

PURPOSE

To determine the amount of time and volume of LN2 required to freeze eight supplied bottles filled with tap water from room temperature (20°C) to -80°C using the MVE Vario 1536P freezer.

PROCEDURE

Eight supplied 1L Nalgene bottles were filled with tap water at room temperature. A hole was drilled through one bottle cap to accommodate a Pt-1000 temperature probe for monitoring the bottle temperature. A MVE Vario 1536P freezer was setup to operate between -80°C and -90°C with a DuraCyl 180 22 PSI cylinder as the LN2 supply. Once the MVE Vario reached operating temperature, four racks containing the eight bottles were introduced into the freezer chamber. The temperature of the bottle and the MVE Vario chamber were monitored and the LN2 supply cylinder was weighed to determine the volume used.

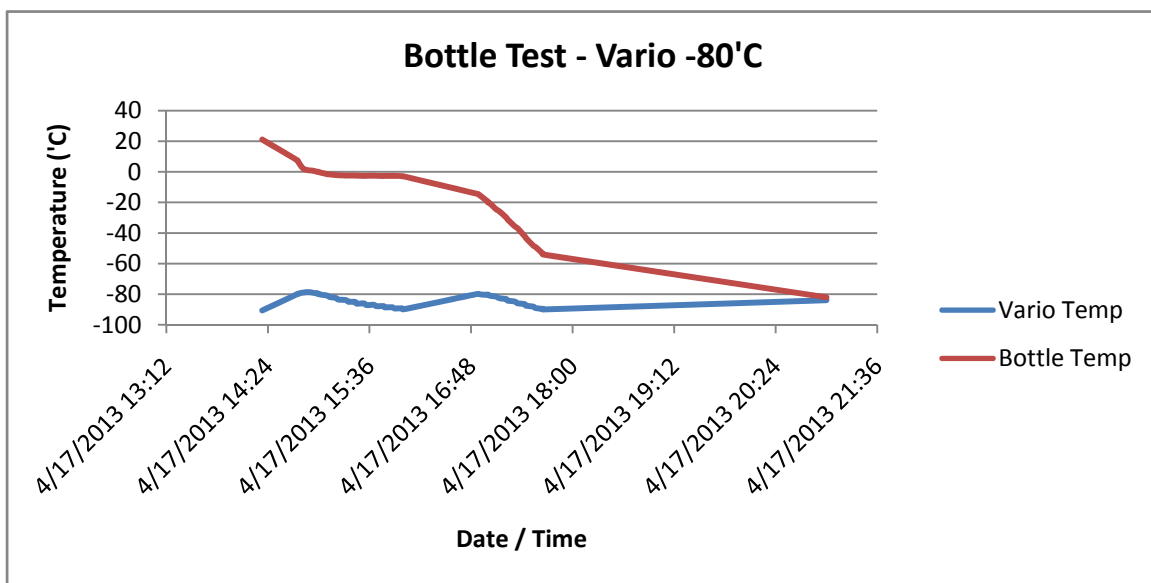
The test was then repeated with the MVE Vario freezer setup to operate between -140°C and -150°C.

RESULTS

With the MVE Vario operating temperature at -80°C to -90°C, 6 hr 40 min and approximately 51L of LN2 were required for the bottle temperature to reach -80°C from 20°C. Once the bottle temperature reached -80°C, it began to track with the MVE Vario chamber temperature. Approximately 10L of LN2 per day was required to maintain the MVE Vario 1536P at an operating range of -80°C to -90°C under static conditions.

MVE Vario -80°C Operating Temperature

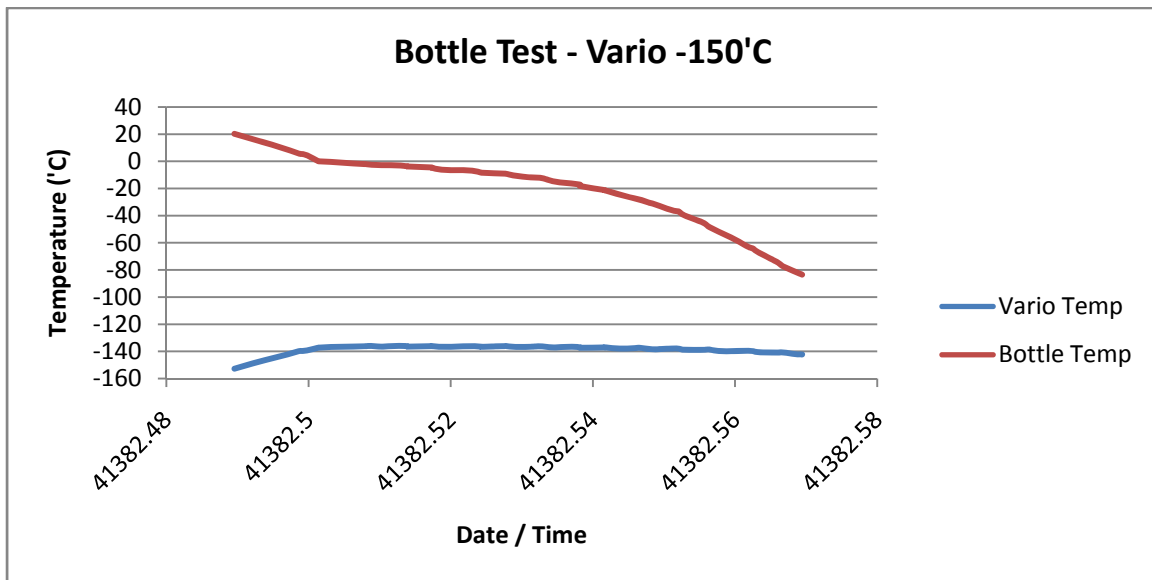
20°C to -80°C	Time	Delta LN2 Supply	LN2 Used
Bottle - Qty 8	6 hr 40 min	90 lbs	51 L



With the MVE Vario operating temperature at -140°C to -150°C, the bottles required 1 hr 53 min and approximately 48L of LN2 to reach -80°C from 20°C. Once the bottle temperature reached -80°C, it continued to get colder and approach the MVE Vario chamber temperature. Approximately 20L of LN2 per day was required to maintain the MVE Vario 1536P at an operating range of -140°C to -150°C under static conditions.

MVE Vario -150°C Operating Temperature

20°C to -80°C	Time	Delta LN2 Supply	LN2 Used
Bottle - Qty 8	1 hr 53 min	85 lbs	48 L



CONCLUSION

The MVE Vario 1536P was able to freezer the eight Nalgene bottles to -80°C in under 7 hours and as little as 2 hours. Depending on the desired procedure, further optimization at both MVE Vario operating temperatures is possible.

DATA**-80°C to -90°C Data:**

Date / Time	Vario Temp	Bottle Temp
4/18/2013 4:09	-81.6	-81.4
4/18/2013 4:04	-81	-80.7
4/18/2013 4:01	-80	-80.5
4/18/2013 4:01	-79.9	-80.5
4/18/2013 1:00	-81.7	-82
4/17/2013 21:00	-83.9	-82
4/17/2013 17:39	-90	-54
4/17/2013 17:39	-89.6	-53.6
4/17/2013 17:34	-89.1	-49.3
4/17/2013 17:32	-88.1	-48.1
4/17/2013 17:27	-87.5	-43.3
4/17/2013 17:26	-86.5	-42
4/17/2013 17:21	-85.9	-36.9
4/17/2013 17:19	-84.8	-35.6
4/17/2013 17:14	-84.2	-31.1
4/17/2013 17:13	-83.2	-29.9
4/17/2013 17:08	-82.6	-25.7
4/17/2013 17:06	-81.6	-24.6
4/17/2013 17:02	-81.1	-21.1
4/17/2013 17:00	-80.4	-20
4/17/2013 17:00	-80.3	-19.5
4/17/2013 16:56	-80.3	-16.6
4/17/2013 16:53	-79.8	-14.5
4/17/2013 16:52	-79.9	-14.3
4/17/2013 16:00	-89.9	-2.9
4/17/2013 15:59	-89.2	-2.8
4/17/2013 15:54	-89.3	-2.6
4/17/2013 15:52	-88.5	-2.6
4/17/2013 15:47	-88.6	-2.6
4/17/2013 15:46	-87.8	-2.7
4/17/2013 15:41	-87.8	-2.6
4/17/2013 15:39	-86.9	-2.5
4/17/2013 15:34	-87.1	-2.6
4/17/2013 15:32	-86	-2.6
4/17/2013 15:27	-86.2	-2.5
4/17/2013 15:26	-85.1	-2.4
4/17/2013 15:22	-84.9	-2.4
4/17/2013 15:22	-84.9	-2.4

4/17/2013 15:21	-84.9	-2.4
4/17/2013 15:19	-83.8	-2.4
4/17/2013 15:14	-83.5	-2.2
4/17/2013 15:12	-82.4	-2.1
4/17/2013 15:08	-81.9	-1.7
4/17/2013 15:06	-80.9	-1.5
4/17/2013 15:01	-80.2	-0.4
4/17/2013 15:00	-79.8	0
4/17/2013 15:00	-79.7	0
4/17/2013 14:59	-79.5	0
4/17/2013 14:59	-79.5	0
4/17/2013 14:59	-79.6	0
4/17/2013 14:59	-79.6	0
4/17/2013 14:55	-78.9	0.9
4/17/2013 14:53	-78.7	1
4/17/2013 14:49	-78.9	2.2
4/17/2013 14:45	-79.8	7.2
4/17/2013 14:45	-79.9	7.5
4/17/2013 14:20	-90.6	21.1

-140°C to -150°C Data:

Date / Time	Vario Temp	Bottle Temp
4/18/2013 13:40	-142.3	-83.5
4/18/2013 13:38	-141.8	-80.4
4/18/2013 13:36	-140.7	-77.1
4/18/2013 13:35	-140.9	-74.4
4/18/2013 13:31	-140.6	-66.8
4/18/2013 13:30	-139.8	-64.2
4/18/2013 13:29	-139.6	-62.9
4/18/2013 13:25	-139.9	-55
4/18/2013 13:23	-139.7	-51.8
4/18/2013 13:21	-138.6	-48
4/18/2013 13:20	-138.9	-45.3
4/18/2013 13:16	-138.8	-39.6
4/18/2013 13:15	-138	-37
4/18/2013 13:14	-137.9	-36.5
4/18/2013 13:10	-138.5	-31.5
4/18/2013 13:09	-138.3	-30.5
4/18/2013 13:07	-137.4	-28.1
4/18/2013 13:05	-137.9	-26.5

4/18/2013 13:02	-137.8	-23.4
4/18/2013 13:00	-137	-21.4
4/18/2013 13:00	-137.1	-21.3
4/18/2013 12:55	-137.4	-18.2
4/18/2013 12:55	-137	-17.2
4/18/2013 12:53	-136.6	-16.3
4/18/2013 12:50	-137.1	-15.1
4/18/2013 12:49	-137	-14.2
4/18/2013 12:47	-136.3	-12.2
4/18/2013 12:45	-136.6	-11.9
4/18/2013 12:42	-136.8	-10.7
4/18/2013 12:40	-136.1	-9.2
4/18/2013 12:40	-136.1	-9.2
4/18/2013 12:35	-136.7	-8.4
4/18/2013 12:35	-136.6	-8.4
4/18/2013 12:33	-136.1	-6.8
4/18/2013 12:30	-136.6	-6.6
4/18/2013 12:27	-136.6	-6.2
4/18/2013 12:25	-136.1	-4.8
4/18/2013 12:25	-136.2	-4.6
4/18/2013 12:20	-136.5	-3.8
4/18/2013 12:20	-136.2	-3.7
4/18/2013 12:18	-136	-3
4/18/2013 12:15	-136.5	-2.9
4/18/2013 12:14	-136.4	-2.8
4/18/2013 12:13	-136.1	-2.6
4/18/2013 12:12	-136.1	-2.2
4/18/2013 12:10	-136.5	-1.9
4/18/2013 12:08	-136.5	-1.3
4/18/2013 12:06	-136.6	-0.8
4/18/2013 12:05	-136.8	-0.6
4/18/2013 12:02	-137.3	0
4/18/2013 12:02	-137.3	0
4/18/2013 12:00	-139.1	3.9
4/18/2013 11:59	-139.7	5.2
4/18/2013 11:58	-139.9	5.7
4/18/2013 11:55	-143	9.5
4/18/2013 11:50	-147.6	14.9
4/18/2013 11:45	-152.8	20.2