

# BOILER CONTROL UPGRADE SAVINGS ANALYSIS REPORT

For The  
Millipore Corporation



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*Prepared and Submitted by:*



**GDS Associates, Inc.**  
Engineers and Consultants

**GDS Associates, Inc.** • 1181 Elm Street • Suite 205 • Manchester, NH 03101 • [www.gdsassociates.com](http://www.gdsassociates.com)  
Marietta, GA • Austin, TX • Auburn, AL • Manchester, NH • Madison, WI

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# 1. Acknowledgement:

Special thanks to Paul Lukitsch, Sal Monaco and Dave Bodwell of Millipore for their unwavering support throughout this project. The Millipore facilities group was extremely responsive to request for information and working with GDS on notification when boilers were available for visual inspection and data requests for Millipore and utility data. Without Millipore's commitment to energy savings and green house gas reduction this one year study would not have been possible.

# 2. Introduction:

In the spring of 2008 GDS was contracted by Millipore to provide natural gas savings analysis for an upcoming boiler burner and control system upgrade. The savings analysis included developing a baseline of natural gas usage prior to the upgrade which was to be compared against two months of post upgrade gas usage interval data. During the initial data analysis the savings was inconsistent which suggested more data was needed to provide a clearer picture of the actual natural gas usage reduction. GDS expanded the analysis to include a few months of winter natural gas usage for the initial report. After the initial report was issued Millipore requested GDS expand the scope of the contract to include natural gas usage savings analysis at both 6 months and 1 year post upgrades.

In summary Millipore requested GDS provide three natural gas savings analysis reports. The first report provided detailed pre and post gas usage analysis, which utilized gas usage data from the summer of 2008 and the winter period from 2008<sup>1</sup>. The results of this first analysis report found lower than expected gas savings of 11%. Note: The 11% was the original findings but after the report was issued it was discovered that the final tuning and gas vent leak repair were not completed until the end of October 2008. Based on the November and December pre and post usage the savings was 18%. The second analysis report focused on verifying the savings from 6 months of pre and post gas usage which included weather normalization of the gas usage.<sup>2</sup> The weather normalization of the gas usage included both weather BIN hour analysis and heating degree day (HDD) analysis. The results of the second analysis report found a 29% savings which included more of the shoulder months and included weather normalization and production level normalization. Part of the effort of the second analysis report was determining the facilities heating balance point which the analysis found to be 59°F. The heating balance point is the outside air temperature where below that point the natural gas load serves both space heating and process heating needs but at or above that point the natural gas load serves only the process heating needs. The heating balance point is used to calculate the typical annual natural gas usage from the TMY3 weather data. This report is the third and final gas savings analysis, the 1 year post upgrade analysis report Millipore requested.

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<sup>1</sup> ["Boiler Control Upgrade Draft Report for Millipore Corporation and National Grid" February 12, 2009 by GDS Associates, Inc.](#)

<sup>2</sup> ["Boiler Control Upgrade Draft Report for Millipore Corporation and National Grid" July 31, 2009 by GDS Associates, Inc.](#)

### 3. Overview Of Activities & Methods

#### 3.1 Executive Summary:

After one full year of operations with the upgraded boiler controls and burner, the savings have been sustainable and appear consistent with the savings expected with this type of upgrade. The usage comparison found an **average 30% savings**. When the gas usage from the two years prior to the upgrade is compared to the one year post upgrade gas usage the natural gas usage reduction is greatest in the warmer month's but smaller in the colder months, see Figure 1 below. This is consistent with the expected savings from the upgraded boiler controls provide the greatest savings at low steam loads due to superior turn down ratio while maintaining an efficient combustion.

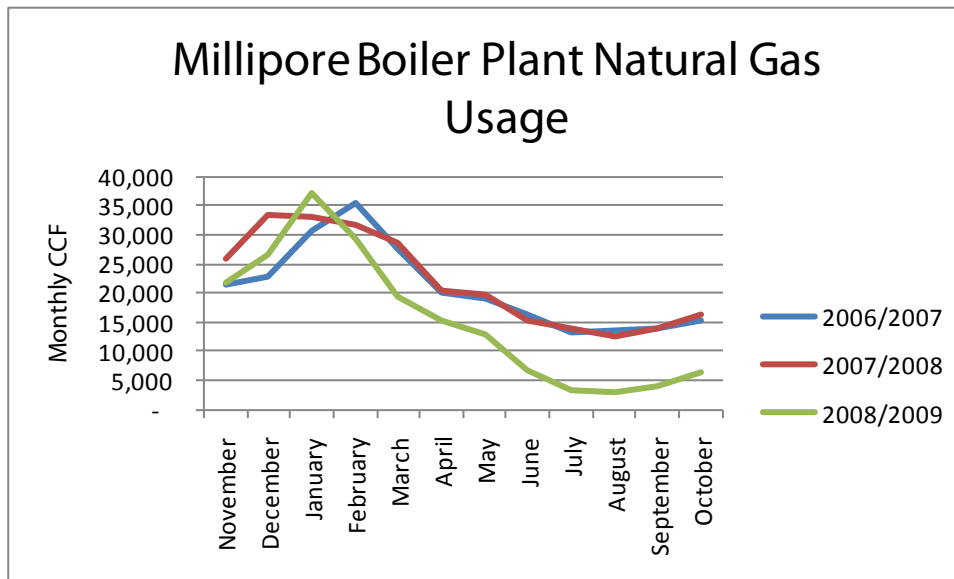


Figure 1: Natural Gas Usage Results

#### 3.2 Methodology:

Over the course of this project GDS made six site visits to record data, install data logging metering and take photos of Millipore's 80 Ashby, Bedford, MA - Building D boiler plant. The Building D boiler plant had two 300 hp Cleaver Brooks, low pressure steam boilers fueled by natural gas. Boiler one is an original boiler installed in the 1960's (reference equipment data table 1 below). Boiler two is similar and was a Cleaver Brooks fire tube low pressure steam boiler installed in the 1990's. Each boiler supplies a common 15 PSIG steam header that supplies steam to buildings D, C and F. Buildings C & F utilized the steam for heating, reheat and process needs. Building D steam utilization is primarily space heating with a small process load.

### Millipore Process Boilers

Building D	Model #	Input Btu/hr	Combustion Blower HP
Boiler 1	CB 200-300	12,553,000	10
Boiler 2	CB 700 300 05	12,247,000	15

**Table 1 Boiler Name Plate Data**

The findings presented in this report are based on site visits, information provided by Millipore's Salvatore Monaco and Dave Bodwell and the interval natural gas usage data recorded from the boiler rooms dedicated natural gas meter (meter #: 52364) provided by National Grid.

The calculated natural gas savings associated with the boiler upgrades are based on pre and post natural gas usage data and weather data from two sources, National Oceanic Atmospheric Administration (NOAA) and the National Climatic Data Center (NCDC). The current Typical Meteorological Year weather data (TMY3) from Boston's Logan Airport<sup>3</sup> was used as the normalization levels. Boston was the closet class I data set available. Production rates during the first six month study were consistent with those of the previous year and the production rates during the last six months of the study were nearly the same as the previous periods. The process areas operate around clock and are considered at capacity. Because the pre and post production levels were relatively unchanged production normalization was not considered necessary for the 1 year study.

### 3.3 Analysis:

GDS used the pre and post corrected million cubic feet (MCF) per hour of natural gas usage provided by National Grid from the dedicated meter to the boiler plant. The hourly weather data is from the weather station at the Bedford, MA Hanscom Field<sup>4</sup> which was downloaded from the National Climatic Data Center (NCDC). The dry bulb temperature used in the analysis was from the NCDC weather data. The methodology GDS used to determine the natural gas savings is described below:

Step 1 – Determine the monthly natural gas usage for three years. Two years of pre usage and one year of post usage<sup>5</sup>.

Step 2 – Retrieve weather data from the NOAA NCDC web site for Bedford MA from November 2006 – November 2009.

<http://www.ncdc.noaa.gov/oa/climate/climatedata.html#surface>

Step 3 – Determine the heating balance point temperature by graphing the outdoor temperature and the natural gas usage (reference Figure 2).

<sup>3</sup> Massachusetts Boston Logan international Airport (725090) Class I [http://rredc.nrel.gov/solar/old\\_data/nsrdb/1991-2005/tmy3/by\\_state\\_and\\_city.html#M](http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/by_state_and_city.html#M)

<sup>4</sup> Laurence G Hanscom Field APT (14702/BED) <http://cdo.ncdc.noaa.gov/qclcd/QCLCD>

<sup>5</sup> Data was provided from National Grid original data files: b010-2 3-2006-3-2007.txt, b010-3 3-2007-3-2008.txt, b010-4 3-2008-2-2009.txt, b010mar8th-may6th.txt, b010jan1st-mar8th.txt, millipore.txt, & millipore1.txt

Step 4 – Utilize the heating balance point temperature to determine the weather related natural gas usage. Use the hourly weather data and the heating balance point temperature to calculate the heating degree days.

<http://www.degreedays.net/>

Step 5 – Use the pre and post natural gas usage along with the HDD pre and post information to weather normalize the post usage. Note the HDD (pre, post and TMY3) are all at a heating balance point temperature of 59°F

$$\frac{\text{Monthly Natural Gas Usage}_{pre} (CCF)}{\text{Heating Degree Days}_{pre} (HDD)} = \text{Weatherized Usage Factor}_{pre} \left( \frac{CCF}{HDD} \right)$$

**Equation 1**

$$\begin{aligned} \text{Weather Normilzed Natural Gas Usage}_{pre} \\ = \text{Weatherized Usage Factor}_{pre} \times \text{TMY3 HDD} \end{aligned}$$

**Equation 2**

$$\frac{\text{Monthly Natural Gas Usage}_{post} (CCF)}{\text{Heating Degree Days}_{post} (HDD)} = \text{Weatherized Usage Factor}_{post} \left( \frac{CCF}{HDD} \right)$$

**Equation 3**

$$\begin{aligned} \text{Weather Normilzed Natural Gas Usage}_{post} \\ = \text{Weatherized Usage Factor}_{post} \times \text{TMY3 HDD} \end{aligned}$$

**Equation 4**

Step 6 – Calculate the weather normalized natural gas savings or difference.

$$\left( \frac{\text{Weather Normilzed Natural Gas Usage}_{pre} - \text{Weather Normilzed Natural Gas Usage}_{post}}{\text{Weather Normilzed Natural Gas Usage}_{pre}} \times 100 \right)$$

= % Difference

**Equation 5**

## 4. Results:

Details of each step of the analysis mentioned in the previous section are described below in more detail with sample graphs, tables and results.

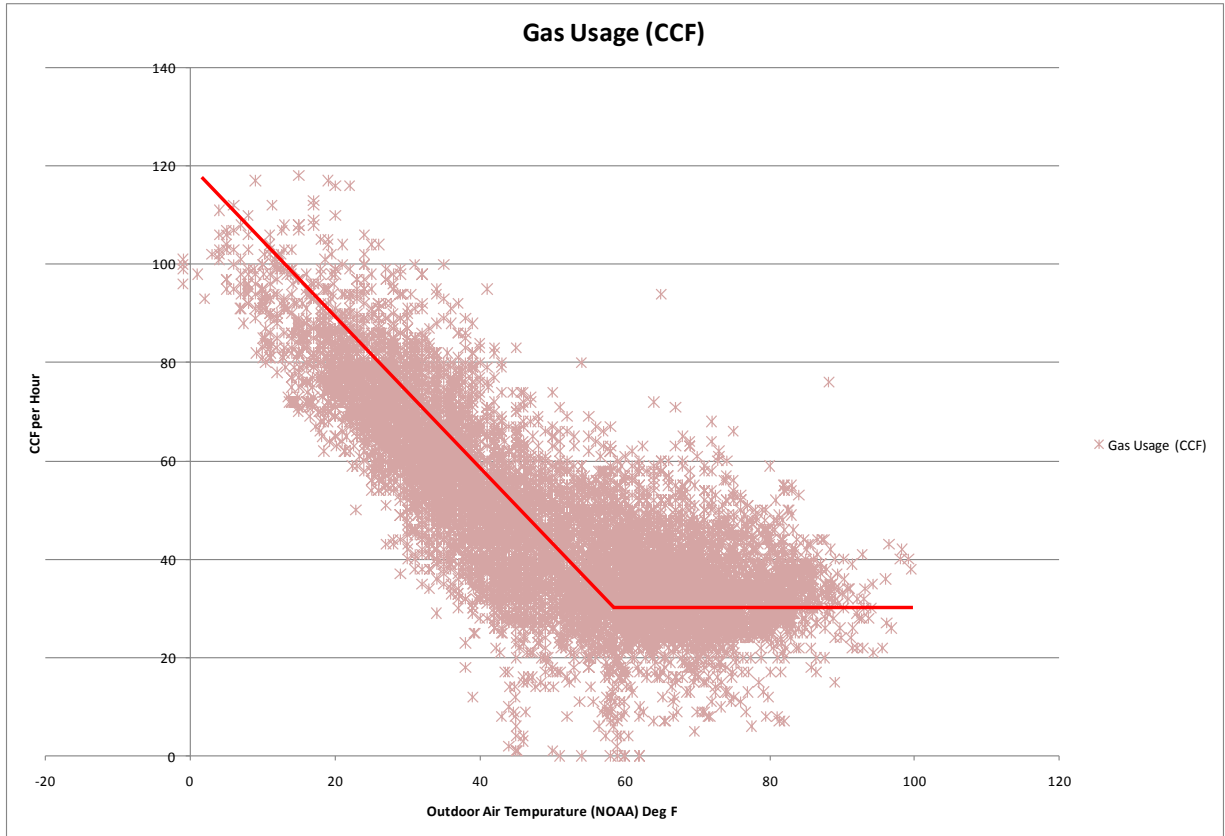
Monthly Gas Usage (Step 1): The monthly gas usage was provided in a txt file format from National Grid on four separate occasions. The data used for the analysis was the corrected MCF (1 MCF = 10 therms) usage from meter number 52364, which is the dedicated meter that serves the boiler plant in building D. The building D boiler plant had two natural gas consuming appliances, the two boilers. The controls on each boiler were upgraded in the summer of 2008. The tuning of the new burners and controls was reported to be complete at the end of October 2008. GDS used November 2008 as the starting point for the one year study. As a matter of

clarification, the first study GDS published in February 2009 included data from the periods prior to the November 2008 date. GDS was unaware of the final tuning of the burner and controls which was not completed until the end of October 2008.

<b>Natural Gas Usage Millipore 80 Ashby Boiler Plant</b>			
	2006/2007	2007/2008	2008/2009
	(therms/month)	(therms/month)	(therms/month)
November	21,320	25,860	21,750
December	22,980	33,450	26,770
January	30,680	32,970	37,380
February	35,370	31,740	29,190
March	27,640	28,500	19,310
April	20,180	20,600	15,140
May	19,000	19,770	12,870
June	16,340	15,340	6,890
July	13,160	13,900	3,280
August	13,700	12,700	3,050
September	14,010	13,790	4,150
October	15,310	16,490	6,370
<b>Totals (therms)</b>	<b>249,690</b>	<b>265,110</b>	<b>186,150</b>

**Table 2 Three Year Natural Gas Usage**

GDS determined the heating balance point temperature of the spaces served by the boilers (Step 3) by graphing calendar year 2008 hourly average temperature to the corresponding hourly gas usage. The best fit curve was plotted with the data. The curve showed a level line from 59°F and higher outdoor temperature the usage was nearly flat. At temperatures less than 59°F the hourly usage showed a sharp increase. Reference Figure 2 for an example of the pre boiler upgrade graph.



**Figure 2 Baseline Temperature Graph For 2008**

Figure 2 is a graph of the hourly natural gas usage for 2008 (CCF on the Y axis) and the corresponding outdoor dry bulb temperature for 2008 (NOAA Weather Data on the X axis). The Red trend line shows the weather dependent natural gas usage when the outdoor dry bulb temperature is below the heating balance point of 59°F. The flat part of the line above the balance point is consistence with the reported process loads.

The 59°F heating balance point temperature was used to calculate the heating degree days. The heating degree days for both a full year prior to the boiler control and burner upgrade and full year after was used to weather normalized the post upgrade gas usage to the pre upgrade gas usage.

Twelve Month Weather Normalized Pre - Post							
	Gas usage			HDD Normalized			
	pre	post	Savings	pre	post	CCF Saved	% Saved
Nov.	25,860	21,750	4,110	787	732	2,476	20%
Dec.	33,450	26,770	6,680	1,146	1,024	3,491	17%
Jan.	32,970	37,380	(4,410)	1,122	1,376	2,490	13%
Feb.	31,740	29,190	2,550	1,072	988	68	0.4%
Mar.	28,500	19,310	9,190	894	890	9,103	60%
Apr.	20,600	15,140	5,460	506	493	5,061	69%
May	19,770	12,870	6,900	195	136	1,317	20%
Jun	15,340	6,890	8,450	28	38	10,263	n/a
Jul	13,900	3,280	10,620	1	18	13,718	n/a
Aug	12,700	3,050	9,650	18	15	9,040	n/a
Sep	13,790	4,150	9,640	78	110	10,847	n/a
Oct	16,490	6,370	10,120	323	344	10,509	n/a
<b>Annual</b>	<b>265,110</b>	<b>186,150</b>	<b>78,960</b>	<b>6,170</b>	<b>6,164</b>	<b>78,382</b>	<b>30%</b>

Table 3 Weather Normalized Natural Gas Usage

The level of production was taken into consideration on the first two gas usage analysis reports. During the post upgrade one year the reported production rates had remained the same over the previous two years. As a result of the steady production no additional coincidence factors were used other than weather.

## 5. Summary:

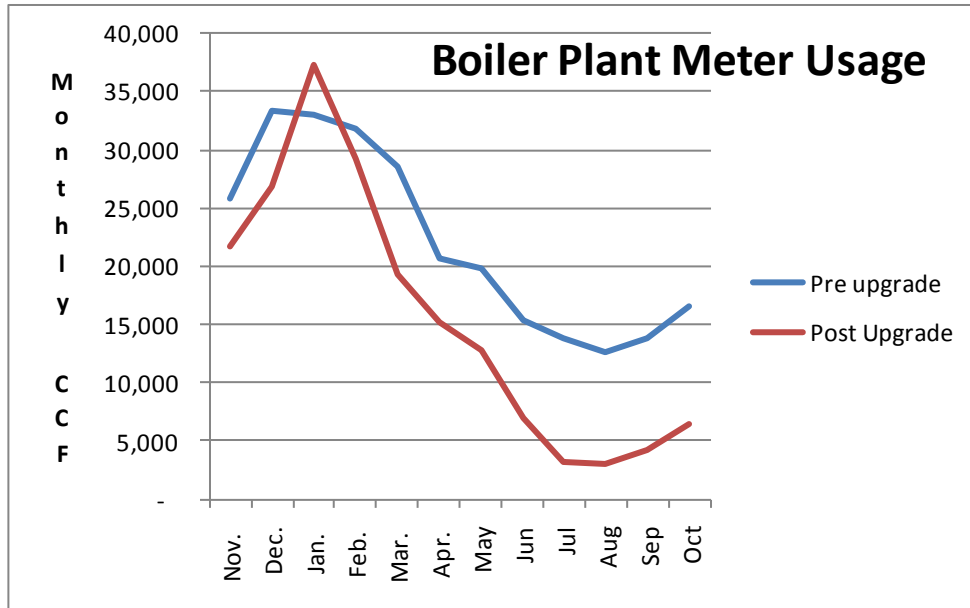
Based on the analysis and findings the boiler control and burner upgrades made to building D boilers have proven to show significant natural gas usage savings. The boilers operate at guaranteed steam to fuel efficiency (85%<sup>6</sup>). The natural gas savings proves to show savings based on the ability to operate efficiently with low demand. The savings for the one year analysis once weather normalized proved to be nearly 30%. With an assumed average cost of \$1.30 per therm fully blended annual cost savings of over \$100,000.

$$78,382 \text{ therms}_{\text{post weather normalized annual savings}} \times \frac{\$1.30}{\text{therm}} = \$101,896 \text{ annual savings}$$

The estimate project for the boiler upgrades were nearly \$95,000. The cost savings from this project represent a less than one year pay back. The original estimate of the savings from this project was predicted to be approximately 11%-24%.

The table below (Figure 3 Pre verse Post Weatherized Usage) shows one full year of pre upgrade natural gas usage (November 2007-October 2008) and is plotted with one full year of post upgrade natural gas usage (November 2008 – October 2009)

<sup>6</sup> Cleaver Brooks CBE 300 (CB-7767-R1 2/96) Boiler efficiency facts



**Figure 3 Pre verse Post Weatherized Usage**

Over the course of the past 18 months GDS has gained valuable insight in the Millipore building D boiler plant operation. GDS also has several resource related to the project that might prove helpful for other energy related analysis for the 80 Ashby campus. For Millipore staff that might benefit for these resources please feel free to contact Keith McBrien ad GDS Associates for additional resource upon request.