

RATE OF HEAT TRANSFER IN HYDROCOLLATOR PADS & GEL ICE PACK

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Abstract: Chattanooga corporation manufactures a product called a Hydrocollator that is a hot water tank into which silicon-filled packs are placed to heat up. These packs are used to apply moist heat in medical, chiropractic, and physical therapy offices. Many manufacturers make gel-filled ice packs designed to be placed in a freezer to cool, then applied to injured body parts for pain relief and swelling reduction. The issue is whether either device has the potential burn a patient both in normal use and in extended use beyond manufacturer's recommendations.

Results: The Hydrocollator pack retains heat sufficient to burn human skin for at least fifty minutes even with appropriate towels for insulation. The interface temperature between heat pack and body part is exactly the same at fifty minutes as the temperature of the actual Hydrocollator pack even with a manufacturer's terry cloth pad and twelve layers of additional terry cloth towel between heat pack and patient. The gel-filled ice pack does not retain cold properties long enough to cause frostbite to large body parts (e.g. leg). Also, the interface between ice pack and body part is not the same as the temperature of the ice pack itself, with the difference being 14.4 degrees within one minutes of application. The gel ice pack is 59 degrees after thirty-one minutes and room temperature after sixty minutes. Both the 31 minute and 60 minute temperatures of the gel ice pack are insufficient to cause frostbite.

Conclusions: Doctors and therapists must use a high degree of caution when using Hydrocollator packs on patients and follow standard guidelines of adequate insulation/towels and not exceed twenty minutes of continuous heat even with adequate insulation. Doctors and therapists should use mild caution with the use of gel ice packs, use appropriate insulation between and skin and the pack, and not repeat ice therapy continuously with freshly frozen gel ice packs. One single gel ice pack generally lacks the heat transfer capacity to cause frostbite or ice burn with a single application and a waiting period of at least thirty minutes between applications because the gel ice pack becomes room temperature within one hour of application.

TESTING PROCEDURES FOR HYDROCOLLATOR PACK

On April 24, 2008, I took a standard heat pack out of my own Hydrocollator unit, place it inside the original equipment Hydrocollator pad that comes with the unit, placed three hand-towel size terry cloth towels (folded into quarters, thus making 12 thicknesses of towel) against the pad and placed it on a table with 3 inches of foam covered by vinyl.

I place my scientific thermometer against the hydrocollator pack, between the pack itself and the towels used for insulation, and started a stopwatch. I used the stopwatch to allow me to measure the temperature every minute for 50 minutes, again at 63 minutes, 82 minutes, 91 minutes, 106 minutes, 120 minutes, and 130 minutes. I also recorded at 50 minutes the temperature on the *outside* of the towels by placing the thermometer between the outside towel and the pad of the

table upon which it was resting. The temperatures of the hot pack itself and the interface between the outside towel and the tabletop were both 132.8 (F), exactly the same.

The scientific thermometer is calibrated in Celsius so I recorded the temperature and then converted it to Fahrenheit degrees using the formula $[(A + 40) \times 9 / 5] - 40$.

HYDROCOLLATOR PACK MEASUREMENTS

<u>Time</u>	<u>Temperature (F)</u>	<u>Time</u>	<u>Temperature (F)</u>
1 minute	147.0	32 minutes	138.2
2 minutes	154.4	33 minutes	138.2
3 minutes	154.4	34 minutes	136.4
4 minutes	154.4	35 minutes	136.4
5 minutes	154.4	36 minutes	136.4
6 minutes	154.4	37 minutes	136.4
7 minutes	154.4	38 minutes	136.4
8 minutes	154.4	39 minutes	136.4
9 minutes	154.4	40 minutes	136.4
10 minutes	154.4	41 minutes	134.6
11 minutes	152.6	42 minutes	134.6
12 minutes	152.6	43 minutes	134.6
13 minutes	152.6	44 minutes	134.6
14 minutes	152.6	45 minutes	134.6
15 minutes	150.8	46 minutes	132.8
16 minutes	150.8	47 minutes	132.8
17 minutes	150.8	48 minutes	132.8
18 minutes	149.0	49 minutes	132.8
19 minutes	149.0	50 minutes	132.8
20 minutes	147.2	63 minutes	131.0
21 minutes	147.2	82 minutes	124.7
22 minutes	147.2	91 minutes	122.0
23 minutes	145.4	106 minutes	117.5
24 minutes	143.6	120 minutes	113.0
25 minutes	143.6	130 minutes	109.4
26 minutes	141.8		
27 minutes	141.8		
28 minutes	141.8		
29 minutes	140.0		
30 minutes	140.0		

Note: at fifty minutes, I placed my left fingertips (digits 2, 3, and 4) against the pack and touched for as long as I could. I had to remove my fingers at eleven (11) seconds because it got too hot. About 30 seconds later my fingertips were still uncomfortable so I had to run cool water from a faucet over them for about 30 seconds. The result was a first degree burn of my fingertips with desensitization and mild pain (similar to a sunburn) for at least 18 hours.

OPINIONS AND CONCLUSIONS ABOUT HYDROCOLLATOR PACK FINDINGS

1. After two hours and ten minutes, the temperature of the Hydrocollator pack was still three degrees hotter than is permissible for a Jacuzzi or hot tub.
2. After fifty minutes, I burned my own fingers by holding them directly against Hydrocollator pack (not against the towels) for eleven (11) *seconds*. Eighteen hours after this experiment I would assess my fingers as having a first degree burn.
3. The temperature of the room in which the experiment was performed was 68 F. The difference between room temperature and the head pack was 86.4 F at its peak (2 minutes). Therefore, the heat pack lost only 25% of its heat during the first 50 minutes after removal from the heat source (water tank.) The heat retention of a Hydrocollator is, therefore, 75% after fifty minutes.

ICE PACK MEASUREMENTS

I obtained a gel-filled ice pack and placed it in the freezer of my office's refrigerator for 24 hours. I removed it and placed it directly on my leg with a fabric covering approximately as thick as a t-shirt. I placed my scientific thermometer between the ice pack and the fabric covering over my skin and left it on my leg for 31 minutes. I recorded the temperature every minute for the first 31 minutes, then at 60 minutes. I also recorded the temperature of my skin upon removal of the ice pack at the 31 minute mark as well as the ice pack by itself wrapped around the thermometer at the 31 minute mark.

<u>Time</u>	<u>Temperature (F)</u>	<u>Time</u>	<u>Temperature (F)</u>
0 minutes	32.0	17 minutes	53.6
1 minute	46.4	18 minutes	53.6
2 minutes	46.4	19 minutes	54.5
3 minutes	46.4	20 minutes	54.5
4 minutes	46.4	21 minutes	55.4
5 minutes	46.4	22 minutes	55.4
6 minutes	47.3	23 minutes	56.3
7 minutes	48.2	24 minutes	57.2
8 minutes	48.2	25 minutes	57.2
9 minutes	49.1	26 minutes	57.2
10 minutes	50.0	27 minutes	57.2
11 minutes	50.9	28 minutes	57.2
12 minutes	50.9	29 minutes	58.1
13 minutes	51.8	30 minutes	58.1
14 minutes	51.8	31 minutes	59.0
15 minutes	52.7	60 minutes	68.0 degrees (room temp)
16 minutes	52.7		

Temperature of my skin after 31 minutes was measured as 64.4 degrees Fahrenheit
Temperature of the ice pack after 31 minutes was measured as 59.0 degrees (measured 2nd after skin temperature was measured and by wrapping the ice pack around the thermometer.)
Temperature of the ice pack after 60 minutes was measured as 68 degrees.

OPINIONS AND CONCLUSIONS REGARDING ICE PACK MEASUREMENTS

Although the temperature of the ice pack taking directly out of the freezer was 32 degrees Fahrenheit (freezing point of water), within *one minute* after applying it to my leg the measured temperature of the pack against my leg rose to 14.6 degrees to 46.4. Therefore, it is physiologically impossible for this gel ice pack to crystallize water in my skin (the first stage of frostbite or ice burn).

I left the ice pack directly against my own leg for 31 minutes (with the thin cloth insulator) with no discomfort. As I type this report approximately five hours after the removal of the ice pack I have no discomfort in the area and completely normal sensation in the area of application. Comparing that to my experience with the Hydrocollator pack, I touched the heat pack with my fingers for 11 seconds *after the heat pack had been outside of the Hydrocollator water tank for 50 minutes* and my fingers still feel numb and slightly burned still more than 5 hours after it happened. I am paying special attention to my sensation in the left pinky finger and comparing it to the three fingers that touched the Hydrocollator pack and the pinky finger feels normal and much more sensitive to touch than that other three.

I stopped the ice pack testing at 31 minutes because I play golf in my shirtsleeves when the temperature is 59 degrees. Common sense told me that frostbite cannot possibly occur at a temperature at which I go outside in a golf shirt and short pants and walk around a golf course for 5 hours.

After 60 minutes (31 minutes applied to my leg and 29 minutes sitting out at a room temperature of 74 degrees), the gel ice pack measured 68 degrees. Common sense tells me that 68 degrees is a nice and reasonably warm day in Southern California and is highly unlikely to cause frostbite.

The gel ice pack lost 20.7 degrees of temperature within 15 minutes. Comparing that heat transfer to the Hydrocollator pack, it took 41 minutes for the heat pack to also lose 20 degrees.