# USING DATA LOGGERS TO VERIFY BOILER HOT WATER RESET

A strategy to reduce heat loss from boiler water distribution systems is to reset the supply water temperature based on heating demand. Lowering the supply water temperature reduces the energy loss from the distribution system and saves energy. The most common method is to reset hot water supply temperature based on outside air temperature. This can easily be accomplished with stand-alone boiler temperature control systems. Buildings with Building Automation Systems (BAS) can also use a combination of outside air temperature and heating valve position to determine heating demand.

In either case, how can you determine if a hot water temperature reset schedule is in use and operating properly? Here is how you can use data loggers to verify the performance of a hot water reset control.

# To log the boiler water temperature and outside air temperature you need the following supplies

For Hot Water Temperature:

- 1. 4-Channel thermocouple data logger: Onset HOBO UX120-006M (one per boiler)
- 2. Surface temperature adhesive thermocouple: Onset TMCx-HE (two per logger)
- 3. Pipe Insulation
- 4. Pipe Insulation Tape

For Outside Air Temperature:

5. Temperature/Relative humidity logger: Onset HOBO U12-012 (one per building)

Also Required:

- 6. Personal computer with USB port
- 7. Hoboware<sup>®</sup> software installed on computer
- 8. USB to mini USB cable
- 9. Microsoft Excel

## Configuring the loggers

Install and launch the Hoboware<sup>®</sup> software on your computer. Connect the 4-channel logger to the computer via the USB cable and launch the logger. Configure the logger as follows:

- 1. Ensure that the logger has enough battery life for the trending period before you start the configuration process. If battery life is less than 30% replace the battery.
- 2. In the description box type in the site location and boiler ID
- In the "sensors" section, select the appropriate sensor from the pull-down menu. The thermocouple ports should be named after the parameter that is being recorded. (e.g., Hot Water Supply Temperature and Hot Water Return Temperature)
- 4. In the deployment section, set the logging interval to 15 minutes.
- 5. Under "Start Logging" select "On Date/Time". Set the loggers top start logging after the installation is complete
- 6. Under "Stop Logging", select "never (wrapping)
- 7. By default, the LCD will always remain on while logging data. Verify that the 'Tune LCD off" box is not checked.
- 8. Click "Delayed Start" to launch the logger.





9. Disconnect the logger from the USB cable when the launching window closes.

Connect the Temperature/Humidity logger to the computer via the USB cable and launch the logger. Configure the logger as follows:

- 1. Ensure that the logger has enough battery life for the trending period before you start the configuration process. If battery life is less than 30% replace the battery.
- Name the logger to include the building name, system name, and parameter measured (e.g., "AnytownHS\_Boiler\_OAT")
- 3. Set the logging interval to 15 minutes.
- 4. Select "On Date/Time" to schedule logging start time. Set the logger top start logging after the installation is complete. Use the same start time used for the 4-chanell logger configuration
- 5. Select "never" (wrap when full) in the stop logging memory options
- 6. Select 'Start" to launch the logger.
- 7. Disconnect the logger from the USB cable when the launching windows closes.

#### Installation Procedure

- 1. Stick or attach the first temperature sensor on the hot water supply pipe, ensuring that the sensor is in good physical contact with the pipe and under insulation. Be sure that the sensor is secure. Alternately you could use a hose clamp to secure the sensor.
- 2. Stick or attache the second temperature sensor on the hot water return pipe, ensuring that the sensor is in good physical contact with the pipe and under insulation. Be sure that the sensor is secure. Alternately you could use a hose clamp to secure the sensor.

Note: The material and thickness of pipes vary. To ensure that the temperature sensor is measuring the temperature of the fluid inside the pipe, wrap insulation all the way around the pipe. Also, make sure the insulation traverses twelve to eighteen inches along the pipe, with the sensor centered in the insulation and the insulation secured with pipe insulation tape. This will help to minimize measurement error due to heat transfer to and/or from surroundings.





- 3. Deploy the UX120-006 4-channel logger within reach of the thermocouple(s). Use the mounting magnets on the back of the logger or use mounting tape and cable ties to secure the logger.
- 4. Plug the thermocouple cables into the correct mounting port. Verify temperature readings on the LCD dsplay.
- 5. Using cable ties or tape mount the Temperature/Humidity logger in a location outside the building where it is protected from rain and direct sunlight. It is important that the logger be placed where it will not be influenced by any sources of heat or other factors that could add

error to the measurements; this includes but is not limited to exhaust vents, dampers, and chilled or hot water pipes.

#### Data Acquisition

- 1. Retrieve the loggers after a minimum 2-week logging period. Repair/replace any disturbed piping insulation.
- 2. Launch the Hoboware<sup>®</sup> software on your computer and connect the loggers using the USB cable.
- 3. Select "Readout" from the device menu.
- 4. Wait for the data to be read out. Once the readout is complete, choose a location and /or a new filename, or accept the default filename and location. Click "Save"
- 5. The plot window will appear after you save. Select the data series you want to plot and click "Plot" to view the data.





- 6. Export the raw data file to Excel for further analysis. Click on "Export Table Data" under the File menu. Save the document to a new folder designated for this project.
- 7. Repeat these steps for the Temperature/Humidity data logger and export the table data to the same folder for further analysis.
- 8. You can use the "Merge Data Files" under the File menu to combine the Temperature/Humidity data with the 4-Channell logger data and plot the data for analysis.

## Data Visualization using Excel

Microsoft Excel can be used to combine the raw data from the data loggers and provide a graphical visualization of the data to determine if hot water reset is being used. Excel is also a handy method to determine min/max and average temperature during the logging period. Alternately, there are free Excel based Macro tools that can be downloaded and installed with built-in data visualization tools. Examples include Energy Charting & Metrics (ECAM), OpenEIS, and the noBAS Building Retuning Guide from the Building Performance Lab at CUNY. Regardless of what tool you use you want to plot hot water supply temperature verses outdoor air temperature.

Here is an example of the raw logger data that has been imported into the Building Performance Lab's Hot Water Reset Visualization Tool for Excel. The data is recorded at 1-minute intervals which is not necessary but will give you more a more detailed visualization of reset performance. This example compares the outside air temperature to the hot water supply temperature for three boilers.

-	🔏 Cut Calibri	* 11 * A A	= = = *	• Wrap Te	xt Gen	eral *	<=	Normal	Bac
ste	B I <u>U</u> →	🗄 •   🌺 • 🛓 •		E 🛊 🔤 Merge 8	Center - \$	• % • <mark>•.0</mark> • % •	Conditional Forr Formatting * as Tal	mat ble +	Exp
_	Clipboard 😼 I	Font G		Alignment	15a	Number 🕞			
	F4 • (* fx	132.346							
	A	В	С	D	E	F	G	н	1
	1. Select the number of boilers								
1.0	Instructions:	Date/Time	UAT	HVVSII	HWSTZ	HIVSI 3			
	1. Select the number of boilers								
	1. Select the number of boilers for which you have data.	2/10/2016 14:02	49.311	132.346	129.19	132.346			
	Select the number of boilers for which you have data. 3	2/10/2016 14:02 2/10/2016 14:03	49.311 47.604	132.346 132.634	129.193 130.341	132.346			
	I. Select the number of boilers for which you have data. 3	2/10/2016 14:02 2/10/2016 14:03 2/10/2016 14:04	49.311 47.604 46.782	132.346 132.634 133.306	129.193 130.341 131.596	132.346 132.634 133.306			
	I. Select the number of boilers for which you have data. 3 ↓ 2. Import Data	2/10/2016 14:02 2/10/2016 14:03 2/10/2016 14:04 2/10/2016 14:05	49.311 47.604 46.782 47.017	132.346 132.634 133.306 133.992	129.193 130.343 131.596 132.85	132.346 132.634 133.306 133.992			
	Select the number of boilers for which you have data.	2/10/2016 14:02 2/10/2016 14:03 2/10/2016 14:04 2/10/2016 14:05 2/10/2016 14:06	49.311 47.604 46.782 47.017 47.201	132.346 132.634 133.306 133.992 134.353	129.193 130.343 131.596 132.89 133.412	3 132.346 132.634 5 133.306 9 133.992 2 134.353			
	Select the number of boilers for which you have data.	2/10/2016 14:02 2/10/2016 14:03 2/10/2016 14:04 2/10/2016 14:05 2/10/2016 14:06 2/10/2016 14:07	49.311 47.604 46.782 47.017 47.201 60.096	132.346 132.634 133.306 133.992 134.353 134.485	129.193 130.343 131.596 132.89 133.412 133.492	132.346 132.634 133.306 133.992 134.353 134.485			
3	2. Select the number of boilers for which you have data. 3 2. Import Data Import 4. Click "Plot" to graph your data. (Click once)	2/10/2016 14:02 2/10/2016 14:03 2/10/2016 14:04 2/10/2016 14:05 2/10/2016 14:06 2/10/2016 14:07 2/10/2016 14:08	49.311 47.604 46.782 47.017 47.201 60.096 51.433	132.346 132.634 133.306 133.992 134.353 134.485 134.539	129.193 130.343 131.596 132.89 133.412 133.497 118.639	132.346 133.306 133.302 134.353 134.455 134.539			
3	2. Select the number of boilers for which you have data. 3 2. Import Data Import 4. Click "Plot" to graph your data. (Click once)	2/10/2016 14:02 2/10/2016 14:03 2/10/2016 14:04 2/10/2016 14:05 2/10/2016 14:06 2/10/2016 14:07 2/10/2016 14:08 2/10/2016 14:09	49.311 47.604 46.782 47.017 47.201 60.096 51.433 46.098	132.346 132.634 133.306 133.992 134.353 134.485 134.539 134.557	129.193 130.343 131.596 132.88 133.412 133.497 118.638 108.513	132.346 132.634 133.306 133.992 134.353 134.485 134.539 134.557			

Screen capture courtesy of the Building Performance Lab

The BPL visualization tool can plot the relationship between hot water supply temperature and outside temperature for each boiler. An example is below. Note that during occupied periods when the boiler is enabled the hot water supply temperature stays at a relatively fixed temperature setpoint. There is no reset strategy functioning or in place. If there was a functioning reset strategy we would see a clear correlation between hot water supply temperature and outside air temperature. Building operators can further check the sequence of operation of the boiler and verify that the hot water reset strategy setpoints are correct.

A	B	С	D	E	F	G	н	1	J	K	L	M	N O	P Q R
fhis Excel <del>v</del> orkbook is ι	used to visualize	the Hot ₩	ater Supply	and Outdo	or Air Temp	erature						_		
Instructions:	Date/Time	OAT	HVST1	HVST 2	HWST 3				Graphs	₩ill Appear	Below			
/ Select the number of											alles d Llet M	later	Outdawn Air Tem	-
boilers for which you have	2/10/2016 14:02	49.311	132.346	129.193	132.346					D	oller THOUN	vater vs.	Outdoor Air Tem	þ
3 🔄	2/10/2016 14:03	47.604	132.634	130.341	132.634				180	1				
-	2/10/2016 14:04	46.782	133.306	131.596	133.306									
2 Import Data	2/10/2016 14:05	47.017	133.992	132.89	133.992				160	-				
import	2/10/2016 14:06	47.201	134.353	133.412	134.353				_			л		
	2/10/2016 14:07	60.096	134.485	133.497	134.485				240		0~	ST-11		
Click "Plot" to graph your											111		6 ( )	
data. (Llick once)	2/10/2016 14:08	61.433	134.539	18.639	134.539				- C 120			1 1		
First Boilers	2r10r2016 14:09	46.098	134.557	108.513	134.557						11	1		
Proceedings.	2/10/2016 14:10	45.833	134.539	112.719	134.539				- E 100					
If you would like to adjust									E 00			X		
the									5			1	~~1 <b>1</b> .	Hot weter supply 1
ange of time to view, select									- 60			+ + A	A	Outdoor Air Temperat
sired range below, then click											~	1 4 1	V Viewell 1	
Change Date/Time Range"									40	<b>k</b>	/ \www.	111	9 / WI	
the graph you would like to	2/10/2016 14:11	45.095	134.479	105.993	134.479				_	N4 A.4	17	~~		
/10030	2/10/2016 14:12	45.187	134.323	111.929	134.323				20		- Part			
22846 42:52	2/10/2016 14:13	43.75	134.389	115.484	134.389				_	1	4. C			
Change Date/Time Range	2/10/2016 14:14	44.753	135.036	118.15	135.036						*			
for Plat	2/10/2016 14:15	44.681	135.75	120.222	135.75					14:02	a:02 14:02 18	02 14:02	14:02	
1 🖵	2/10/2016 14:16	43.945	136.189	121.788	136.189				3/20/20- 3	175120 - 517el20 -	5/20/20 5/28/20.	5/30/20. 5/351	2 ]]A ] [0 .	
Change Data (Time for all fints	2/10/2016 14:17	43.281	136.452	123.107	136.452				_		Date	Time		
	2/10/2016 14:18	43.324	136.629	124.212	136.629									
	2/10/2016 14:19	44.73	136.753	125.112	136.753								o	
PDI	2/10/2016 14:20	43.218	136.818	125.816	136.818				_	B	oller 2 Hot W	vater vs.	Outdoor Air Tem	р
БРБ	2/10/2016 14:21	43.394	136.864	126.347	136.864				160	1				
	2/10/2016 14:22	42.771	136.87	126.727	136.87									
LDING performance LAB	2/10/2016 14:23	42.042	136.791	126.981	136.791				140	han and		1~1~		
	2/10/2016 14:24	42.048	136.717	127.135	136.717				120			-11 11		
	2/10/2016 14:25	41.797	136.753	127.213	136.753				e .			1 1		
	2r10r2016 14:26	42.453	141.264	127.238	141.264				8 100	1				
Clear Data	2r10r2016 14:27	44.224	143.609	127.231	143.609							¥.		
	2/10/2016 14:28	45.365	143.132	127.193	143.132				<u>1</u>					
	2/10/2016 14:29	45.118	142.394	127.209	142.394				E eo	+	44	ILA	All ra	Hot west Supply 2
	2/10/2016 14:30	43.609	141.729	127.324	141.729					k	1 1	1 1	Y Yunger	Outsoor Air Temperat
	2/10/2016 14:31	42.694	141.033	127.456	141.033				- 40	NA A.		~~		
	2r10r2016 14:32	43.336	140.626	127.571	140.626				20	1 20 20	The second se			
	2r10r2016 14:33	43.381	140.578	127.737	140.578					· ·	-v			
	2/10/2016 14:34	42.868	140.749	128.043	140.749				°	-				
	2/10/2016 14:35	43.327	140.057	120.450	140.057				10136 34.0	12 110 14:07 110 3	4:02 14:02 14:02	02 139 14:02	16 34:02	
	2/10/2016 14:36	42.645	140.916	128.878	140.916				21501 2	Dvi. 3 Nelv.	5 2mi . 5 28  v.	31.101 - 31.511	2] 100	
	2r10r2016 14:37	42.582	140.92	129.238	140.92						Dete	Time		
	2r10r2016 14:38	42.78	140.846	129.526	140.846									

Screen capture courtesy of the Building Performance Lab

Hot water supply temperature (HWST) can be reset based on outdoor air temperature (OAT) or heating demand to reduce heating energy consumption. High HWST is appropriate when OAT is low, but energy savings can be achieved when a low HWST is used when OAT is high when only modest heating is required. If the data shows that hot water reset is not being used or is not operating correctly enable (or repair a reset capability so that HWST is reduced when OAT increases. A typical controller might have HWST vary from 160-180°F when OAT temperature varies from 20-50°F. Condensing type boilers allow much more aggressive reset schedules reducing energy consumption further.

This article was written by Duane Lewellen- Senior Project Manager of the Tool Lending Library at the Smart Buildings Center. The data loggers and accessory sensors mentioned in this article are available for loan to building operators and service providers in the states of Washington and Oregon free of charge. Visit our website for more information http://www.smartbuildingscenter.org/tool-library/