

**AIL Research**

## **SOA Series**

# **Liquid Desiccants for Solar Cooling**

### **Economic Solar Cooling**

Our advanced liquid-desiccant technology has for the first time created an economically viable solar powered air conditioner. AILR's SOA Series – the end products of a seven year, \$5 million development program funded by the Department of Energy's SBIR program and the National Renewable Energy Laboratory – can convert hot water provided by solar thermal collectors into useful cooling and dehumidification. The patented low-flow technology that these units use has lowered the cost, increased the efficiency and reduced maintenance for liquid-desiccant air conditioners.

### **Applications**

The SOA series of liquid-desiccant air conditioners completely changes the competition between solar cooling and conventional electric air conditioners. In the past, a cooling system that used solar thermal collectors would most likely use an absorption chiller. But the 45°F chilled water that this solar cooling



system delivered is neither better nor worse than that provided by a conventional electric chiller. The larger size and higher costs of absorption chillers put solar cooling at an immediate disadvantage.

The SOA will do something that a conventional air conditioner cannot – they will meet high latent loads (i.e. dehumidification loads) without inefficient and expensive overcooling/reheating. In addition the SOA requires lower activation temperature than absorption chillers or solid desiccant systems. The SOA provides high efficient latent cooling at temperatures from 180 °F to 160 °F.

Two broad classes of applications – one obvious and one not so obvious – meet this latent-load requirement. The obvious one occurs in areas such as the humid eastern half of the U.S.

where the ventilation air to buildings during peak summer conditions creates latent loads that can be 2.5 times as great as the sensible loads. The SOA can over dry a building's ventilation air even in the most humid climates. In many applications, the building's entire latent load can be handled by this over-drying, leaving only sensible load for the main cooling system (which then can operate more efficiently with higher coil temperatures).

The less obvious applications are in areas such as the dry, western half of the U.S. In most western locales, electric vapor-compression air conditioners dominate despite the fact that in dry climates, evaporative coolers (both direct and indirect) are often much more efficient.

One reason evaporative coolers are not more widely used is that they cannot handle latent loads. Many western locations have "monsoon" seasons when latent loads become large and outdoor wetbulb temperatures are too high to effectively use evaporative cooling. In other applications, internal latent loads are handled by flowing a large volume of evaporatively cooled air through the building. Fan power for moving this air is significant, as is the filtration needed to eliminate the dust and pollen.

The SOA will overcome many of the barriers to evaporative cooling in these 'dry' areas. When used with cooling towers, they are evaporative coolers – that is they cool the building using the evaporation that occurs in the cooling

tower. But they are evaporative coolers that can operate at high wetbulb temperatures and which handle latent loads. Our liquid-desiccant air conditioners will retain the benefits of an evaporative cooler, while reducing fan power and extending operating range. Using solar thermal energy to drive these systems captures still more environmental and energy benefits.

## LD Based Solar Cooling versus Solar Photovoltaic

For many people, solar energy means photovoltaic (PV) cells. This is not surprising since in this country the publicity, R&D funding and corporate investment is far greater for PV than all solar heating and cooling combined. We recognize the value of a technology that can convert sunlight into electricity, since electricity can be used in many applications. However, if you look closely at one critical application now served almost exclusively by electric equipment – air conditioning and dehumidification – *the most effective technology for converting this application to a renewable resource is solar thermal driving the SOA, not PV.*

## How it works

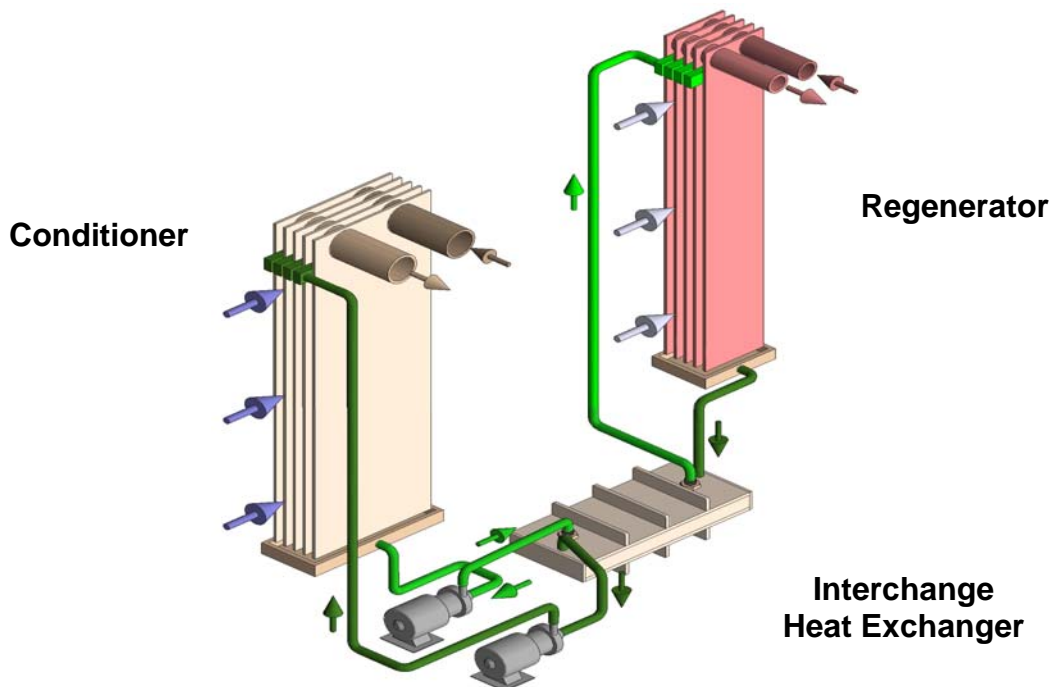
A liquid-desiccant air conditioner has three main components: the conditioner, the regenerator and the interchange heat exchanger. The conditioner is a parallel-plate liquid-to-air heat exchanger. A coolant, typically cooling tower water or water from a geothermal well, lake or swimming pool, flows within the plates and a very-low flow of liquid desiccant flows down the outer surfaces of the plates. Thin wicks on the plate surfaces create uniform desiccant films. The air to be processed flows horizontally through the gaps between the plates. As this humid air comes in contact with the desiccant, water vapor is absorbed. The heat released by this absorption is transferred to the coolant. The air leaves the conditioner drier and at a much lower wet-bulb temperature.

The dilute desiccant that leaves the

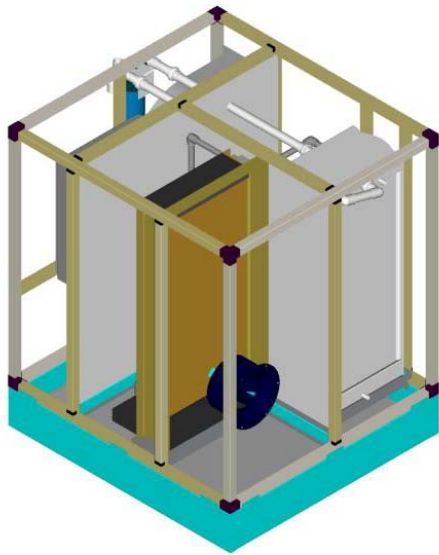
conditioner is pumped to the regenerator. The regenerator has the same configuration as the conditioner: a parallel-plate liquid-to-air heat exchanger.

Again, very thin films of desiccant flow in wicks on the outer surfaces of the plates, and air flows in the gaps between the plates. For the regenerator, however, a hot heat transfer fluid flows within the plates which can be supplied by solar thermal collectors or another energy source. As the temperature of the desiccant increases, it evaporates water into an air stream that is then discharged outdoors.

The hot, concentrated desiccant that leaves the regenerator and the cool, dilute desiccant that flows to the regenerator exchange thermal energy in the interchange heat exchanger. This exchange increases the efficiency of the regenerator and decreases the cooling load on the conditioner.



# SOA3000



SOA-6000 with Optional Auxiliary Hot-Water Boiler

## SYSTEM SPECIFICATIONS

### Conditioner

total cooling	see tables
latent cooling	see tables
minimum air flow	2,000 cfm
nominal air flow	3,000 cfm
maximum air flow	4,000 cfm
cooling water flow	38 gpm
desiccants	43% lithium chloride

43% calcium chloride

desiccant additives	none
desiccant flow	2 gpm

### Regenerator and Water Heater

nominal air flow	500 cfm
hot water flow	20 gpm
hot water supply temperature	160 F to 210 F
regeneration COP	see tables
nominal thermal input	200,000 Btu/h

### Dimensions/Weights

height	76 inches
width	61 inches
length	65 inches
shipping weight (est.)	1,400 lbs
operating weight (est.)	2,000 lbs

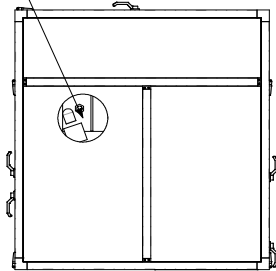
### Pumps and Fans

main blower	1,000 W
(sized for 1.5" w.c. external pressure drop)	
regeneration blower	120 W
desiccant pumps (2)	150 W (each)

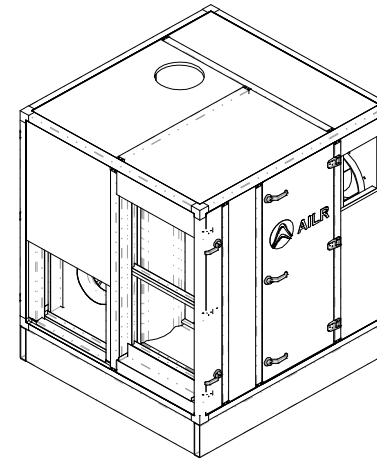
# OA3000 Layout & Dimensions

(louvers and exit ducts not shown for clarity)

Regeneration air outlet  
Nominal: 12" diameter

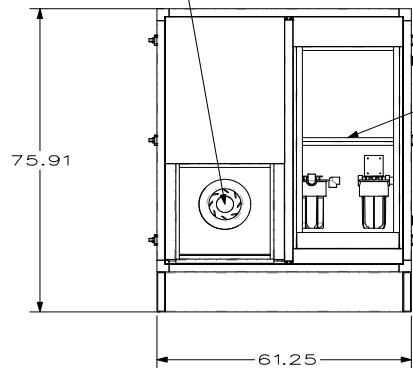


TOP



ISOMETRIC

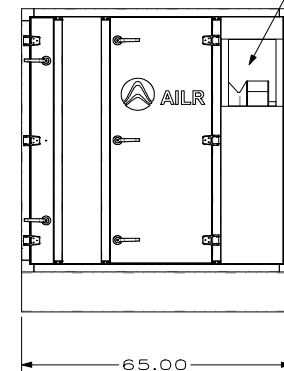
Regeneration air inlet  
Nominal: Width 24"x Height 24"



FRONT

Process air inlet  
Nominal: Width 24"x Height 48"

Process air outlet  
Nominal: Width 15"x Height 16.63"



RIGHT

## OA-3000 Conditioner Performance

3,000 cfm

12" conditioner depth

10 F delta T for coolant

43% LiCl

4 point change for desiccant

[Total Cooling / Latent Cooling]

Btu/h

Air DB T (F)	Coolant T (F)	Air WB T(F)		
		74	78	80
85	65	171,990 / 137,290	210,357 / 175,679	230,202 / 196,232
	75	136,269 / 123,994	174,636 / 162,214	194,481 / 182,656
	85	95,256 / 105,864	133,623 / 144,043	153,468 / 164,414
90	65	170,667 / 124,582	209,034 / 162,859	228,879 / 183,426
	75	134,946 / 111,244	173,313 / 149,381	193,158 / 169,836
	85	93,933 / 93,044	132,300 / 131,167	152,145 / 151,552
95	65	170,667 / 111,958	207,711 / 150,053	228,879 / 170,607
	75	133,623 / 98,606	171,990 / 136,547	191,835 / 157,002
	85	92,610 / 80,309	130,977 / 118,291	152,145 / 138,691
100	65	169,344 / 99,349	207,711 / 137,654	227,556 / 157,801
	75	133,623 / 85,955	171,990 / 124,134	191,835 / 144,183
	85	91,287 / 67,531	130,977 / 105,822	150,822 / 125,815

## OA-3000 Conditioner Performance

3,000 cfm

24" conditioner depth

10 F delta T for coolant

43% LiCl

4 point change for desiccant

[Total Cooling / Latent Cooling]

Btu/h

Air DB T (F)	Coolant T (F)	Air WB T(F)		
		74	78	80
85	65	226,233 / 174,053	275,184 / 221,759	301,644 / 247,329
	75	181,251 / 159,020	230,202 / 206,810	256,662 / 232,365
	85	129,654 / 137,766	179,928 / 185,934	206,388 / 211,602
90	65	226,233 / 158,446	273,861 / 206,025	300,321 / 231,595
	75	181,251 / 143,342	230,202 / 191,034	255,339 / 216,603
	85	128,331 / 121,934	178,605 / 170,088	205,065 / 195,770
95	65	224,910 / 142,950	273,861 / 190,292	298,998 / 215,875
	75	179,928 / 127,790	228,879 / 175,258	255,339 / 200,842
	85	128,331 / 106,172	177,282 / 154,200	203,742 / 179,924
100	65	224,910 / 127,454	272,538 / 175,090	298,998 / 200,141
	75	178,605 / 112,197	228,879 / 160,001	254,016 / 185,066
	85	127,008 / 90,326	177,282 / 138,831	202,419 / 164,064

## OA-3000 Conditioner Performance

3,000 cfm

12" conditioner depth

10 F delta T for coolant

43% CaCl<sub>2</sub>

4 point change for desiccant

[Total Cooling / Latent Cooling]

Btu/h

Air DB T (F)	Coolant T (F)	Air WB T(F)		
		74	78	80
85	65	141,561 / 106,382	178,605 / 143,959	198,450 / 164,050
	75	92,610 / 80,575	129,654 / 118,165	149,499 / 138,158
	85	27,783 / 41,331	71,442 / 82,410	91,287 / 102,824
90	65	140,238 / 93,717	177,282 / 131,223	197,127 / 151,314
	75	91,287 / 67,755	128,331 / 105,373	149,499 / 125,381
	85	47,628 / 42,256	68,796 / 69,324	89,964 / 89,850
95	65	138,915 / 81,135	175,959 / 118,473	195,804 / 138,579
	75	89,964 / 54,977	128,331 / 92,540	148,176 / 112,589
	85	46,305 / 28,862	67,473 / 56,084	88,641 / 76,848
100	65	138,915 / 68,526	175,959 / 106,130	195,804 / 125,843
	75	88,641 / 42,074	127,008 / 80,112	146,853 / 99,783
	85	43,659 / 13,927	66,150 / 43,125	87,318 / 63,734

## OA-3000 Conditioner Performance

3,000 cfm

24" conditioner depth

10 F delta T for coolant

43% CaCl<sub>2</sub>

4 point change for desiccant

[Total Cooling / Latent Cooling]

Btu/h

Air DB T (F)	Coolant T (F)	Air WB T(F)		
		74	78	80
85	65	190,512 / 139,419	239,463 / 186,929	264,600 / 212,302
	75	128,331 / 108,176	178,605 / 156,400	205,065 / 181,955
	85	70,119 / 75,139	101,871 / 111,608	129,654 / 138,354
90	65	190,512 / 123,769	238,140 / 171,209	264,600 / 196,596
	75	128,331 / 92,246	177,282 / 140,526	203,742 / 166,151
	85	68,796 / 58,620	99,225 / 95,188	128,331 / 122,186
95	65	189,189 / 108,176	238,140 / 155,461	263,277 / 180,890
	75	127,008 / 76,288	175,959 / 124,610	202,419 / 150,305
	85	66,150 / 41,625	97,902 / 78,571	127,008 / 105,906
100	65	187,866 / 92,568	236,817 / 140,232	263,277 / 165,157
	75	124,362 / 60,091	175,959 / 109,184	201,096 / 134,417
	85	62,181 / 22,683	96,579 / 62,207	124,362 / 89,472

## OA-3000 Regenerator Performance

10 F delta T for hot water

39% LiCl

[COP / Water Removal lb/h]

4 point change for desiccant

50% effective air-air heat exchanger

Air DB T (F)	Hot Water T (F)	Air WB T(F)					
		74		78		80	
85	160	0.644	40.3	0.612	34.5	0.592	31.3
	180	0.736	80.2	0.723	74.9	0.715	72.0
	200	0.808	136.1	0.801	131.2	0.797	128.6
90	160	0.667	42.3	0.638	36.5	0.620	33.4
	180	0.749	82.2	0.737	76.8	0.729	74.0
	200	0.817	138.0	0.810	133.1	0.806	130.5
95	160	0.690	44.3	0.663	38.6	0.647	35.5
	180	0.762	84.1	0.750	78.8	0.743	75.9
	200	0.825	139.9	0.818	135.0	0.815	132.4
100	160	0.711	46.3	0.687	40.5	0.673	37.5
	180	0.774	86.0	0.763	80.7	0.757	77.9
	200	0.833	141.8	0.827	136.9	0.823	134.3

## OA-3000 Regenerator Performance

10 F delta T for hot water

39% CaCl<sub>2</sub>

[COP / Water Removal lb/h]

4 point change for desiccant

50% effective air-air heat exchanger

Air DB T (F)	Hot Water T (F)	Air WB T(F)					
		74		78		80	
85	160	0.798	92.7	0.789	87.6	0.784	84.9
	180	0.863	157.6	0.857	152.9	0.854	150.4
	200	0.933	246.7	0.930	242.4	0.928	240.1
90	160	0.810	94.6	0.801	89.5	0.796	86.8
	180	0.871	159.4	0.865	154.8	0.862	152.3
	200	0.939	248.5	0.935	244.2	0.933	242.0
95	160	0.821	96.5	0.813	91.4	0.809	88.7
	180	0.878	161.3	0.873	156.6	0.870	154.1
	200	0.944	250.3	0.941	246.1	0.939	243.8
100	160	0.833	98.4	0.825	93.3	0.821	90.6
	180	0.886	163.1	0.881	158.5	0.878	156.0
	200	0.950	252.1	0.946	247.9	0.944	245.6