How to Keep the Heat in Your Oven

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Proper insulation in your industrial process oven can be the difference between efficient production and costly energy losses.

When designing ovens for process heating applications, insulation typically is the last and least considered area. Insulation isn't sexy. It cannot think for the operator like a controller can. It can be itchy. And those who handle it have to wear a hot, sweaty mask and other protective apparel that might be considered uncomfortable. As a result, some industrial process ovens might not be as well insulated as they could or should be.

TABLE 1. INSULATION MATERIALS AND TYPES

Material	Type and Form	Max. Use Temperature	Approximate K Factor BTU in/hr-ft²-°F 300°F	700°F
Fiberglass	Preformed, Molded, Bulk Fiber, Rigid Board, Flexible Blanket, Textiles	1,200°F	0.35	0.64
Mineral Wool (Basalt)	Preformed, Molded, Bulk Fiber, Rigid Board, Flexible Blanket	1,800°F	0.35	0.65
High Purity Silica (Quartz)	Paper, Textiles, Flexible Blanket,	1,800°F	0.37	0.68
Ceramic Fiber	Rigid Preformed, Molded, Bulk Fiber Paper, Flexible Blanket, Textiles	2,300°F	0.36	0.65
Calcium Silicate	Rigid Molded, Block	1,200°F	0.47	0.72
Expanded Perlite	Rigid Molded, Block	1,200°F	0.58	0.77

High temperature insulation is available in numerous materials and forms.

Keeping the heat in your process oven is important for a number of reasons. Temperature control, safety, environmental pollution and energy conservation are the big ones. For good reason, we tend to spend most of our time and energy on achieving proper temperature, environmental and safety controls. As energy prices continue to climb, better energy conservation and the economic benefits of insulation thickness should be examined.

TABLE 2. INSULATION THICKNESS USED TO CALCULATE HEAT AND STEAM SAVINGS

NPS Pipe Size (in)	Insulation Thicknesses — Nominal Operating Temperature 212°F	300°F	400°F	500°F	600°F	700°F	800°F	900°F	1,000°F	1,100°F	1,200°F
0.5	1	1	1	1	1.5	1.5	1.5	2	2	2	2
0.75	1	1	1	1	1.5	1.5	1.5	2	2	2	2
1	1	1	1	1.5	1.5	1.5	2	2	2	2	2.5
1.25	1	1	1	1.5	1.5	2	2	2	2	2	2.5
1.5	1	1	1.5	1.5	2	2	2	2.5	2.5	2.5	2.5
2	1	1	1.5	1.5	2	2	2	2.5	2.5	2.5	3
2.5	1	1	1.5	1.5	2	2	2.5	2.5	2.5	3	3
3	1	1	1.5	1.5	2	2	2.5	2.5	2.5	3	3
3.5	1	1.5	1.5	2	2	2.5	2.5	2.5	3	3	3
4	1	1.5	1.5	2	2	2.5	2.5	3	3	3	3.5
5	1	1.5	1.5	2	2	2.5	2.5	3	3	3	3.5
6	1.5	1.5	2	2	2	2.5	3	3	3.5	3.5	3.5
8	1.5	1.5	2	2	2.5	3	3	3.5	3.5	4	4
10	1.5	1.5	2	2	3	3.5	3.5	3.5	4	4	4.5
12	1.5	2	2.5	2.5	3	3.5	3.5	4	4.5	4.5	5
14	1.5	2	2.5	2.5	3.5	3.5	4	4	4.5	4.5	5
16	1.5	2	2.5	3	3.5	3.5	4	4	4.5	4.5	5
18	1.5	2	2.5	3	3.5	4	4	4.5	4.5	5	5
20	1.5	2	2.5	3	3.5	4	4	4.5	4.5	5	5
24	1.5	2	2.5	3	3.5	4	4.5	4.5	5	5	5.5
30	2	2.5	3	3.5	4	4.5	4.5	5	5.5	5.5	6
36	2	2.5	3	3.5	4	4.5	5	5.5	6	6	6.5
					Insulation Thickness (in)						
Flat	2	2.5	3	3.5	4	4.5	5	5.5	6	6	6.5

Table 2 shows the insulation thickness used to calculate heat savings. *Note: This table is not a table of recommended thicknesses. It represents only a table suitable for a particular type of insulation, ambient condition, surface emmittance and air movement. These tables 14, 15, 16, 17, 18, 19, 20, 21 and 22 all are based on this single condition, which is not representative of any particular set of conditions for industry. This is only presented to illustrate how economics of insulation should be determined.* Source: *Thermal Insulation Handbook*

Parameters to consider when choosing the insulation type, vapor barriers and cladding for each process heating application include:

- Hot face (process) temperature (maximum and normal operation).
- Average ambient cold-face temperature.
- Indoor or outdoor.
- Space considerations.
- Vibration.
- Moisture and corrosion potential.
- Installation configurations.
- Thermal conductivity requirement.
- Wind factor.
- Removability requirement.

Because most process heating applications operate above 212°F (100°C), I will confine my discussion to insulation types for with use temperatures at or above 212°F.

TABLE 3. HEAT LOSS — BARE SURFACE (BASED ON 70°F AMBIENT TEMPERATURE — NATURAL CONVECTION)

NPS Pipe Size Nominal (in)	Heat Loss — BTU per Linear Foot per Hour at Specified Operating Temperature 212°F	300°F	400°F	500°F	600°F	700°F	800°F	900°F	1,000°F	1,100°F	1,200°F
0.5	82	166	287	445	649	901	1,218	1,602	2,075	2,644	3,317
0.75	101	205	353	547	801	1,113	1,508	1,984	2,576	3,282	4,122
1	123	250	434	674	989	1,379	1,865	2,460	3,19	4,080	5,123
1.25	153	312	541	843	1,237	1,728	2,342	3,091	4,010	5,123	6,438
1.5	173	352	613	955	1,403	1,960	2,661	3,514	4,508	5,841	7,345
2	213	431	753	1,176	1,732	2,423	3,295	4,355	5,605	7,251	9,133
2.5	252	516	899	1,408	2,077	1,907	3,956	5,235	6,817	8,752	11,005
3	303	620	1,083	1,695	2,505	3,511	4,784	6,337	8,259	10,532	13,344
3.5	343	700	1,226	1,922	2,841	3,987	5,434	7,201	9,390	12,039	15,189
4	383	784	1,370	2,149	3,179	4,467	6,094	8,079	10,545	13,513	17,049
5	420	861	1,513	2,377	3,513	4,989	6,742	8,944	11,676	14,982	18,892
6	544	1,122	1,976	3,105	4,604	6,479	8,858	11,769	15,366	19,740	24,909
8	697	1,436	2,530	3,988	5,927	8,356	11,483	15,211	19,895	25,508	32,293
10	855	1,769	3,114	4,918	7,312	10,325	14,147	18,812	24,621	31,679	40,051
12	1,020	2,079	3,664	5,809	8,627	12,194	16,721	22,248	29,133	37,501	47,429
14	1,180	2,258	3,989	6,316	9,404	13,301	18,236	24,279	31,844	40,965	51,656
16	1,240	2,560	4,529	7,160	10,697	15,124	20,769	27,663	36,257	46,689	59,089
18	1,390	2,875	5,074	8,032	12,010	16,992	23,346	31,109	40,788	52,539	66,456
20	1,530	3,168	5,618	8,897	13,270	18,777	25,810	34,432	45,157	58,159	73,601
24	1,820	3,772	6,679	10,595	15,825	22,375	30,836	41,112	53,958	69,536	88,221
30	2,215	4,642	8,242	13,103	19,606	27,758	38,299	51,107	67,126	86,558	109,872
36	2,660	5,570	9,880	15,720	23,530	33,300	45,900	61,300	80,500	104,000	131,800
	Heat Loss — BTU per Square Foot per Hour										
Flat	319	654	1,145	1,806	2,666	3,765	5,126	6,799	8,885	11,400	14,394

Table 3 shows heat loss data from bare surface area on NPS piping and flat surfaces.

High temperature insulation is available in numerous materials and forms, including fiberglass, mineral wool (basalt), high purity silica (quartz), ceramic fiber, calcium silicate and expanded perlite (table 1).

After the insulation type has been selected, thickness requirements must be determined. Except when there is a limited space requirement, the most economical insulation thickness should be used. This thickness will yield the best return on investment. Table 2 shows the insulation thickness used to calculate heat savings. Table 3 shows heat loss data from bare surface area on NPS piping and flat surfaces. Table 4 shows heat loss after an appropriate type and insulation thickness has been specified. For the most part, heated processes should be designed to have the insulation perform to a 95 percent or better efficiency level. Considering this, based on energy costing $5 per million BTU, table 5 shows the dollars per square foot that will be lost per year from bare, uninsulated metal surfaces. If the equipment is outdoors and exposed, it can get wet, and the energy dollar loss goes up even more.

Dry Run, Training

After the insulation type and thickness have been determined, it is critical that the insulation remain dry whether the process is operating or not. If the insulation is allowed to get wet, it will lose about 90 percent of its insulation value. In addition, corrosion problems will begin once moisture enters your insulation system. Specifying and installing a good vapor or moisture barrier that is maintained properly will accomplish the job of keeping the heat in your oven.

TABLE 4. HEAT LOSS — INSULATED PIPE AND EQUIPMENT

NPS Pipe Size	Heat Loss — BTU per Linear Foot per Hour at Specified Operating Temperature										
Nominal (in)	212°F	300°F	400°F	500°F	600°F	700°F	800°F	900°F	1,000°F	1,100°F	1,200°F.
0.5	17	29	46	65	70	88	109	116	137	161	185
0.75	20	35	55	77	81	102	126	132	156	182	180
1	22	37	57	66	87	111	118	148	169	197	204
1.25	25	47	74	75	98	113	140	170	201	125	239
1.5	27	48	60	84	89	113	140	150	178	207	239
2	31	55	68	95	106	134	165	177	210	245	257
2.5	36	63	70	100	112	143	156	188	233	239	274
3	43	75	89	126	133	176	189	228	270	283	326
3.5	44	57	89	108	142	159	197	237	252	294	338
4	51	69	108	126	166	181	224	239	283	337	347
5	61	82	129	149	196	211	260	278	330	385	401
6	55	96	121	170	224	242	263	317	331	386	445
8	57	97	150	210	277	284	313	378	402	428	494
10	78	139	175	209	241	272	356	404	435	508	538
12	82	130	170	286	276	311	384	419	455	531	567
14	104	146	191	223	271	342	381	459	497	590	613
16	118	164	214	260	302	382	424	511	553	645	685
18	132	182	238	288	335	380	468	512	607	653	752
20	149	200	260	315	366	415	510	560	662	710	818
24	172	237	307	370	429	485	541	652	709	827	862
30	169	242	322	398	468	532	655	724	793	924	990
36	199	291	387	478	562	639	720	803	883	1,004	1,107
	Heat Loss — BTU per Square Foot per Hour										
Flat	19	29	38	46	53	60	67	73	79	87	98

Table 4 shows heat loss after an appropriate type and insulation thickness has been specified.

North American Insulation Manufacturers Association (NAIMA) and National Insulation Association (NIA) offer training programs that teach how to determine proper insulation practices. Each offers 3 E Plus, a software program for determining heat loss and the most economical insulation thickness.

TABLE 5. THE COST OF FAILING TO INSULATE

300°F	400°F	500°F	600°F	700°F	800°F	1,000°F
$25	$45	$65	$90	$125	$170	$270.

Table 5 shows the dollars per square foot that will be lost per year from bare, uninsulated metal surfaces.