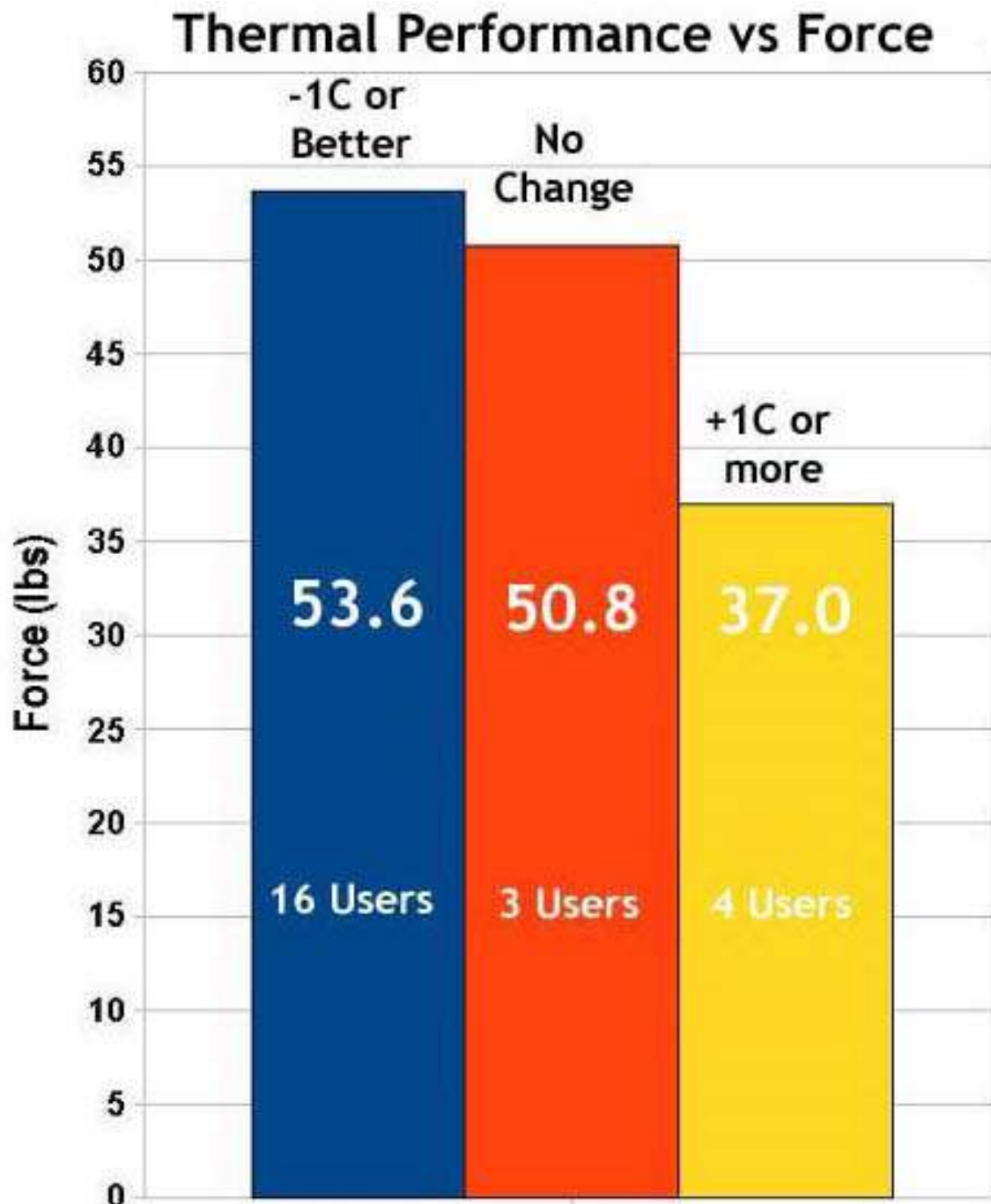


## Combined Thermal and Contact Tests

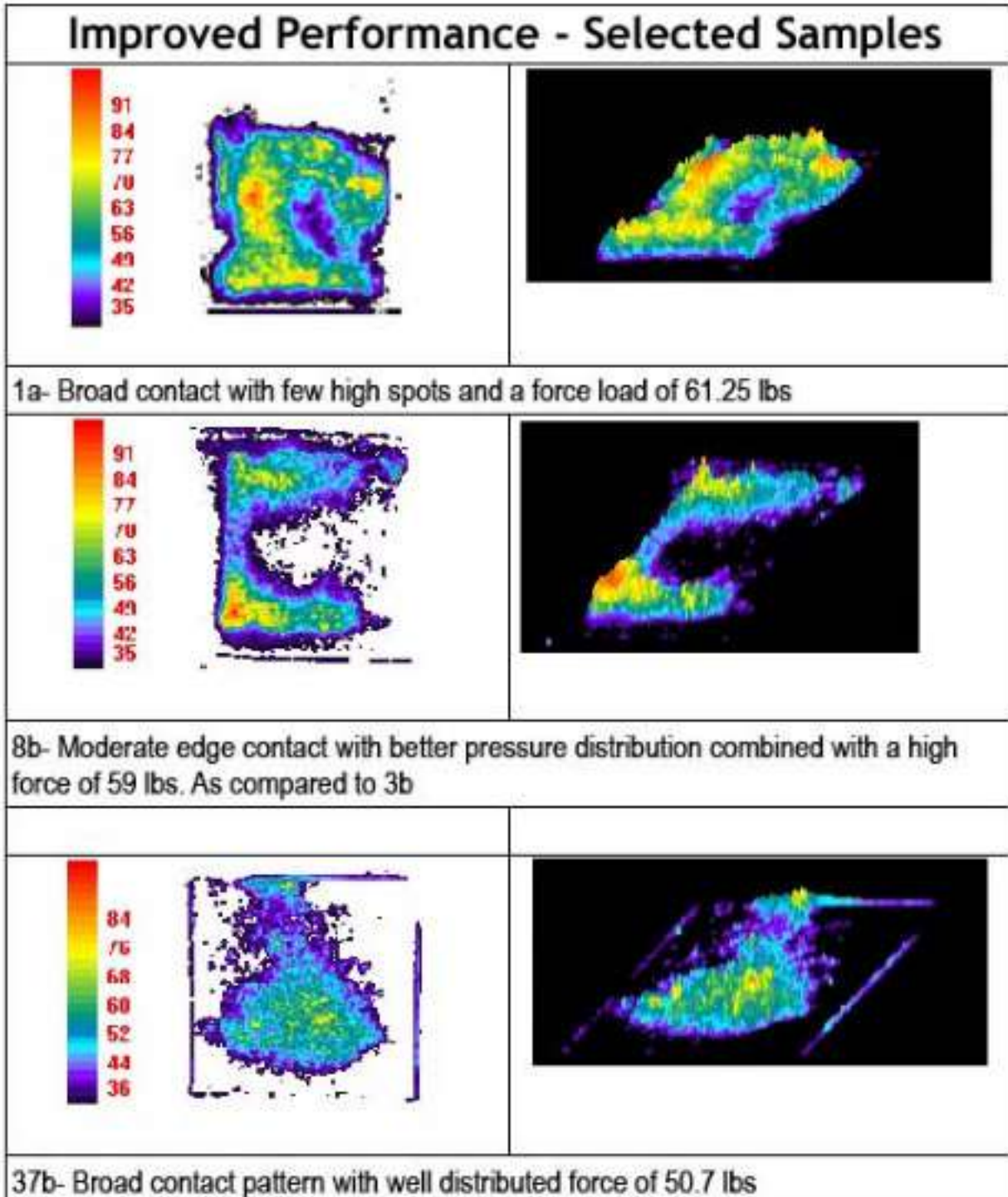
As a continuation of work to better understand the dynamics impacting thermal grease performance, tests were conducted by users in four different forums using contact pressure film from Sensor Products. The total span of temperatures in the sample group ranged from **-5°C to +3.9°C, a non trivial 9°C spread**. Results show that careful attention to contact and pressure can yield significant benefits - as much as the difference between a stock heat sink and an expensive, high performance heat sink. Forces over 60 lbs will not yield significant performance gains



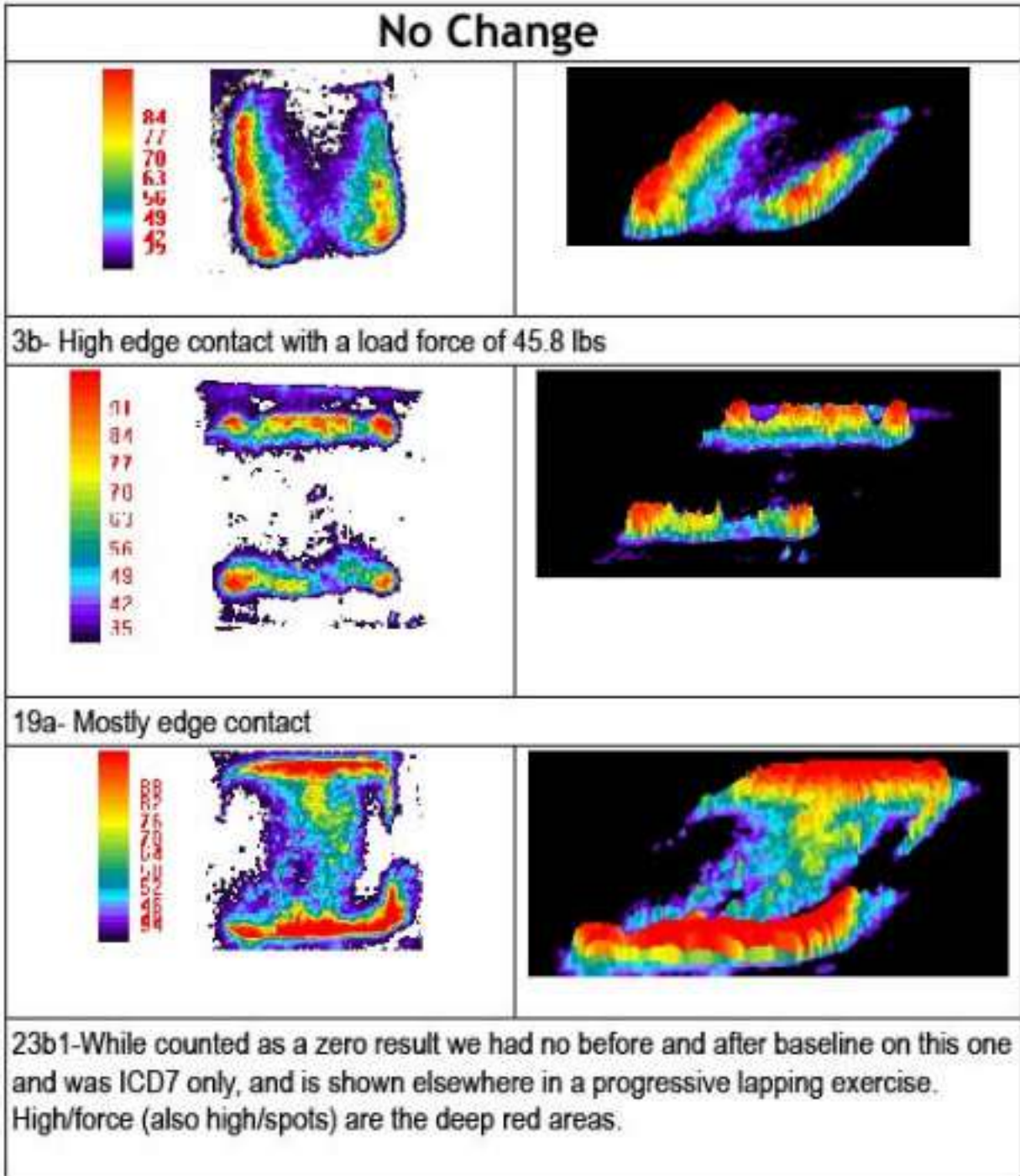
The test involved inserting pressure sensitive film to record mounting force between the heatsink and CPU after installing the heatsink on the CPU. The film records pressures on the IHS from 28 to 98 pounds, which is translated into data, two and three dimensional images by Sensor Products for analysis.

The results below are selected samples; samples not included were multiples of the same heatsink and CPU mount or those that appear to have been roughly handled in shipping and look to be over exposed; others that were lacking complete thermal data were not included.

In most cases, improved performance is indicated by total force loads above 45 lbs, averaging 53.6 lbs for 16 users. The contact images show broad, even contact with few high spots:

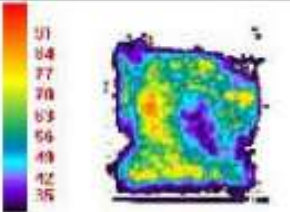
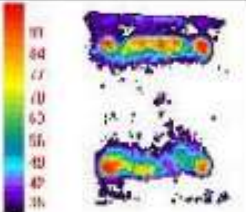
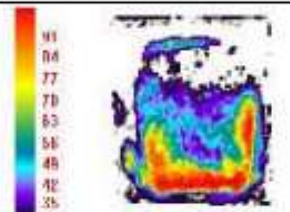
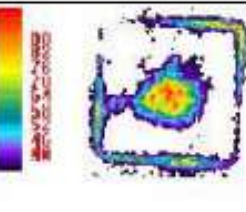
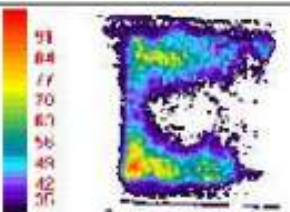
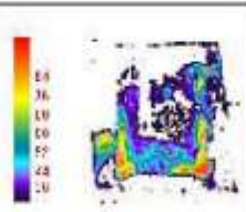
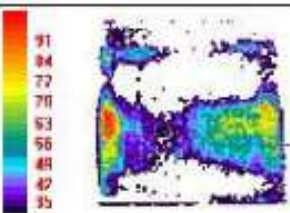
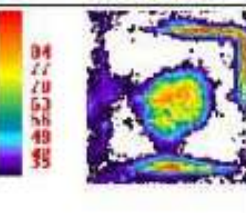
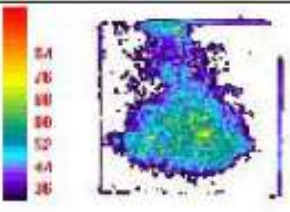
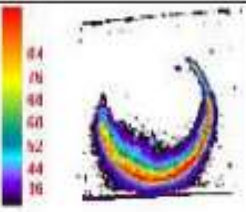
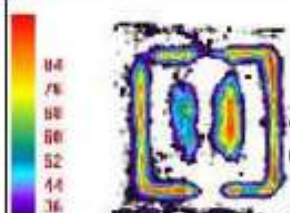
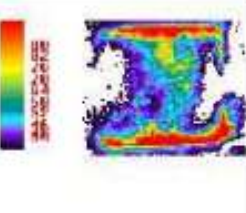


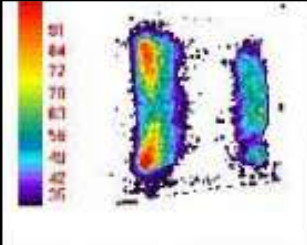
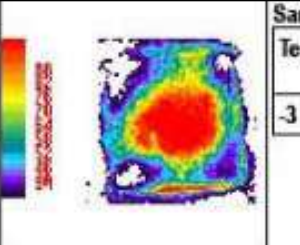
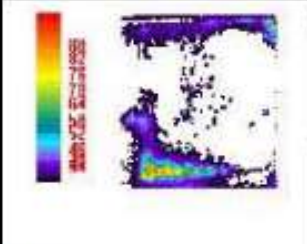
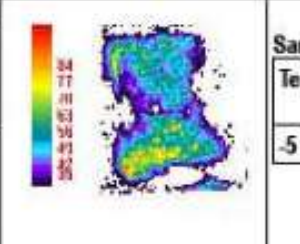
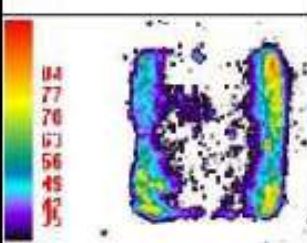
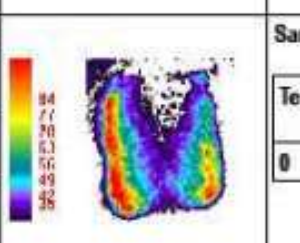
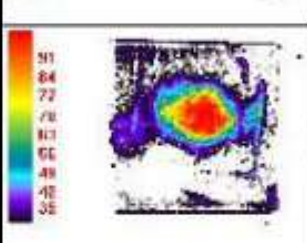
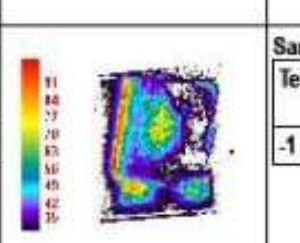
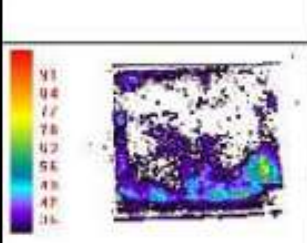
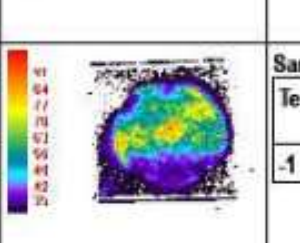
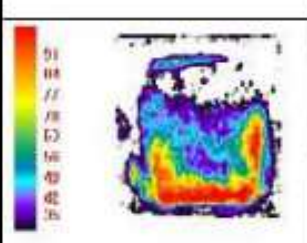
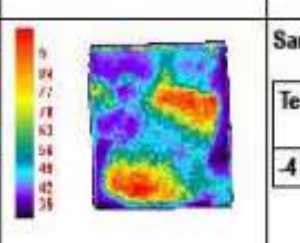
Three users experienced no change even though they had adequate force with an average of 50.8 lbs. Closer examination of the images show uneven contact, with most of the force applied on the edges:



While almost all results fell into the pressure analysis comfortably, samples 14 and 24 did not. A possible explanation is that under marginal conditions, the accuracy of the internal diode or hardware monitoring program are at their limit, being only accurate to within a degree or so. Alternative speculation is welcomed.

Mounting force over 60 lbs indicates diminishing returns.

Data Samples															
	<b>Sample # 1A</b> <table border="1"> <thead> <tr> <th>Temp</th> <th>Average Load</th> <th>Force</th> </tr> </thead> <tbody> <tr> <td>-3.55</td> <td>48.66</td> <td>61.25</td> </tr> </tbody> </table>	Temp	Average Load	Force	-3.55	48.66	61.25		<b>Sample # 19A</b> <table border="1"> <thead> <tr> <th>Temp</th> <th>Average Load</th> <th>Force</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>40.37</td> <td>49.2</td> </tr> </tbody> </table>	Temp	Average Load	Force	0	40.37	49.2
Temp	Average Load	Force													
-3.55	48.66	61.25													
Temp	Average Load	Force													
0	40.37	49.2													
	<b>Sample # 26A</b> <table border="1"> <thead> <tr> <th>Temp</th> <th>Average Load</th> <th>Force</th> </tr> </thead> <tbody> <tr> <td>-2</td> <td>46.28</td> <td>58.51</td> </tr> </tbody> </table>	Temp	Average Load	Force	-2	46.28	58.51		<b>Sample # 20B1</b> <table border="1"> <thead> <tr> <th>Temp</th> <th>Average Load</th> <th>Force</th> </tr> </thead> <tbody> <tr> <td>3.7</td> <td>40.59</td> <td>32.44</td> </tr> </tbody> </table>	Temp	Average Load	Force	3.7	40.59	32.44
Temp	Average Load	Force													
-2	46.28	58.51													
Temp	Average Load	Force													
3.7	40.59	32.44													
	<b>Sample # 8B</b> <table border="1"> <thead> <tr> <th>Temp</th> <th>Average Load</th> <th>Force</th> </tr> </thead> <tbody> <tr> <td>-5</td> <td>40.96</td> <td>59.21</td> </tr> </tbody> </table>	Temp	Average Load	Force	-5	40.96	59.21		<b>Sample # 2B</b> <table border="1"> <thead> <tr> <th>Temp</th> <th>Average Load</th> <th>Force</th> </tr> </thead> <tbody> <tr> <td>2.65</td> <td>45.08</td> <td>43.52</td> </tr> </tbody> </table>	Temp	Average Load	Force	2.65	45.08	43.52
Temp	Average Load	Force													
-5	40.96	59.21													
Temp	Average Load	Force													
2.65	45.08	43.52													
	<b>Sample # 13B</b> <table border="1"> <thead> <tr> <th>Temp</th> <th>Average Load</th> <th>Force</th> </tr> </thead> <tbody> <tr> <td>-2.7</td> <td>41.12</td> <td>56.28</td> </tr> </tbody> </table>	Temp	Average Load	Force	-2.7	41.12	56.28		<b>Sample # 20B2</b> <table border="1"> <thead> <tr> <th>Temp</th> <th>Average Load</th> <th>Force</th> </tr> </thead> <tbody> <tr> <td>3.85</td> <td>40.11</td> <td>46.26</td> </tr> </tbody> </table>	Temp	Average Load	Force	3.85	40.11	46.26
Temp	Average Load	Force													
-2.7	41.12	56.28													
Temp	Average Load	Force													
3.85	40.11	46.26													
	<b>Sample # 37B</b> <table border="1"> <thead> <tr> <th>Temp</th> <th>Average Load</th> <th>Force</th> </tr> </thead> <tbody> <tr> <td>-3</td> <td>42</td> <td>50.7</td> </tr> </tbody> </table>	Temp	Average Load	Force	-3	42	50.7		<b>Sample # 22 a&amp;b</b> <table border="1"> <thead> <tr> <th>Temp</th> <th>Average Load</th> <th>Force</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>41.38</td> <td>25.76</td> </tr> </tbody> </table>	Temp	Average Load	Force	1	41.38	25.76
Temp	Average Load	Force													
-3	42	50.7													
Temp	Average Load	Force													
1	41.38	25.76													
	<b>Sample # 7b</b> <table border="1"> <thead> <tr> <th>Temp</th> <th>Average Load</th> <th>Force</th> </tr> </thead> <tbody> <tr> <td>-3.3</td> <td>42.05</td> <td>39.8</td> </tr> </tbody> </table> <p>Direct heatpipe contact</p>	Temp	Average Load	Force	-3.3	42.05	39.8		<b>Sample 23b1</b> <table border="1"> <thead> <tr> <th>Temp</th> <th>Average Load</th> <th>Force</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>44.5</td> <td>57.35</td> </tr> </tbody> </table>	Temp	Average Load	Force	0	44.5	57.35
Temp	Average Load	Force													
-3.3	42.05	39.8													
Temp	Average Load	Force													
0	44.5	57.35													

	<p><b>Sample #13A</b></p> <table border="1"> <thead> <tr> <th>Temp</th> <th>Average Load</th> <th>Force</th> </tr> </thead> <tbody> <tr> <td>-2.3</td> <td>37.88</td> <td>48.55</td> </tr> </tbody> </table>	Temp	Average Load	Force	-2.3	37.88	48.55		<p><b>Sample # 23 b2</b></p> <table border="1"> <thead> <tr> <th>Temp</th> <th>Average Load</th> <th>Force</th> </tr> </thead> <tbody> <tr> <td>-3</td> <td>48.39</td> <td>56.9</td> </tr> </tbody> </table>	Temp	Average Load	Force	-3	48.39	56.9
Temp	Average Load	Force													
-2.3	37.88	48.55													
Temp	Average Load	Force													
-3	48.39	56.9													
	<p><b>Sample # 20A</b></p> <table border="1"> <thead> <tr> <th>Temp</th> <th>Average Load</th> <th>Force</th> </tr> </thead> <tbody> <tr> <td>-2.7</td> <td>35.35</td> <td>32.02</td> </tr> </tbody> </table>	Temp	Average Load	Force	-2.7	35.35	32.02		<p><b>Sample # 23b3</b></p> <table border="1"> <thead> <tr> <th>Temp</th> <th>Average Load</th> <th>Force</th> </tr> </thead> <tbody> <tr> <td>-5</td> <td>43.75</td> <td>59.92</td> </tr> </tbody> </table>	Temp	Average Load	Force	-5	43.75	59.92
Temp	Average Load	Force													
-2.7	35.35	32.02													
Temp	Average Load	Force													
-5	43.75	59.92													
	<p><b>Sample #3A</b></p> <table border="1"> <thead> <tr> <th>Temp</th> <th>Average Load</th> <th>Force</th> </tr> </thead> <tbody> <tr> <td>-.05</td> <td>43.7</td> <td>31.27</td> </tr> </tbody> </table>	Temp	Average Load	Force	-.05	43.7	31.27		<p><b>Sample # 3b</b></p> <table border="1"> <thead> <tr> <th>Temp</th> <th>Average Load</th> <th>Force</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>44.91</td> <td>45.8</td> </tr> </tbody> </table>	Temp	Average Load	Force	0	44.91	45.8
Temp	Average Load	Force													
-.05	43.7	31.27													
Temp	Average Load	Force													
0	44.91	45.8													
	<p><b>Sample # 14 a</b></p> <table border="1"> <thead> <tr> <th>Temp</th> <th>Average Load</th> <th>Force</th> </tr> </thead> <tbody> <tr> <td>-4</td> <td>40.16</td> <td>40.53</td> </tr> </tbody> </table>	Temp	Average Load	Force	-4	40.16	40.53		<p><b>Sample #24a</b></p> <table border="1"> <thead> <tr> <th>Temp</th> <th>Average Load</th> <th>Force</th> </tr> </thead> <tbody> <tr> <td>-1</td> <td>42.23</td> <td>59.92</td> </tr> </tbody> </table>	Temp	Average Load	Force	-1	42.23	59.92
Temp	Average Load	Force													
-4	40.16	40.53													
Temp	Average Load	Force													
-1	42.23	59.92													
	<p><b>Sample #14b</b></p> <table border="1"> <thead> <tr> <th>Temp</th> <th>Average Load</th> <th>Force</th> </tr> </thead> <tbody> <tr> <td>-1.75</td> <td>36.8</td> <td>38.75</td> </tr> </tbody> </table>	Temp	Average Load	Force	-1.75	36.8	38.75		<p><b>Sample #24b</b></p> <table border="1"> <thead> <tr> <th>Temp</th> <th>Average Load</th> <th>Force</th> </tr> </thead> <tbody> <tr> <td>-1</td> <td>43.55</td> <td>62.41</td> </tr> </tbody> </table>	Temp	Average Load	Force	-1	43.55	62.41
Temp	Average Load	Force													
-1.75	36.8	38.75													
Temp	Average Load	Force													
-1	43.55	62.41													
	<p><b>Sample #26b</b></p> <table border="1"> <thead> <tr> <th>Temp</th> <th>Average Load</th> <th>Force</th> </tr> </thead> <tbody> <tr> <td>-2</td> <td>46.28</td> <td>58.51</td> </tr> </tbody> </table>	Temp	Average Load	Force	-2	46.28	58.51		<p><b>Sample #32</b></p> <table border="1"> <thead> <tr> <th>Temp</th> <th>Average Load</th> <th>Force</th> </tr> </thead> <tbody> <tr> <td>-4</td> <td>48.3</td> <td>97.57</td> </tr> </tbody> </table>	Temp	Average Load	Force	-4	48.3	97.57
Temp	Average Load	Force													
-2	46.28	58.51													
Temp	Average Load	Force													
-4	48.3	97.57													

Many thanks to those that assisted us in this effort.