Master-Bilt® Master Controller with Reverse Cycle Refrigeration System

vs.

Standard Mechanical Refrigeration System

MASTER-BILT®
Refrigeration Solutions

The Master Controller and Energy Savings

To Understand “How” the Master-Controller can save you energy, we must first understand how operating at a lower ambient temperature can help your efficiency.

A Standard Mechanical Refrigeration System must maintain a significant pressure drop (typically about 100 psi) between the low side and the high side for the expansion valve to function properly. This is achieved by falsely inflating the head pressure through the use of a head pressure control (a “headmaster”) or a fan cycle control. The result is that a condensing unit condenses at a minimum temperature regardless of the ambient temperature. In layman’s terms, a unit with a head pressure control could be operating as if it were in a 90°F ambient condition even if it was in a 20°F ambient condition. The Master Controller utilizes an electronic expansion valve which doesn’t require a pressure drop to operate properly. This allows the unit to operate without a head pressure control. The head pressure “floats” with the ambient temperature. The charts below show how this can impact energy costs.

Table 1 is a Capacity Chart for a typical Master-Bilt® condensing unit. If we assume that we have a -20°F Room with a 10°F TD, then the system is evaporating at -30°F. The two figures that are highlighted show the capacity of the unit at an ambient of 90°F and at 30°F. For this particular unit, the capacity gain is over 35%.

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Capacity (Btuh) at Ambient(F)

Evap	Ambient Temperature (F)										
Temp(F)	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**	**110**	**120**
-40	24186	22998	21887	20826	19784	18732	17640	16478	15220	13838	12312
-35	27414	26156	24958	23792	22628	21437	20190	18857	17414	15835	14099
-30	30642	29315	28029	26758	25472	24142	22739	21237	19608	17831	15887
-25	34680	33211	31766	30317	28836	27295	25666	23922	22041	20000	17783
-20	38718	37108	35503	33876	32200	30448	28592	26608	24474	22169	19680
-15	43584	41762	39927	38052	36111	34078	31928	29638	27187	24558	21739
-10	48451	46417	44351	42228	40022	37709	35265	32668	29900	26946	23798
-5	54138	51820	49453	47013	44476	41818	39019	36060	32923	29595	26069
0	59825	57224	54556	51799	48930	45928	42774	39451	35945	32243	28339

Table 1. Typical Capacity Chart for a Master-Bilt® Unit.

Table 2 is a Compressor Power Chart for a typical Master-Bilt® condensing unit. The two figures that are highlighted show the required power for the compressor of the unit at an ambient of 90°F and at 30°F. For this particular unit, the compressor required power is reduced by almost 40%.

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Power (W) at Ambient(F)

Evap	Ambient Temperature (F)										
Temp(F)	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**	**110**	**120**
-40	2734	2951	3205	3489	3796	4118	4447	4775	5095	5400	5682
-35	2816	3034	3293	3586	3906	4245	4595	4949	5298	5635	5954
-30	2898	3117	3381	3683	4016	4372	4743	5122	5500	5870	6225
-25	3049	3266	3531	3839	4181	4550	4937	5336	5738	6136	6522
-20	3200	3415	3682	3995	4346	4727	5131	5550	5976	6401	6818
-15	3408	3620	3886	4202	4558	4948	5365	5799	6243	6690	7132
-10	3616	3824	4091	4408	4771	5170	5598	6048	6511	6979	7446
-5	3881	4083	4346	4663	5027	5430	5865	6325	6801	7286	7772
0	4146	4342	4601	4917	5282	5690	6133	6602	7092	7593	8098

Table 2. Typical Compressor Power Chart for a Master-Bilt® Unit.

Gaining 35% capacity is big but gaining 35% capacity with about 40% less power is an astounding energy savings! The numbers change constantly as the ambient temperatures change, so it obviously isn’t possible to always get a capacity gain and an energy reduction that is this exaggerated, but this is the principle behind “floating” the head pressure with the ambient temperature.

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The Energy Efficiency Ratio - EER - is a term used to define the cooling efficiency of condensing units or compressors. It ties the two previous charts and information into one unit. The efficiency is typically determined at a single rated condition. It is by definition, the ratio of net cooling capacity (Btu/h) to the total input rate of electric energy applied (W). Therefore, the higher the number, the more efficient the unit is running. Typically, this number is published at one rated condition so it's hard to see the entire picture. Table 3 below shows how this unit's EER changes at different conditions. As you can see, the EER changes from 4.15 at an ambient of 90°F to an EER that has more than doubled at 30°F. It should also be pointed out that at lower ambient temperatures that the compression ratio for the compressor is lowered resulting in higher reliability.

BSLZ0750C

Compressor EER at Ambient(F)

Evap Temp(F)	Ambient Temperature (F)										
	20	30	40	50	60	70	80	90	100	110	120
-40	8.85	7.79	6.83	5.97	5.21	4.55	3.97	3.45	2.99	2.56	2.17
-35	9.74	8.62	7.58	6.63	5.79	5.05	4.39	3.81	3.29	2.81	2.37
-30	10.57	9.41	8.29	7.27	6.34	5.52	4.79	4.15	3.57	3.04	2.55
-25	11.37	10.17	9.00	7.90	6.90	6.00	5.20	4.48	3.84	3.26	2.73
-20	12.10	10.87	9.64	8.48	7.41	6.44	5.57	4.79	4.10	3.46	2.89
-15	12.79	11.54	10.27	9.06	7.92	6.89	5.95	5.11	4.35	3.67	3.05
-10	13.40	12.14	10.84	9.58	8.39	7.29	6.30	5.40	4.59	3.86	3.20
-5	13.95	12.69	11.38	10.08	8.85	7.70	6.65	5.70	4.84	4.06	3.35
0	14.43	13.18	11.86	10.53	9.26	8.07	6.97	5.98	5.07	4.25	3.50

Table 3. Typical EER chart for a Master-Bilt® unit.

There are other energy saving measures that the Master Controller offers. The patented reverse cycle defrost (United States Patent 7073344) is much more efficient resulting in defrost times of less than five minutes over the standard electric defrost times of up to twenty minutes. This is achieved because the heat comes from the refrigerant and is applied efficiently to the coil whereas a conventional electric defrost heater is only heating one surface of the evaporator coil. Also, the power required for a reverse cycle defrost is greatly reduced over the wattage of a conventional electric heater. The reverse cycle feature can reduce defrost costs by up to 80%! The Master Controller also offers demand defrost which will only defrost the evaporator coil when it is needed eliminating unnecessary defrost.

The Master Controller can be applied to Master-Bilt's B-Series units, M-Series units as well as our MRS and DRS units.You can see that the Master Controller's potential for energy savings is heavily dependent on the ever-changing ambient conditions. To determine the savings for each city, we've done a bin weather analysis. A bin weather analysis uses ASHRAE weather data for several major U.S. cities, including a few in Canada. This data shows how many hours of a typical year that the temperature is within a certain range. For instance, we know that in a typical year in Bismarck, ND, there are 309 hours where the temperature is between 5-9°F. From this, we can calculate the anticipated run time of the condensing unit which is related to the capacity and the power input to the compressor as well as the entire system (condenser fans, evaporator fans, defrost heaters, etc.) for a standard system and for a system featuring the Master Controller and reverse cycle defrost. This is done for the entire temperature range and a total cost is computed for each system based on conservative assumptions. The table on the next page shows the annual cost to operate a standard system vs. the Master Controller system for several different size units.

MRS-SERIES

STANDARD SYSTEM VS.
MASTER-CONTROLLER W/REVERSE CYCLE DEFROST

MB MASTER-BILT® Refrigeration Solutions

*Cities in italics assume $.08/kwh, all other cities energy costs are based on 2005 energy costs provided by major customer

Cond. Unit:		MSLZ0101C				MSLZ0151C				MSLZ0181C				MSLZ0221C				BSLZ0750C			
Unit Cooler:		1	E1LZ0090B			1	E1LZ0120B			1	E1LZ0160B			1	E1LZ0200C			1	E1LZ0240C		
Load (Btuh):		6800				9750				12000				15000				17500			
Min. Condensing Temp(F):		90	25			90	25			90	25			90	25			90	25		
Evap Temp:		-20	-20			-20	-20			-20	-20			-20	-20			-20	-20		
City	$/kwh	Electric Defrost - Scheduled	MC Reverse Cycle - Demand	Annual Diff. ($)	% Diff.	Electric Defrost - Scheduled	MC Reverse Cycle - Demand	Annual Diff. ($)	% Diff.	Electric Defrost - Scheduled	MC Reverse Cycle - Demand	Annual Diff. ($)	% Diff.	Electric Defrost - Scheduled	MC Reverse Cycle - Demand	Annual Diff. ($)	% Diff.	Electric Defrost - Scheduled	MC Reverse Cycle - Demand	Annual Diff. ($)	% Diff.
Birmingham, AL	$0.061	$1,155	$1,017	$138	13.6%	$1,431	$1,209	$222	18.4%	$1,778	$1,523	$255	16.7%	$2,258	$1,925	$333	17.3%	$2,872	$2,501	$371	14.8%
Edmonton, Alberta	$0.080	1474	1111	363	32.7%	1846	1325	521	39.3%	2276	1661	615	37.0%	2922	2119	803	37.9%	3689	2744	945	34.4%
Little Rock, AR	$0.053	1010	884	126	14.3%	1249	1052	197	18.7%	1554	1325	229	17.3%	1971	1672	299	17.9%	2508	2173	335	15.4%
Phoenix, AZ	$0.072	1443	1316	127	9.7%	1775	1571	204	13.0%	2220	1982	238	12.0%	2779	2475	304	12.3%	3553	3216	337	10.5%
Vancouver, BC	$0.080	1475	1195	280	23.4%	1847	1417	430	30.3%	2277	1778	499	28.1%	2925	2271	654	28.8%	3692	2947	745	25.3%
Los Angeles, CA	$0.107	1978	1736	242	13.9%	2474	2060	414	20.1%	3053	2593	460	17.7%	3916	3296	620	18.8%	4947	4285	662	15.4%
Denver, CO	$0.061	1140	933	207	22.2%	1420	1110	310	27.9%	1758	1394	364	26.1%	2245	1771	474	26.8%	2844	2298	546	23.8%
Washington, DC	$0.080	1502	1283	219	17.1%	1865	1525	340	22.3%	2313	1919	394	20.5%	2947	2431	516	21.2%	3741	3158	583	18.5%
Miami, FL	$0.084	1632	1548	84	5.4%	1991	1845	146	7.9%	2501	2332	169	7.2%	3135	2922	213	7.3%	4029	3801	228	6.0%
Tallahasee, FL	$0.080	1524	1381	143	10.4%	1881	1644	237	14.4%	2343	2073	270	13.0%	2967	2613	354	13.5%	3783	3397	386	11.4%
Tampa, FL	$0.081	1558	1446	112	7.7%	1914	1721	193	11.2%	2393	2174	219	10.1%	3017	2732	285	10.4%	3858	3553	305	8.6%
Atlanta, GA	$0.063	1183	1034	149	14.4%	1469	1230	239	19.4%	1821	1549	272	17.6%	2321	1960	361	18.4%	2946	2547	399	15.7%
Des Moines, IA	$0.052	971	797	174	21.8%	1210	948	262	27.6%	1497	1192	305	25.6%	1912	1513	399	26.4%	2423	1963	460	23.4%
Boise, ID	$0.050	936	767	169	22.0%	1166	912	254	27.9%	1443	1146	297	25.9%	1843	1456	387	26.6%	2335	1889	446	23.6%
Chicago, IL	$0.062	1159	954	205	21.5%	1443	1134	309	27.2%	1786	1426	360	25.2%	2281	1809	472	26.1%	2890	2348	542	23.1%
Indianapolis, IN	$0.047	878	730	148	20.3%	1093	868	225	25.9%	1353	1091	262	24.0%	1728	1384	344	24.9%	2190	1797	393	21.9%
Dodge City, KS	$0.080	1514	1270	244	19.2%	1880	1512	368	24.3%	2333	1902	431	22.7%	2968	2406	562	23.4%	3767	3124	643	20.6%
Lake Charles, LA	$0.080	1530	1390	140	10.1%	1886	1654	232	14.0%	2352	2087	265	12.7%	2973	2628	345	13.1%	3794	3417	377	11.0%
Boston, MA	$0.106	1971	1622	349	21.5%	2458	1928	530	27.5%	3039	2422	617	25.5%	3889	3079	810	26.3%	4921	3997	924	23.1%
Winnipeg, Manitoba	$0.080	1479	1137	342	30.1%	1848	1358	490	36.1%	2282	1703	579	34.0%	2925	2169	756	34.9%	3697	2809	888	31.6%
Portland, ME	$0.080	1481	1180	301	25.5%	1851	1403	448	31.9%	2285	1761	524	29.8%	2929	2243	686	30.6%	3703	2910	793	27.3%
Detroit, MI	$0.088	1634	1329	305	22.9%	2039	1580	459	29.1%	2520	1986	534	26.9%	3226	2524	702	27.8%	4082	3276	806	24.6%
Minneapolis, MN	$0.054	1006	806	200	24.8%	1254	960	294	30.6%	1551	1206	345	28.6%	1983	1532	451	29.4%	2511	1987	524	26.4%
Kansas City, MO	$0.055	1041	884	157	17.8%	1291	1052	239	22.7%	1603	1324	279	21.1%	2037	1675	362	21.6%	2590	2175	415	19.1%
St. Louis, MO	$0.047	886	749	137	18.3%	1100	891	209	23.5%	1365	1121	244	21.8%	1738	1419	319	22.5%	2206	1842	364	19.8%
Great Falls, MT	$0.080	1485	1184	301	25.4%	1854	1409	445	31.6%	2291	1769	522	29.5%	2933	2252	681	30.2%	3710	2920	790	27.1%
Raleigh-Durham, NC	$0.080	1502	1298	204	15.7%	1866	1544	322	20.9%	2314	1943	371	19.1%	2949	2461	488	19.8%	3742	3197	545	17.0%
Bismarck, ND	$0.080	1490	1171	319	27.2%	1858	1396	462	33.1%	2298	1753	545	31.1%	2939	2228	711	31.9%	3720	2888	832	28.8%
Omaha, NE	$0.080	1502	1242	260	20.9%	1867	1478	389	26.3%	2314	1859	455	24.5%	2950	2356	594	25.2%	3742	3058	684	22.4%
Albuquerque, NM	$0.076	1433	1219	214	17.6%	1780	1450	330	22.8%	2208	1824	384	21.1%	2811	2309	502	21.7%	3569	2999	570	19.0%
Las Vegas, NV	$0.091	1789	1590	199	12.5%	2208	1896	312	16.5%	2754	2390	364	15.2%	3465	2997	468	15.6%	4421	3894	527	13.5%
New York, NY	$0.128	2388	2006	382	19.0%	2973	2384	589	24.7%	3681	2997	684	22.8%	4701	3805	896	23.5%	5958	4941	1017	20.6%
Cleveland, OH	$0.086	1600	1310	290	22.1%	1995	1557	438	28.1%	2467	1957	510	26.1%	3156	2487	669	26.9%	3995	3228	767	23.8%
Dayton, OH	$0.058	1082	899	183	20.4%	1348	1069	279	26.1%	1668	1344	324	24.1%	2131	1705	426	25.0%	2700	2214	486	22.0%
Oklahoma City, OK	$0.057	1083	937	146	15.6%	1342	1115	227	20.4%	1668	1404	264	18.8%	2118	1773	345	19.5%	2693	2303	390	16.9%
Toronto, Ontario	$0.080	1483	1185	298	25.1%	1852	1409	443	31.4%	2287	1769	518	29.3%	2930	2251	679	30.2%	3705	2920	785	26.9%
Medford, OR	$0.080	1496	1235	261	21.1%	1864	1467	397	27.1%	2307	1843	464	25.2%	2947	2343	604	25.8%	3732	3041	691	22.7%
Portland, OR	$0.080	1482	1228	254	20.7%	1852	1457	395	27.1%	2287	1830	457	25.0%	2931	2332	599	25.7%	3705	3027	678	22.4%
Pittsburgh, PA	$0.080	1487	1220	267	21.9%	1855	1450	405	27.9%	2293	1821	472	25.9%	2934	2316	618	26.7%	3713	3005	708	23.6%
Montreal, Quebec	$0.080	1480	1174	306	26.1%	1849	1398	451	32.3%	2283	1755	528	30.1%	2927	2234	693	31.0%	3700	2897	803	27.7%
Charleston, SC	$0.080	1514	1350	164	12.1%	1873	1605	268	16.7%	2329	2023	306	15.1%	2957	2555	402	15.7%	3763	3321	442	13.3%
Nashville, TN	$0.061	1150	995	155	15.6%	1427	1184	243	20.5%	1772	1490	282	18.9%	2254	1886	368	19.5%	2863	2450	413	16.9%
Amarillo, TX	$0.080	1510	1286	224	17.4%	1875	1529	346	22.6%	2327	1925	402	20.9%	2961	2436	525	21.6%	3759	3163	596	18.8%
Brownsville, TX	$0.080	1557	1454	103	7.1%	1908	1733	175	10.1%	2390	2189	201	9.2%	3002	2745	257	9.4%	3847	3570	277	7.8%
Dallas-FW, TX	$0.069	1328	1183	145	12.3%	1639	1409	230	16.3%	2043	1776	267	15.0%	2581	2236	345	15.4%	3291	2906	385	13.2%
El Paso, TX	$0.092	1764	1561	203	13.0%	2180	1858	322	17.3%	2714	2342	372	15.9%	3435	2952	483	16.4%	4376	3835	541	14.1%
San Antonio, TX	$0.069	1330	1206	124	10.3%	1639	1437	202	14.1%	2045	1812	233	12.9%	2581	2280	301	13.2%	3295	2963	332	11.2%
Salt Lake City, UT	$0.080	1506	1242	264	21.3%	1874	1477	397	26.9%	2322	1856	466	25.1%	2959	2353	606	25.8%	3752	3054	698	22.9%
Seattle, WA	$0.065	1201	978	223	22.8%	1502	1160	342	29.5%	1853	1456	397	27.3%	2378	1859	519	27.9%	3003	2413	590	24.5%
Madison, WI	$0.063	1169	935	234	25.0%	1459	1113	346	31.1%	1803	1397	406	29.1%	2308	1777	531	29.9%	2921	2305	616	26.7%
Cheyenne, WY	$0.080	1485	1183	302	25.5%	1854	1407	447	31.8%	2291	1765	526	29.8%	2933	2248	685	30.5%	3710	2916	794	27.2%

Table 4. Annual Operating Cost of Standard Mechanical System vs. System using Master Controller with Reverse Cycle and Percent Savings (Modeled using ASHRAE Bin Weather Data for each city, Assumes –20°F Room Temperature, Standard System modeled with+90°F minimum condensing temperature, Master Controller System modeled with +25°F minimum condensing temperature. Cities in italics have energy prices assumed to be $.080/kwh)

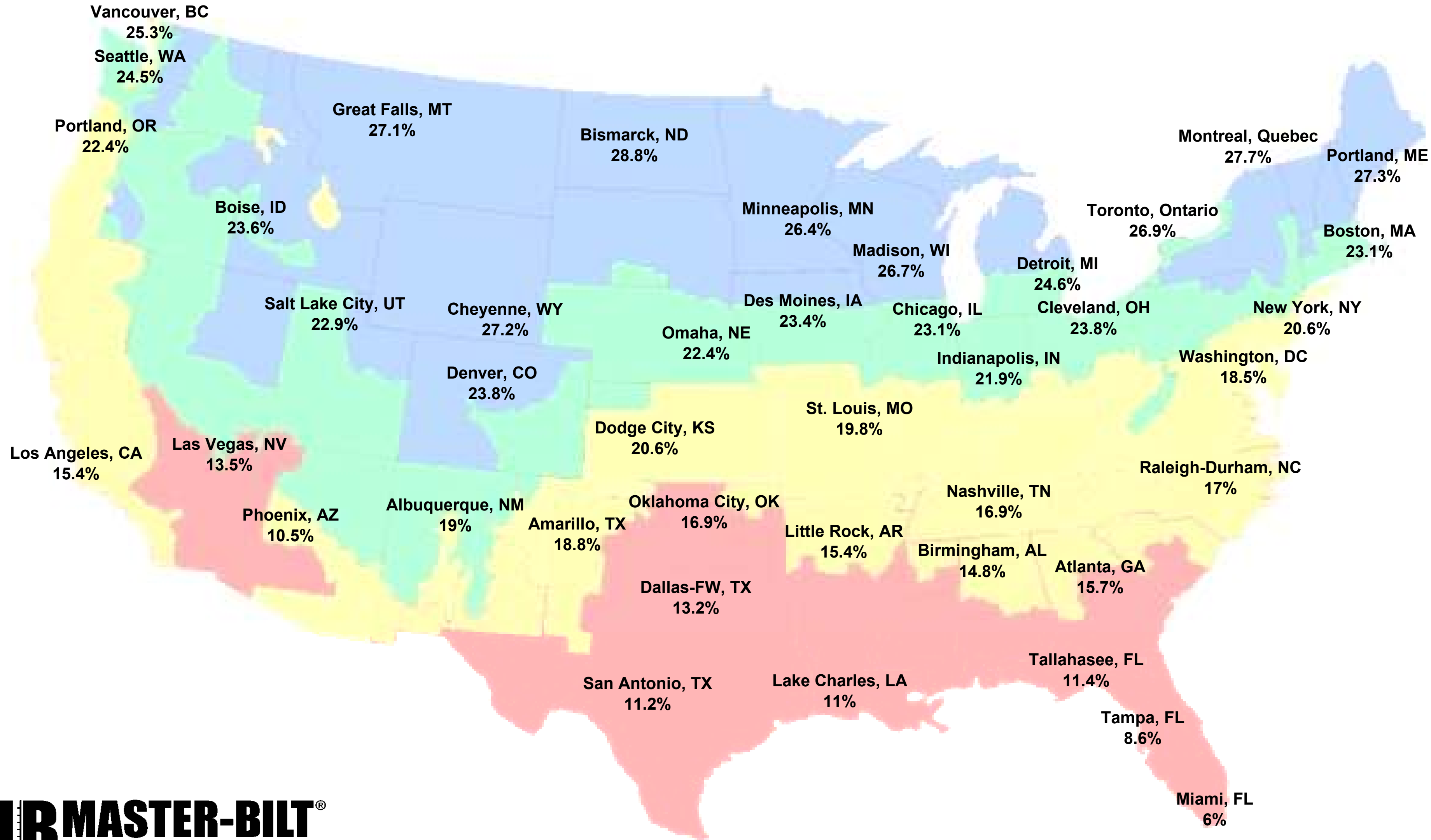

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Figure 1. Continental U.S. map showing typical savings

This map shown in Figure 1 gives gives a pictoral representation of the typical energy savings achievable when using the Master Controller with Reverse Cycle Defrost system for several of the major cities listed in the previous page. These are the theoretical savings of the BSLZ0750C refrigeration system assuming a -20°F room. This is a comparison of a standard mechanical refrigeration system condensing at a minimum of 90°F vs. a Master Controller system condensing at a minimum of +25°F.

The Master Controller and Reliability

Compression Ratio

The compression ratio is defined as the ratio of the absolute discharge pressure (*psia*) to the absolute suction pressure (*psia*). Excessive compression ratios cause excessive wear to the pin connecting the piston to the piston rod of the compressor. Table 5 shows the compression ratios for various condensing temperatures and evaporating temperatures for R-404a. Although the compression ratio of 8.95 (90°F) is not excessive, at a compression ratio of 3.43 (30°F), the “load” on the compressor is greatly reduced. Put simply, the compressor doesn’t have to work as hard! By “floating” the head pressure with the ambient and not falsely inflating it, we can achieve these low compression ratios when the ambient temperatures fall.

R404a

Compression Ratio

Evap Temp(F)	Condensing Temperature (F)										
	20	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**	**110**	**120**
-40	3.64	4.37	5.22	6.19	7.25	8.51	9.88	11.41	13.09	14.98	17.09
-35	3.22	3.87	4.61	5.47	6.40	7.52	8.73	10.08	11.57	13.24	15.10
-30	2.86	3.43	4.10	4.86	5.69	6.68	7.76	8.95	10.28	11.76	13.42
-25	2.54	3.06	3.64	4.33	5.06	5.94	6.90	7.97	9.14	10.47	11.94
-20	2.28	2.73	3.26	3.87	4.53	5.32	6.17	7.13	8.18	9.37	10.68
-15	2.04	2.44	2.91	3.46	4.05	4.76	5.52	6.37	7.31	8.37	9.55
-10	1.83	2.19	2.61	3.11	3.63	4.27	4.95	5.72	6.56	7.51	8.57
-5	1.64	1.97	2.35	2.79	3.26	3.83	4.45	5.14	5.89	6.75	7.69
0	1.48	1.78	2.12	2.51	2.94	3.46	4.01	4.63	5.31	6.08	6.94

Table 5. Compression Ratios for R-404a.

Lower Compressor Runtime

We have shown how the capacity is greatly increased in low ambient conditions. The capacity gain leads to a lower compressor runtime. A lower runtime extends the life of the compressor.

Safe Mode

The Master Controller has a “Safe Mode” that is exclusive to this system. There are three sensors and a pressure transducer on the Master Controller System. If one of the sensors or the pressure transducer fails, an alarm function is activated initiating the safe mode within the system. A flashing light and audible alarm sounds alerting the employees there is a problem so a service tech can be informed of the issue. The MC will maintain operation while in the "safe mode" until someone comes out to correct the problem and deactivates the alarm code. This feature will not allow the refrigeration system to shut down. It will continue to operate the refrigeration system until someone replaces the failed sensor. This feature has proven to save product loads.

Maximum/Minimum Suction Pressure

The Master-Controller has a Maximum Suction Pressure fail safes built into the system. This feature emulates and can eliminate the crankcase pressure regulator valve which are used to prevent overloading of the compressor motor by limiting the crankcase pressure during and after a defrost cycle or after a normal shutdown period.

The Minimum Suction Pressure fail-safe built into the system. This feature protects the compressor from going into a vacuum for Scroll compressors.

Maximum/Minimum Run Time

Minimum On/Off time set points for the valve opening protect against short cycling extending the longevity of the refrigeration system. This feature is necessary because the unit will have more than design capacity in low ambient conditions. Because the unit becomes oversized it has a low run time. The Minimum On/Off Time will insure that the system has good oil return in these low run time situations.

Excess Liquid Flow Protection Failsafe

The same probes that monitor the coil in the refrigeration cycle use a proprietary algorithm to detect the flow of excess liquid that may form and throttle the electronic electric expansion valve during the defrost cycle decreasing the flow to a safe level protecting the compressor. This excess liquid, left unchecked, can lead to compressor “slugging”. This eliminates the need for a re-evaporative heat exchanger (Thermo-bank) or large suction accumulator previously required for this application.