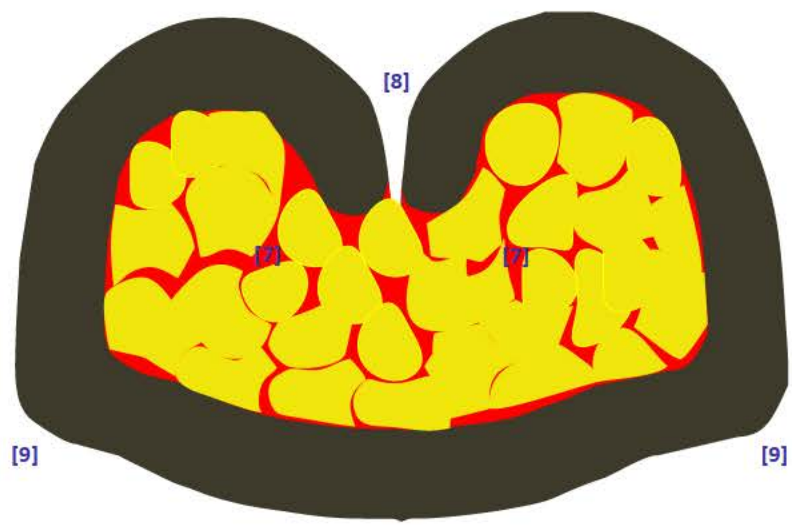
[7] Voids in the crimp barrel.

[8] Crimp barrel open. Crimp wings not touching.

[9] Lack or minimum burrs/extrusions on the crimp barrel







Incident - Sample 0803_02

This sample did not result in a fire.

One of the two blades showed signs of overheating, which resulted in deformation/melting of the plug overmold.

[1] Thermal damage surrounding the crimp connection (not visible on x-rays).

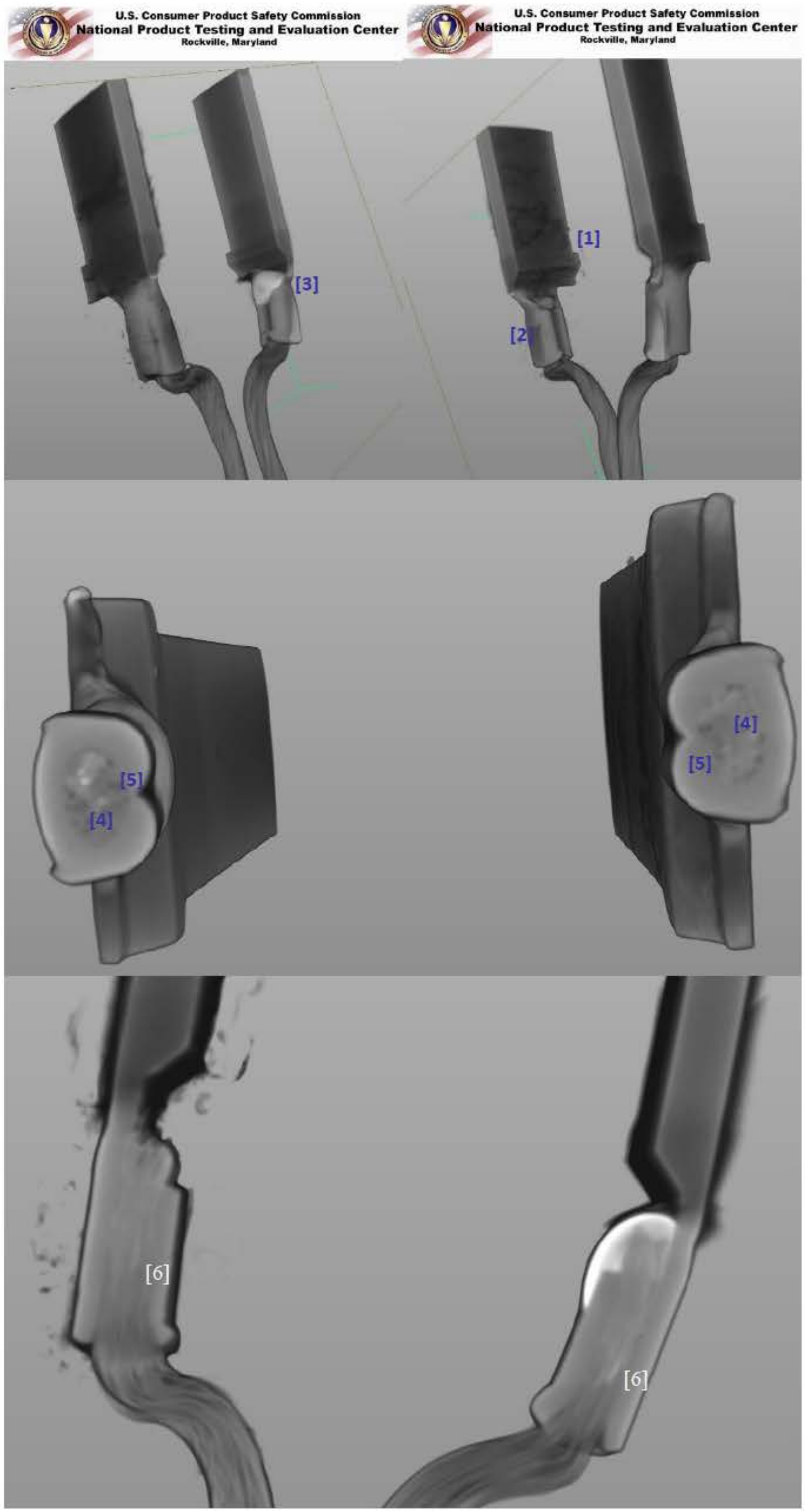
[2] Insufficient solder to bond the wire strands to the terminal surface.

[3] Solder above the crimp barrel location to bond the wire strands to the terminal surface.

[4] Voids in the crimp.

[5] Crimp wing closed but not turned inwards to complete fully closed/pressure crimp barrel.

[6] Solder flow into main crimp area is an indication of voids in the crimp barrel before soldering.



Incident - Sample 0087

This sample did not result in a fire.

One of the two blades showed signs of overheating, which resulted in deformation/melting of the molded plug.

[1] Thermal damage surrounding the crimp connection (not visible on x-ray).

[2] Thermal damage visible on the surface.

[3] Surface solder mainly covering the wings of the crimp barrel.

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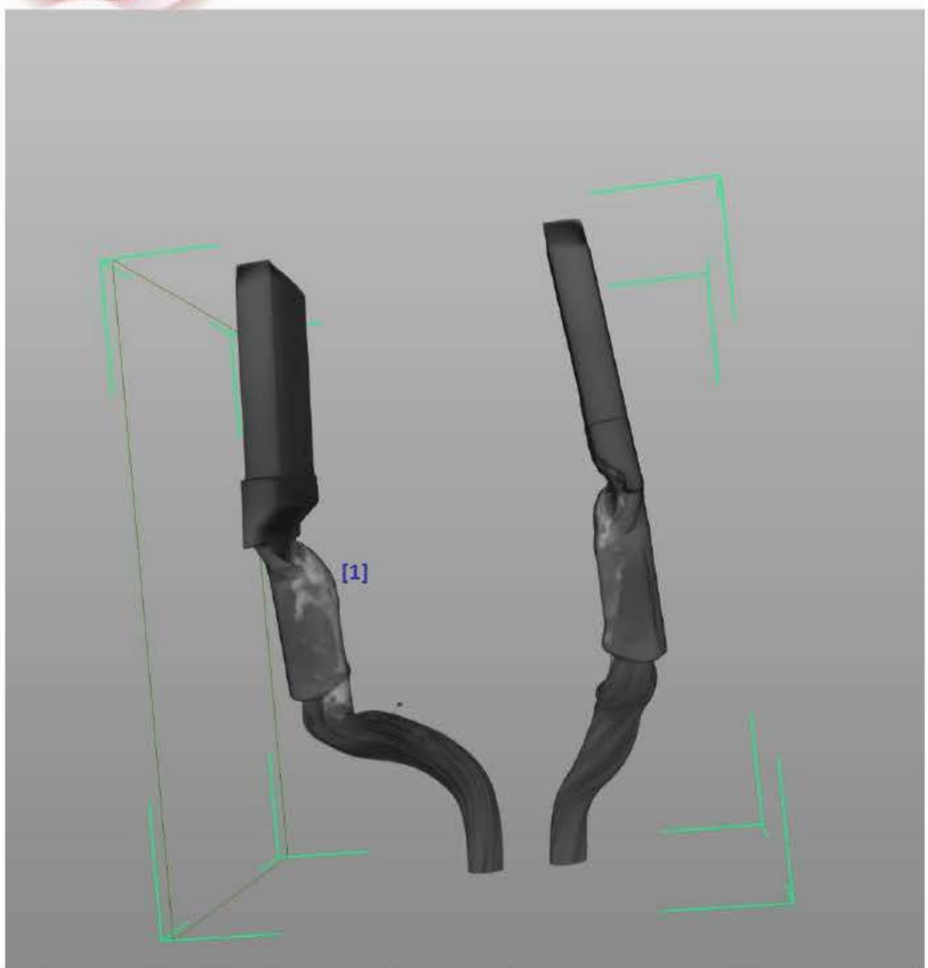
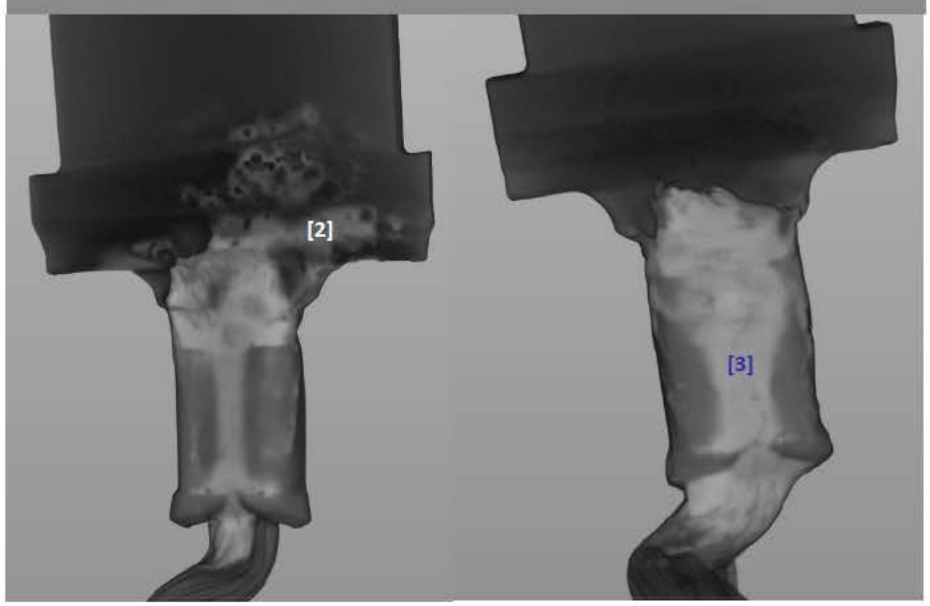




Incident - Sample 0087

A thermocouple was placed between the blades within a hole made in the plug overmold.

This sample did not result in a fire during the temperature test.

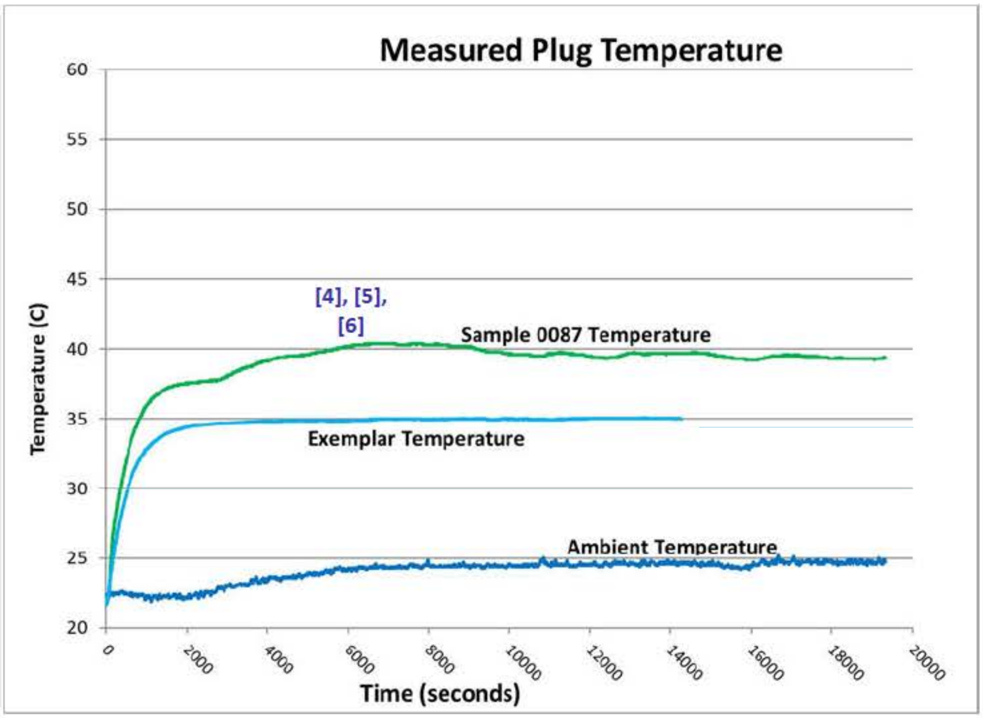
An exemplar plug of the same construction (brand and make) was tested in the same manor.

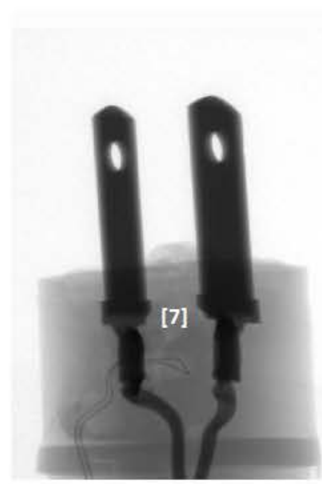
[4] The maximum temperature increase above ambient temperatures was 16.2° C @ about 1.8 hours (6460 seconds).

[5] The maximum temperature increase above exemplar sample temperatures was 5.5° C @ about 1.72 hours (6420 seconds).

[6] The maximum temperature for the incident sample was 40.4° C @ about 1.72 hours (6420 seconds).

[7] Thermocouple located between the crimp barrels within the molded plug.





Incident - Sample 0090

This sample did not result in a fire.

One of the two blades showed signs of overheating, which resulted in deformation/melting of the plug overmold (not visible on the x-rays).

[1] Thermal damage surrounding the crimp connection (not visible on the x-ray).

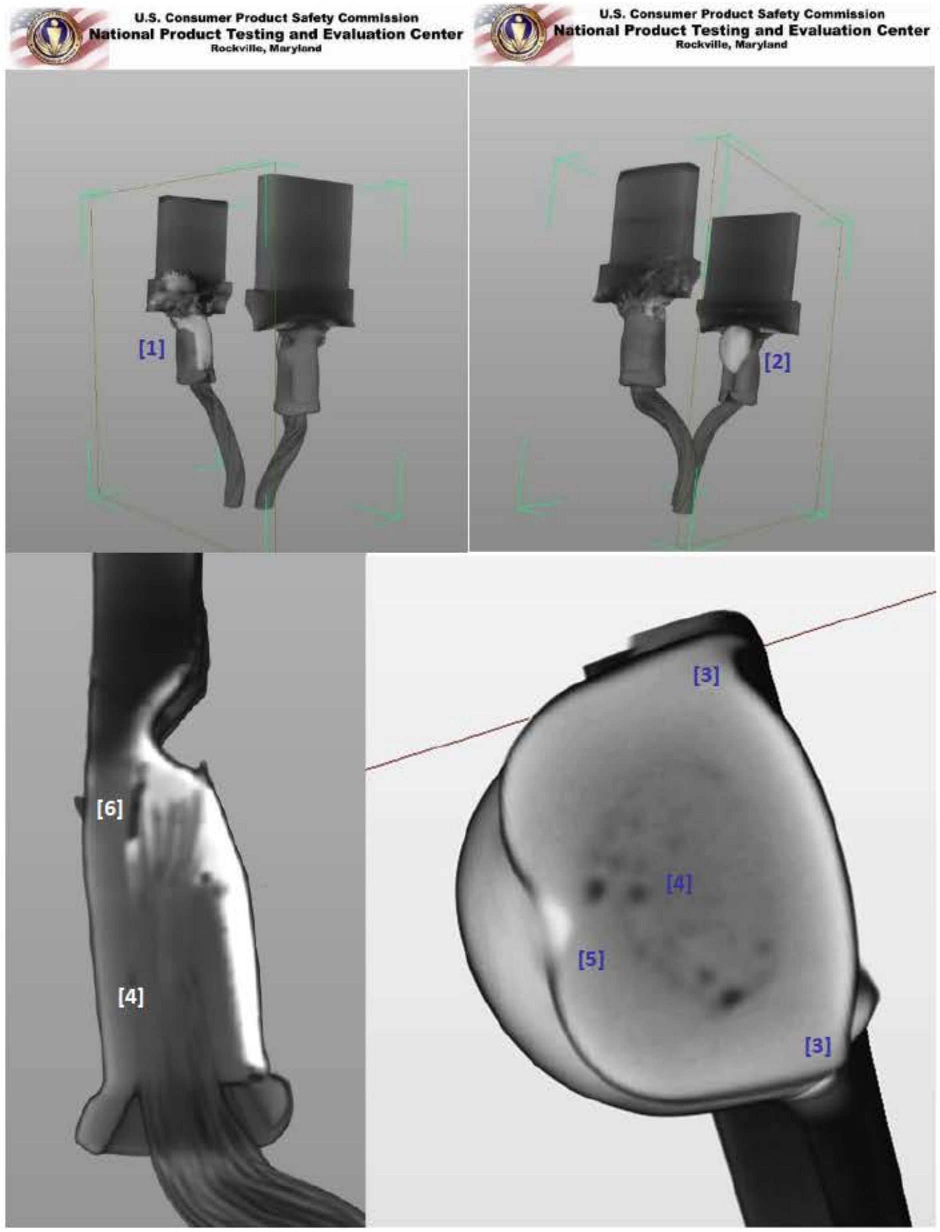
[2] Solder bead at top of wire strands.

[3] Uneven burrs/extrusions (sign of asymmetric crimp pressure).

[4] Voids in the crimp barrel.

[5] Uneven crimp barrel closure.

[6] Voids in the solder bond to terminal surface.



Incident - Sample 0090

This sample did not result in a fire during the temperature test.

A thermocouple was placed within the plug overmold between the blades.

An exemplar plug of the same construction (brand and make) was tested in the same manor.

[6] Steep rise in temperature after about 5 hours.

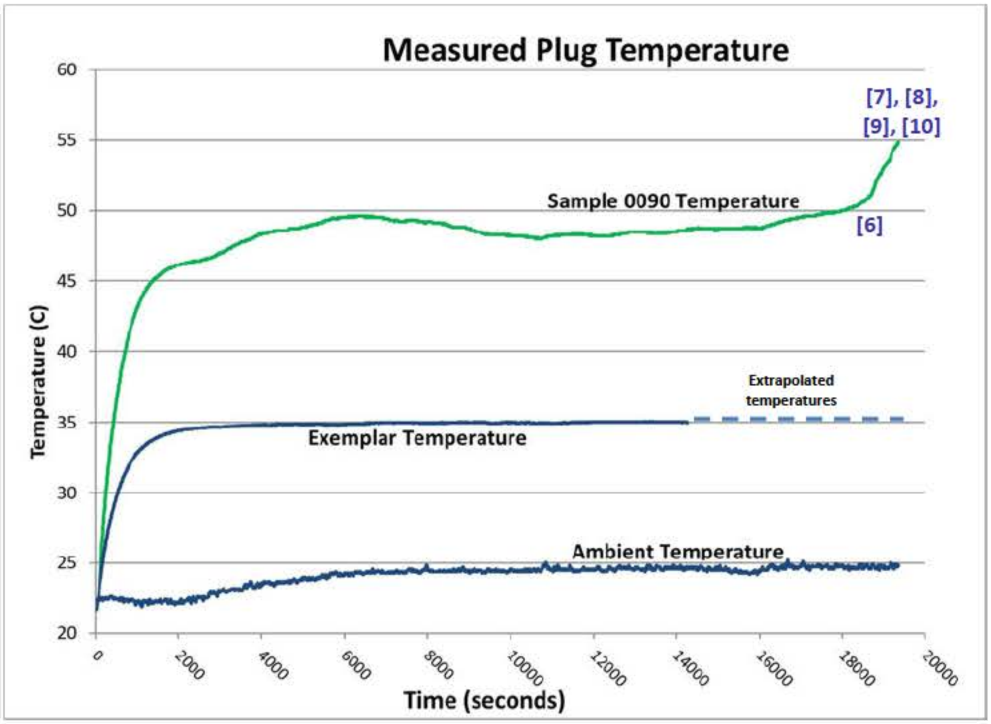
[7] The maximum temperature rise was 30.1° C @ about 5.4 hours (19340 seconds).

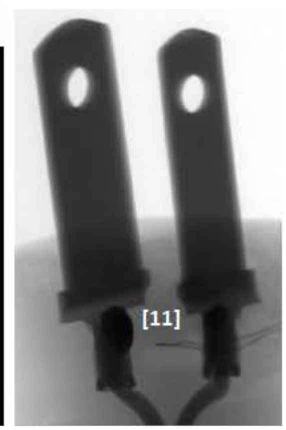
[8] The maximum temperature difference between incident and exemplar temperatures was 19.8° C @ about 5.4 hours (19340 seconds).

[9] The maximum temperature for the incident sample was 54.8° C @ about 5.4 hours (19340 seconds).

[10] The temperature leveled or declined after 19340 seconds.

[11] Thermocouple located between the plug blades within the plug overmold.





Incident - Sample 0803_01

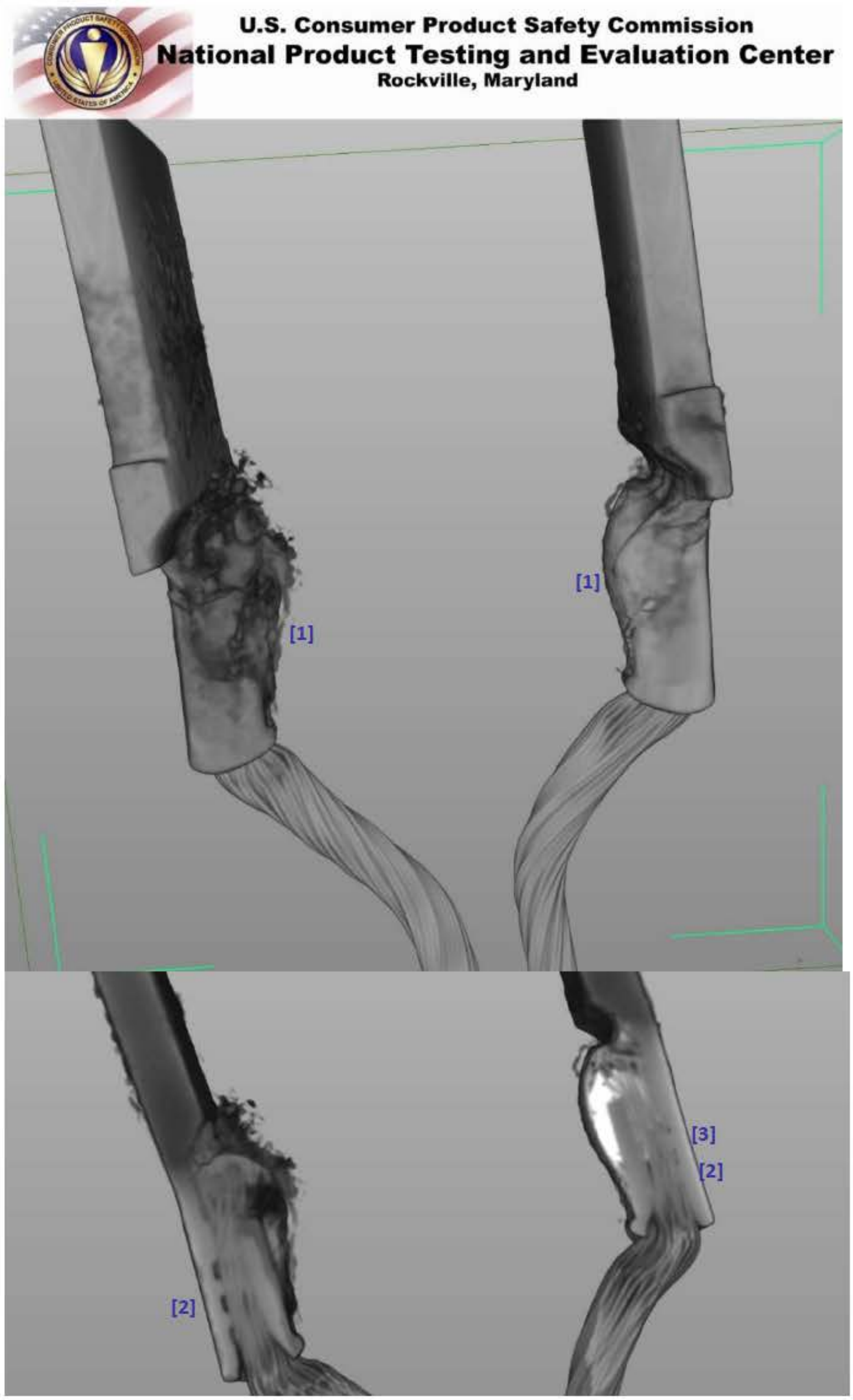
This sample did not result in a fire.

One of the blades showed signs of overheating, which resulted in deformation/melting plug overmold.

[1] Thermal damage surrounding the crimp connection. Solder had melted and solidified.

[2] Voids in the crimp barrel.

[3] Solder flow into main crimp area is an indication of insufficient crimp barrel pressure.



Incident - Sample 0803_01

This sample did not result in a fire during the temperature test.

A thermocouple was placed within the plug overmold between the blades.

An exemplar plug of the same construction (brand and make) was tested in the same manner.

[6] Steep rise in temperature after 3.5 hours.

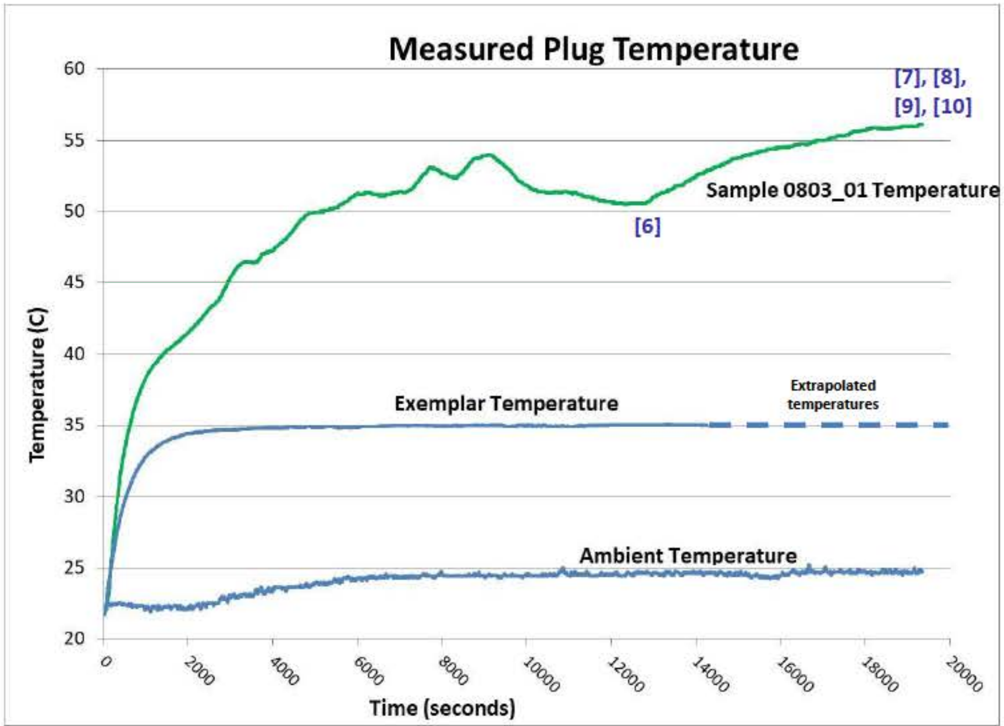
[7] The maximum rise above ambient temperatures was 31.5° C @ about 5.4 hours (19260 seconds).

[8] The maximum rise above exemplar temperatures was 19.8° C @ about 5.4 hours (19260 seconds).

[9] The maximum temperature for the incident sample was 54.8° C @ about 5.4 hours (19260 seconds).

[10] The temperature leveled or declined after 19260 seconds.

[11] Thermocouple located between the plug blades within the plug overmold.



Exemplar - Sample 0447

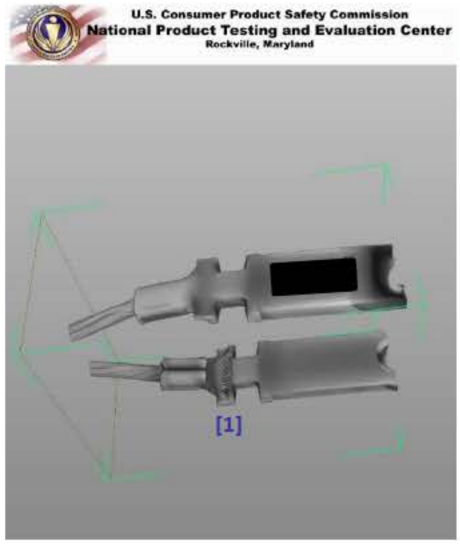
This is an exemplar sample. Crimp and weld configuration. (Note: Black box added to conceal manufacturer markings)

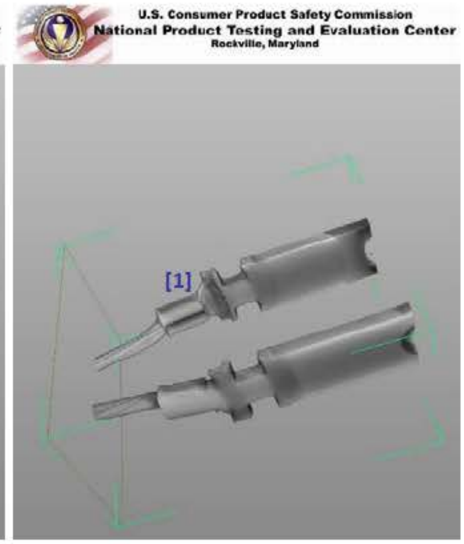
[1] For this sample, a bar weld is used across the wire strands.

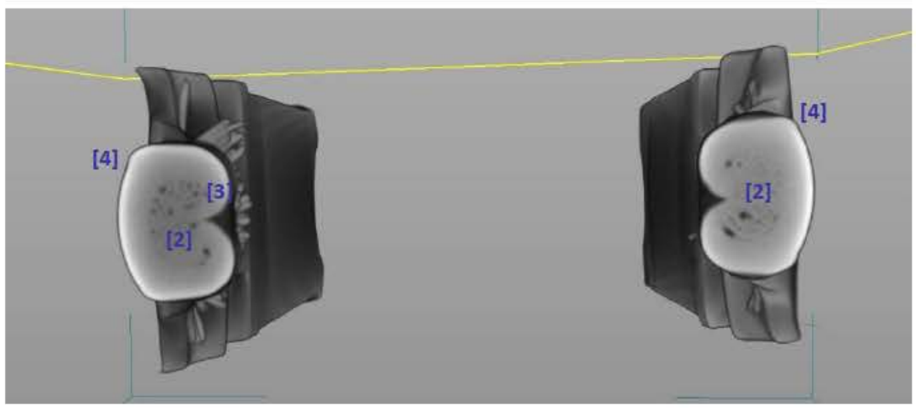
[2] Voids in the crimp barrel.

[3] Uneven crimp barrel closure.

[4] Lack of burrs/extrusions is an indication of insufficient crimp pressure to close crimp barrel.







Exemplar - Sample 2616b

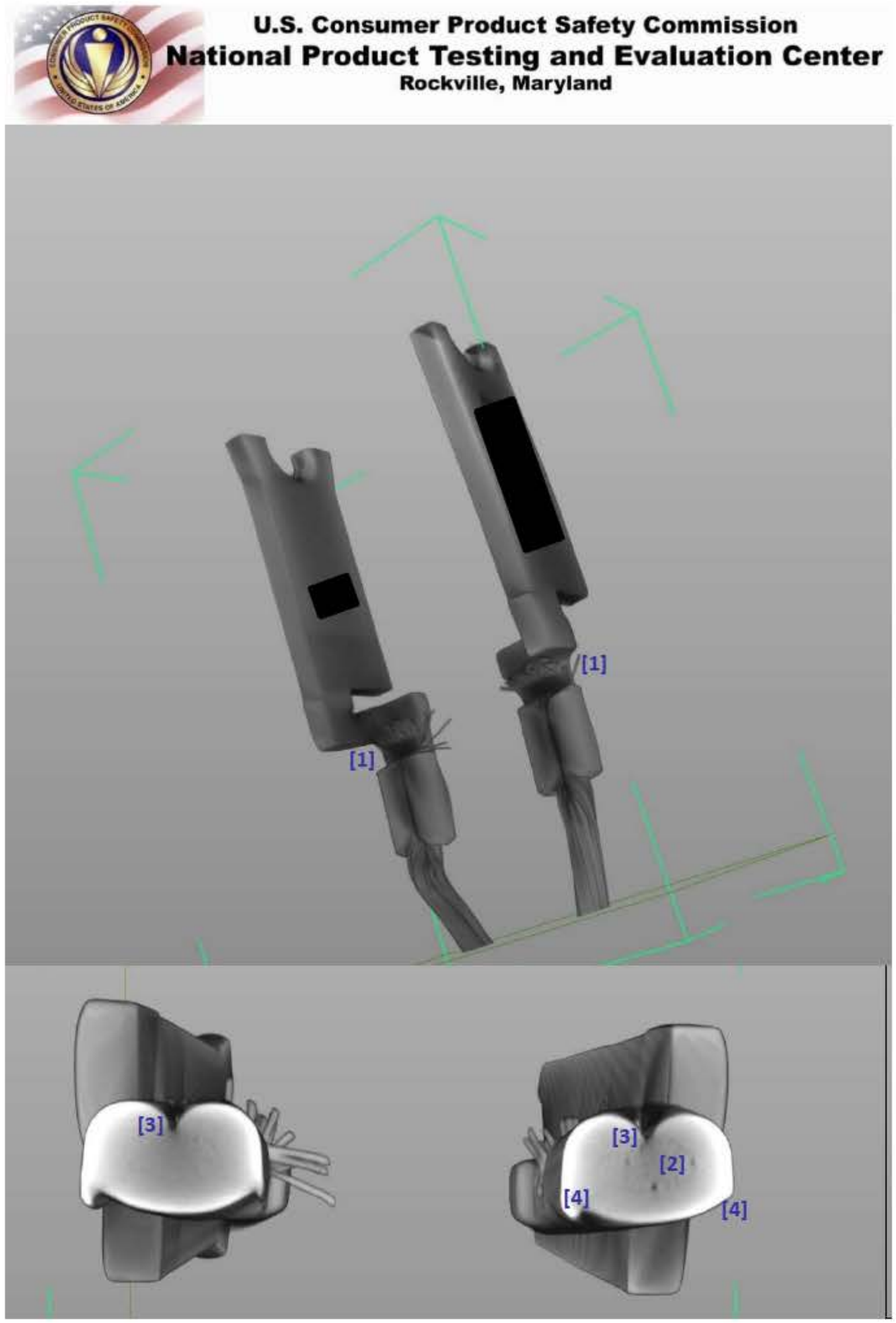
This is an exemplar sample. Crimp and weld configuration. (Note: Black box added to conceal markings

[1] For this sample, bar weld is used across the wire strands.

[2] Voids in the crimp barrel. Not all wire strands are deformed.

[3] Open crimp barrel. Crimp wings partially open and not touching.

[4] Asymmetric crimp. Uneven burrs/extrusions.



Exemplar - Sample 0446

This is an exemplar sample. Crimp and weld configuration.

[1] For this sample, bar weld is used across the wire strands.

[2] Crimp location not centered resulting in excessive bell formation.

[3] Voids in the crimp barrel.

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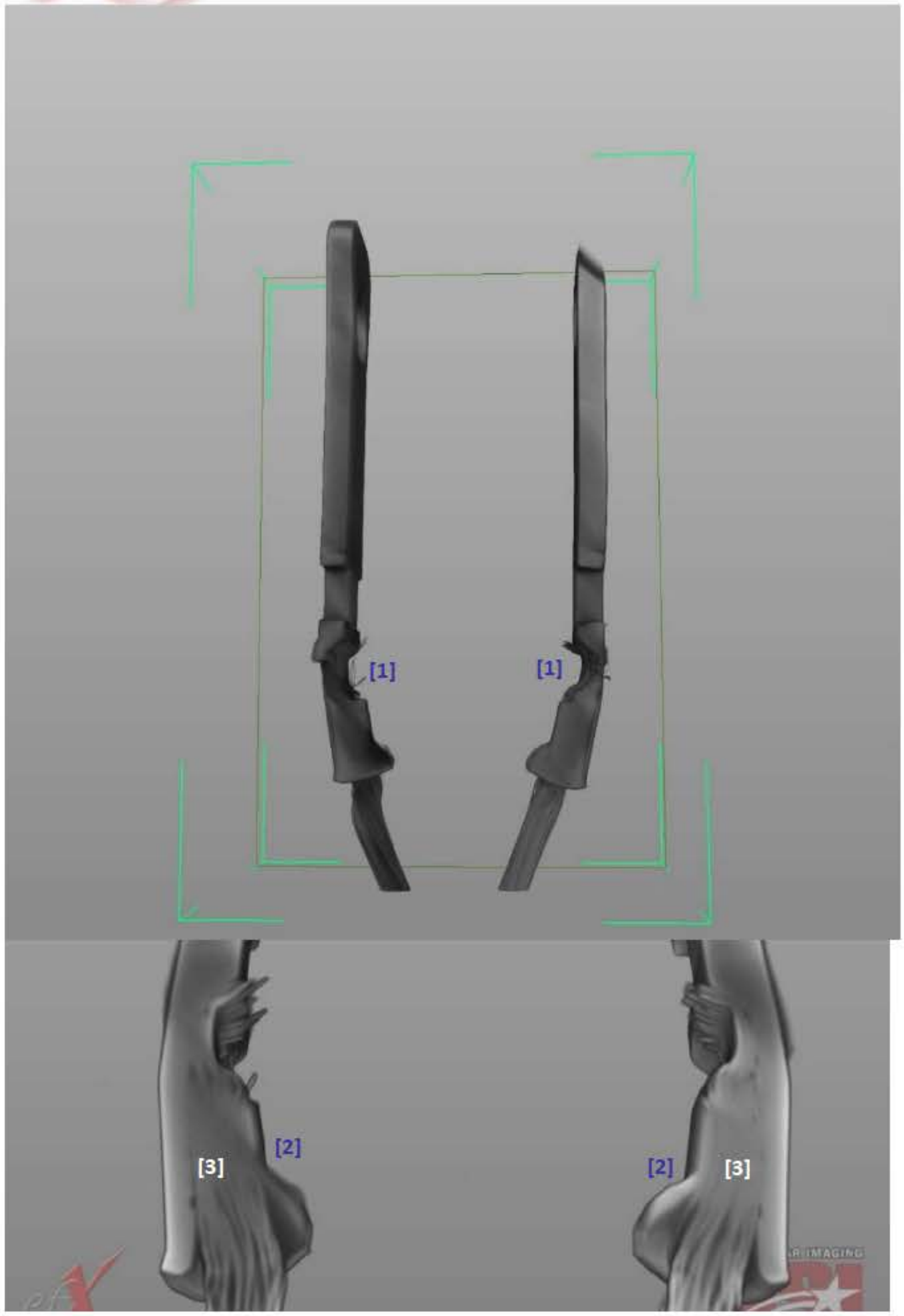
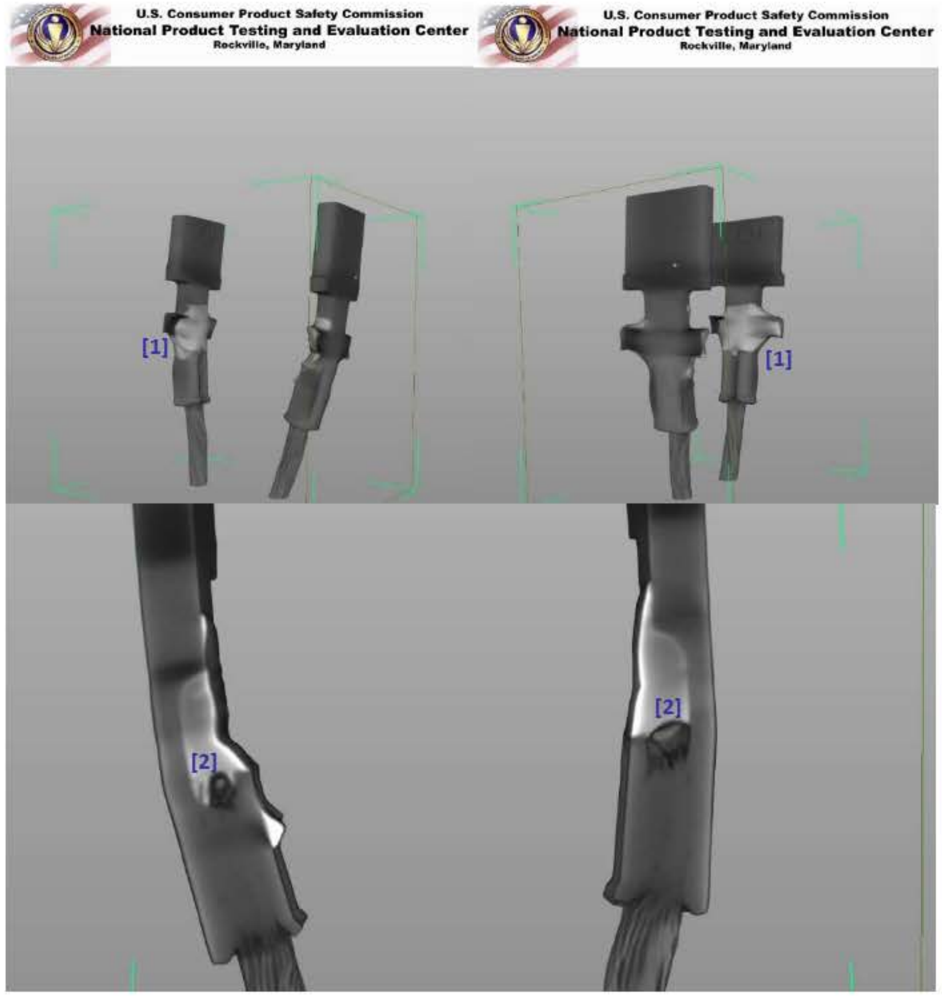


Exemplar - Sample 0689

This is an exemplar sample. Crimp and solder configuration.

[1] For this sample, solder is used to bond wire strands to terminal surface.

[2] Voids in the solder.



Exemplar - Sample 0869

This is an exemplar sample. Crimp and solder configuration.

[1] Surface solder. Solder does not penetrate through wire strands to terminal surfaces.

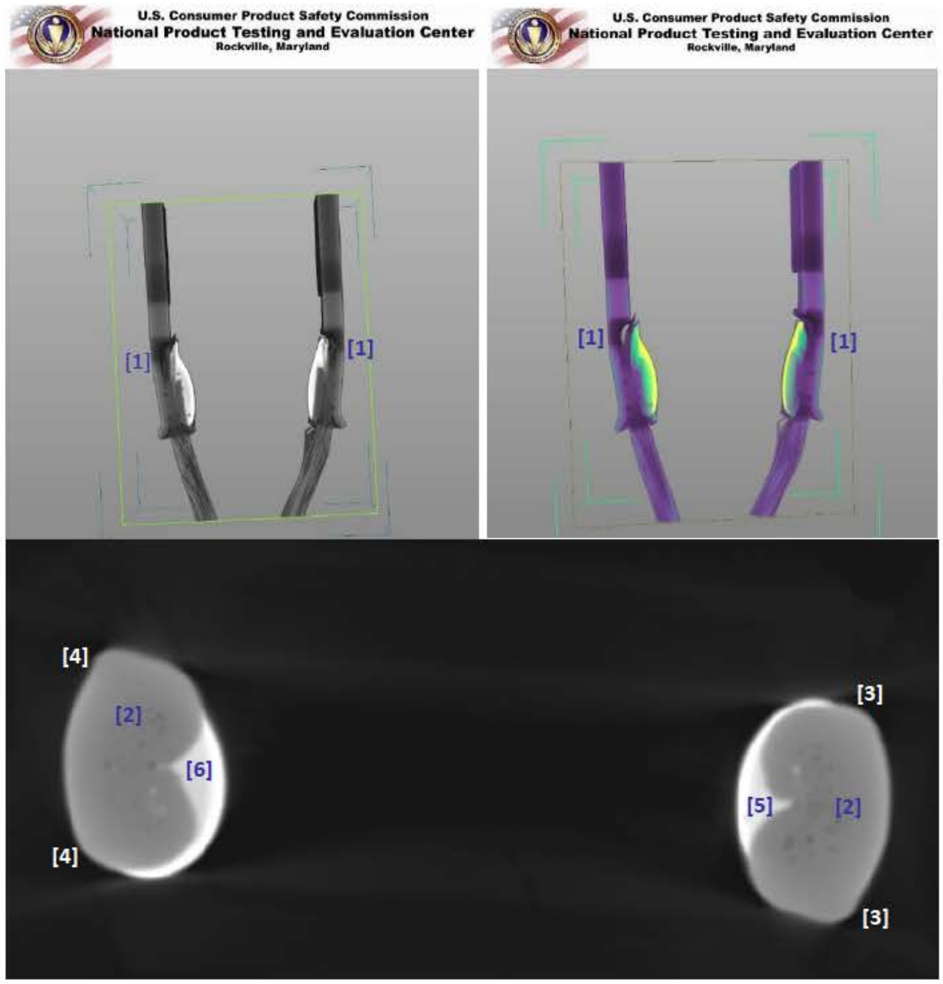
[2] Voids in the crimp barrel.

[3] No burrs.

[4] Asymmetric crimp. Uneven burrs/extrusions.

[5] Uneven crimp barrel closure.

[6] Open crimp barrel.



Exemplar - Sample 2796

This is an exemplar sample. Crimp and weld configuration.

[1] For this sample, bar weld is used across the wire strands.

[2] Crimp barrel not fully closed.

[3] Voids in the weld. Not all the strands are welded to the terminal surfaces.

[4] Asymmetric crimp. Uneven burrs/extrusions.

[5] Voids in the crimp barrel.

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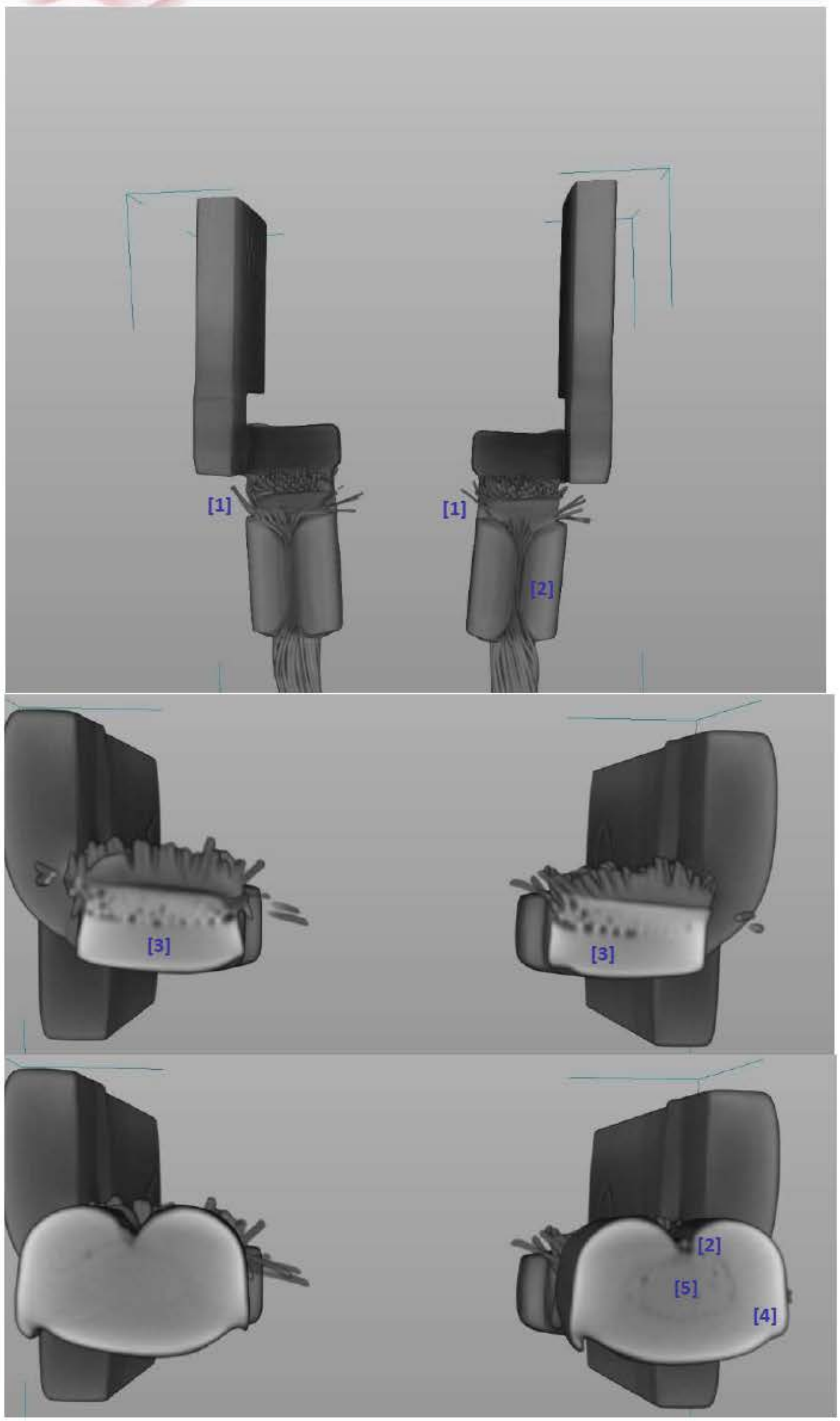


Exemplar - Sample 0020

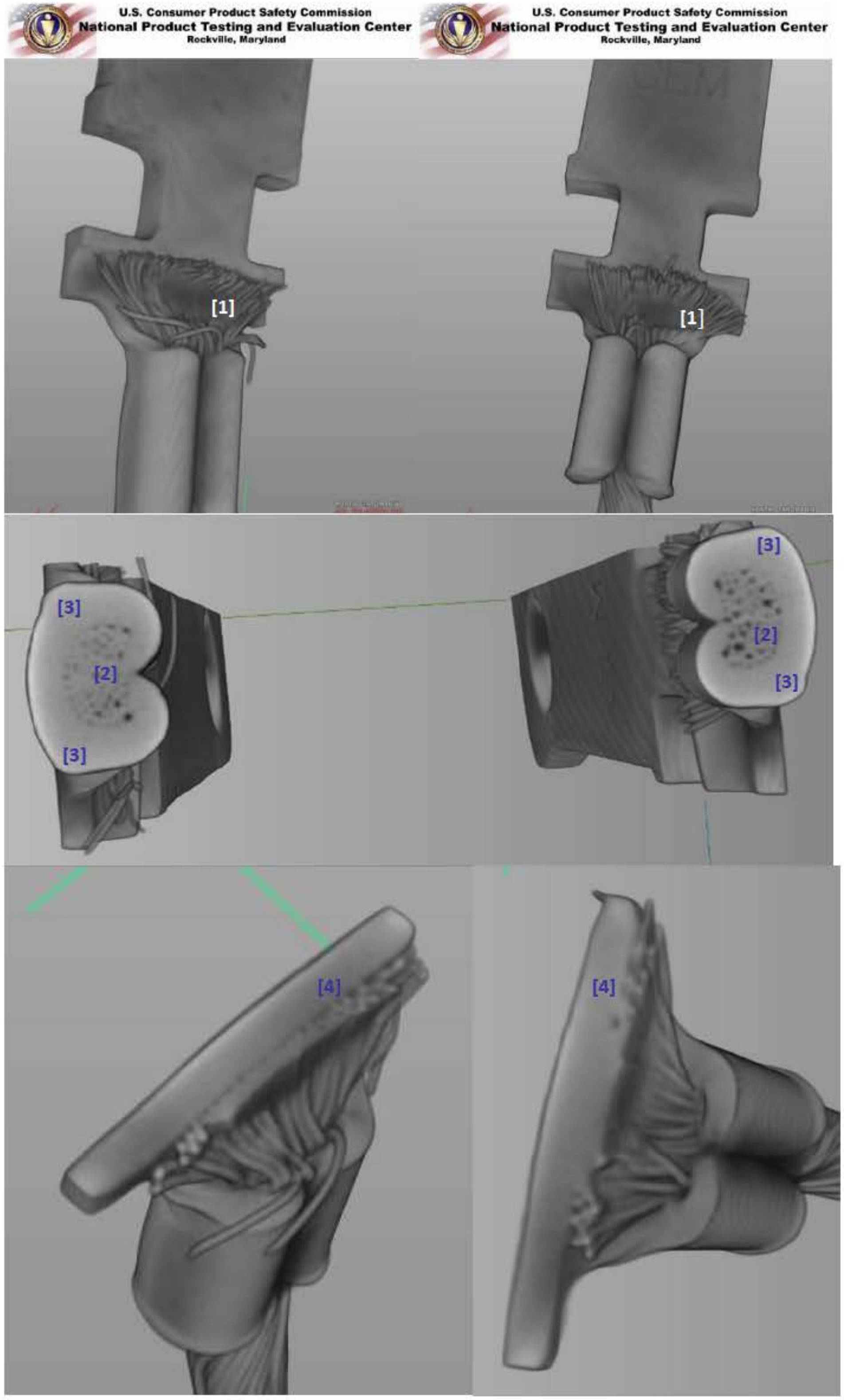
This is an exemplar sample. Crimp and weld configuration.

[1] Bar weld does not span the width of the wire strands.

[2] Voids in the crimp barrel.

[3] Asymmetric crimp. Uneven burrs/extrusions.

[4] Not all the strands are welded to the terminal surfaces.



Exemplar - Sample 0200

This is an exemplar sample. Crimp and solder configuration.

[1] Uneven solder.

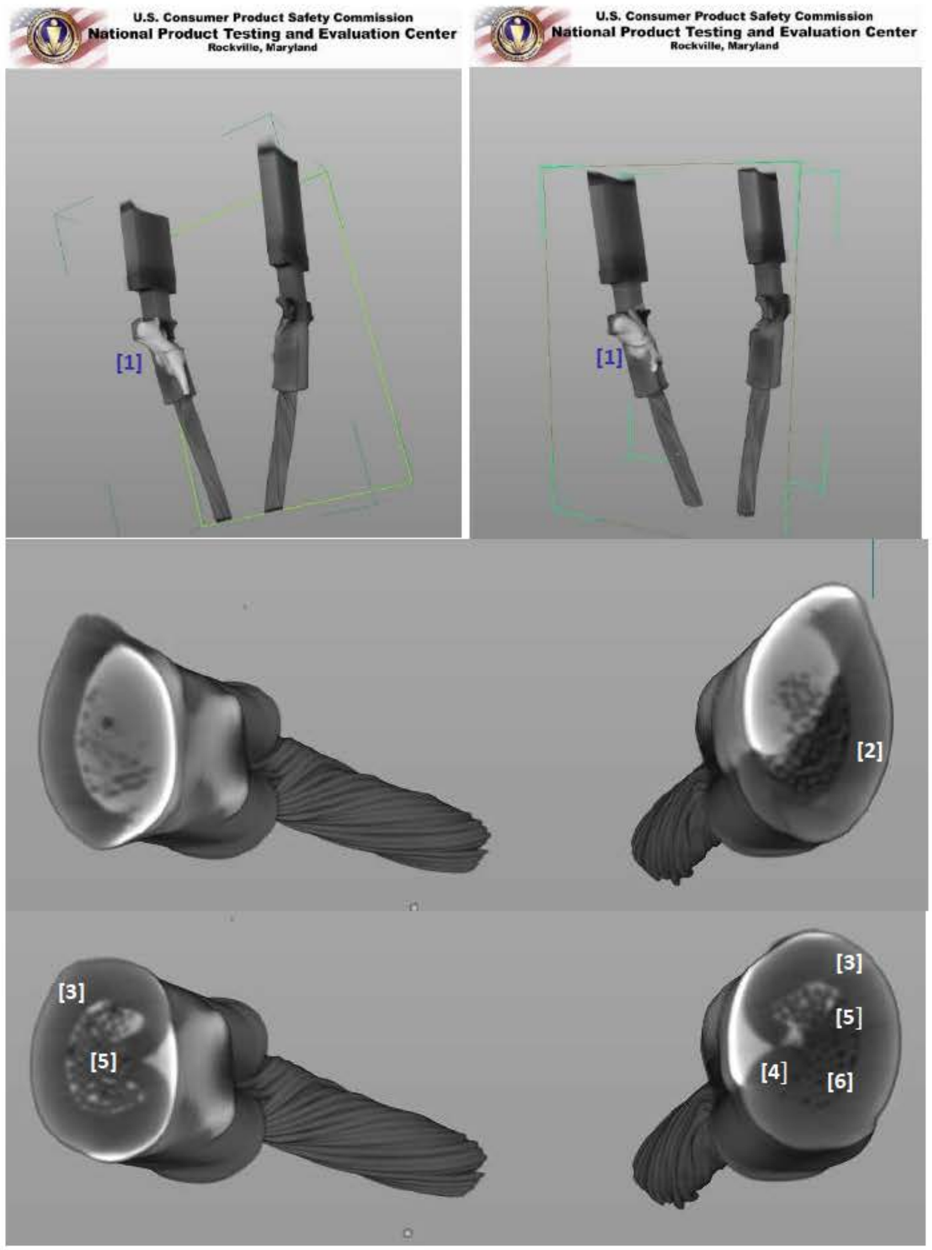
[2] Solder does not cover all the strands and insufficient bonding to the terminal surfaces.

[3] No burrs/extrusions.

[4] Asymmetric crimp barrel.

[5] Solder flow into main crimp area is an indication of insufficient crimp pressure.

[6] Voids in crimp barrel.



Exemplar - Sample 0718

This is an exemplar sample. Crimp and solder configuration.

[1] Solder beaded shape is an indication of insufficient heating of the crimp surfaces.

[2] Solder not fully penetrated into wire strands and not bonded to the terminal surfaces.

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