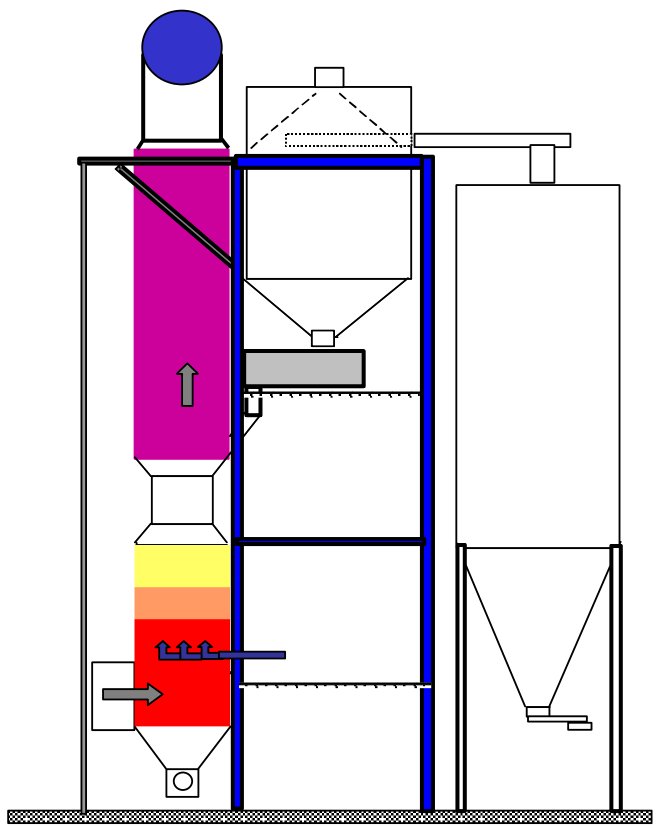
BES

RAP – FLASH DRYING PROCESS
DAP – CONDITIONING PROCESS

IMPROVED PROCESSES FOR TODAY'S SYSTEMS



BEAUMONT ENVIRONMENTAL SYSTEMS

Background
Personnel at "Beaumont have extensive experience in the development of acid gas technologies. The experience ranges from bench scale to full commercialization. We have helped define the technology, develop applications and determine technical limitations of the technology.

The following covers our experience in developing, piloting and installing semi-dry scrubbers for the removal of acid gases from combustion processes. This work includes:

Total of Seven Designs (7)

- Dry Type (1)
- Rotary Type (2)
- Nozzle Type (2)
- Reactor Type (1)
- Flash Dryer (1)

Total of Four Pilot Units (4)

- Rotary type (1)
- Reactor types.(3)

Total of Two Demonstration Units

- Both Reactor Types

Total of Twenty One (21) Installations

- Nozzle type (5) projects
- Rotary type (11) projects
- Reactor type (5) projects

All of the above experience included direct responsibility for application sizing, equipment design, sale of project, project execution, equipment supply and in many cases turnkey services.

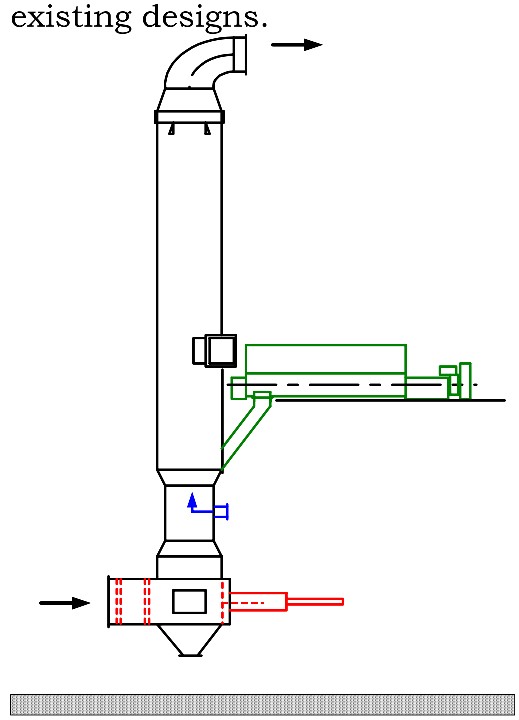
Project execution experience includes design, specification, engineering, purchasing, project execution, field construction and trouble shooting of problem areas.

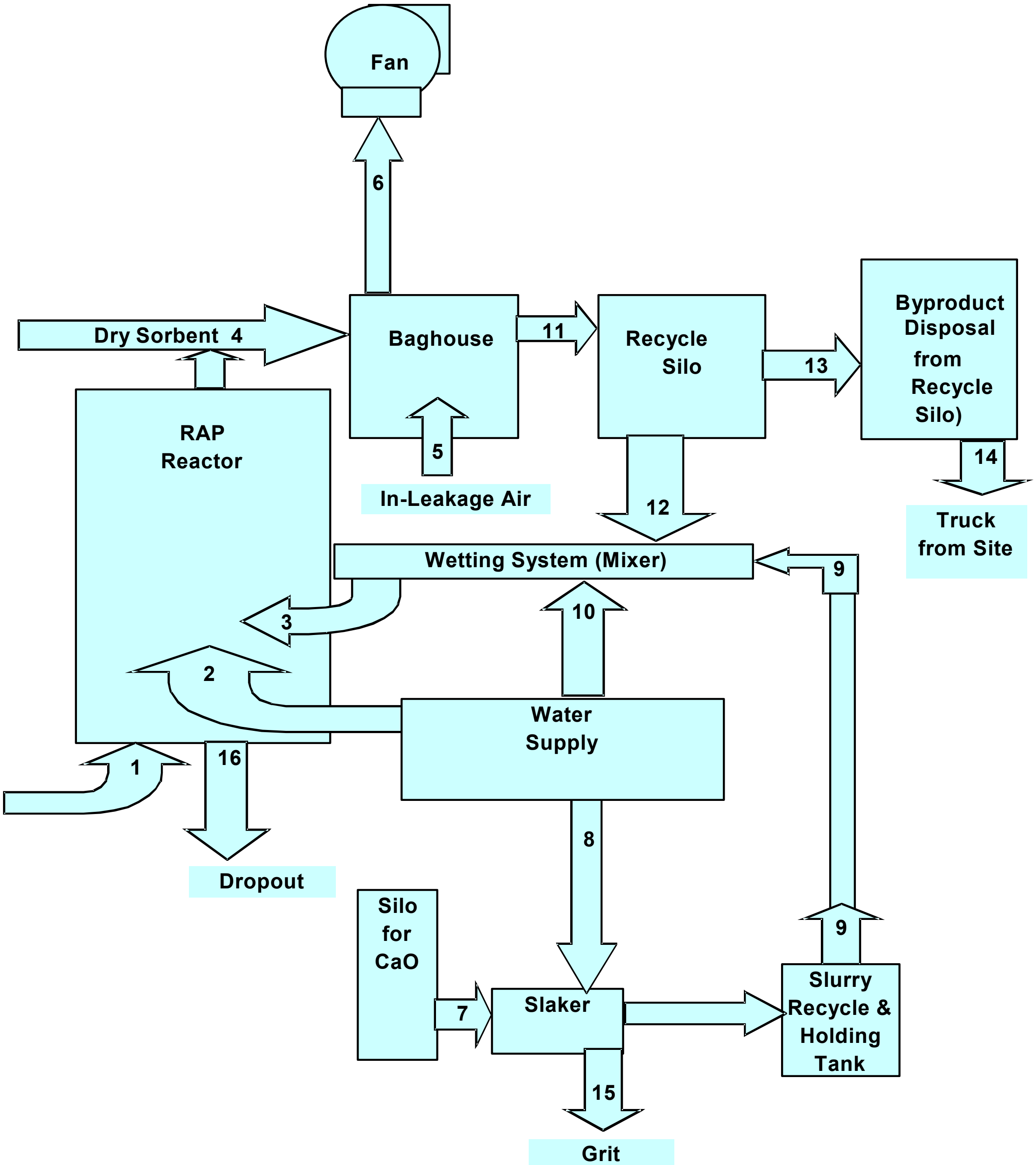
History
The first installation in the USA occurred in late 1970's (Ottertail Power), which was a rotary type unit (sodium based) followed by the development of other lime rotary type based units.

The development of lime based nozzle type designs followed; these were primarily used in industrial application

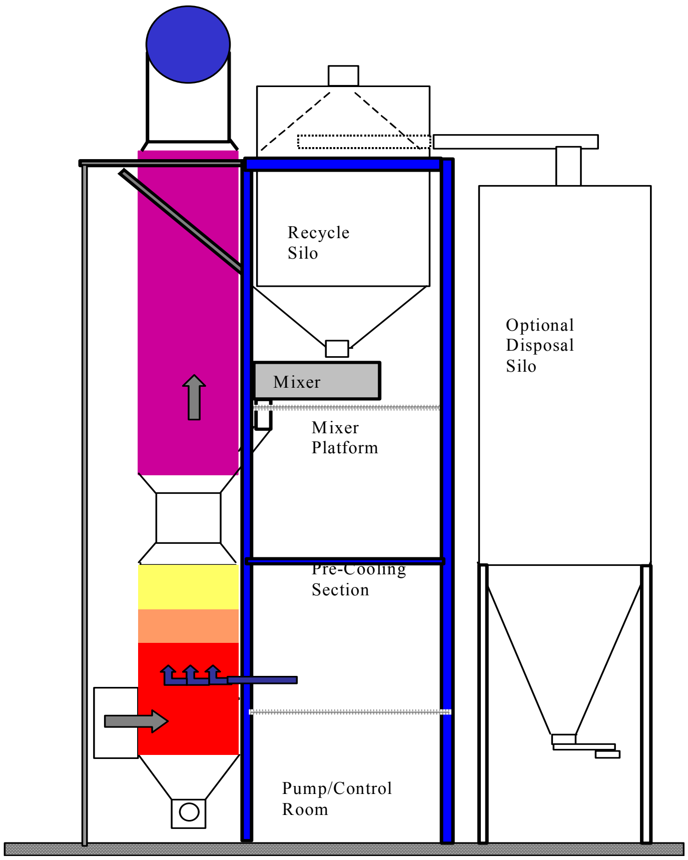
Reactors were introduced in the late 1980's for incineration plants. They were piloted in the USA in the early 1990's. This design offered many improvements over the rotary and nozzle designs.

New Design
Beaumont developed a new Flash Drying design that improved on existing designs.





RAP – Flash Drying Process



The RAP

The RAP design introduces the lime slurry into the recycled material. This takes place in a mixer external to the RAP drying process. Recycle material is introduced from a silo located above the mixer. The amount introduced is controlled by a variable frequency drive rotary valve, which is in turn controlled by the amount of liquid introduced to the mixer.

The moisture concentration is set and maintained by controlling the amount of recycle material introduced into the mixer.
When the wetted recycle material is introduced into the reactor, it is "**Flash Dried**" during which time the SO_2 is reacted. •

Multi-Pollutant Control

This RAP, Flash Drying **Control system replaces the older** series of controls, where each pollutant has it's own "box" where it is removed

By combining **gas conditioning** (patent pending) in the reactor along with **Flash Drying** (patented) for SO_2 removal; we control most boiler flue gas contaminates. In most cases the NOx will be controlled at the boiler.

The need to capture multi-pollutants and do it economically is accomplished by identifying the various pollutants; understanding their physical characteristics and understanding how the pollutants react under varying conditioning methods

After cooling some of the **Acid gases will become solid particles** that can then be collected in the Final Filter.

The most flexible Final Filter is a bag-filtering array or baghouse. Both Reverse Gas cleaning and Pulse Cleaning types can be utilized.

In the Reactor we can introduce alkaline solids. These solids become sites where Mercury, Selenium and other metals can be adsorbed or absorbed.

Therefore, the most flexible Multi-Pollutant control system is one that condenses and sorbs gaseous acids and vapors onto solids that are collected in the final filter

The Mixer is an important aspect of the RAP system.

The mixer shown in these pictures is typical of those used in RAP systems. The top plate is replaced with a housing containing lime slurry and water sprays.

The mixer operates in a center up and sides down material flow forcing the material from the entry chute to the bottom discharge on the opposite end. This boiling like action exposes fresh solids to the surface on a continuous basis.

In the RAP system it is important to maintain the proper water to solids ratio. The mixer then must produce a product that is uniform and has the proper flowability.

The unit is normally designed to operate at a constant rotational speed. Other reactor designs attempt to feed out of a storage bin requiring much higher horsepower than the RAP.

Ash Handling System

All of the material from the boiler and from the RAP mixer pass through the RAP reactor and are collected in the final filter.

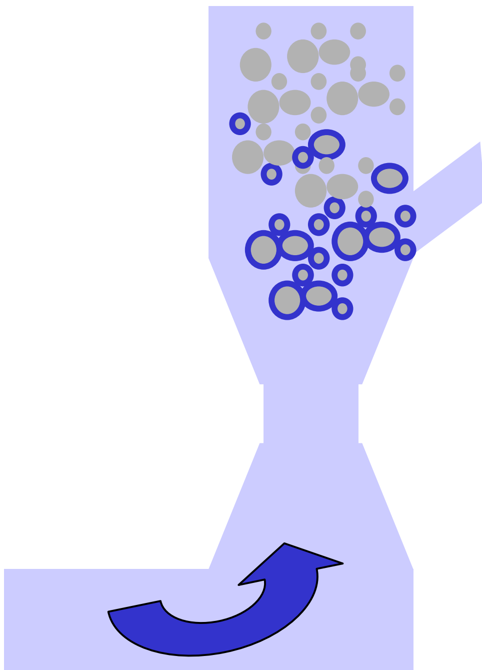
The material from the final filter is then conveyed to the recycle silo. This may be conveyed by a bucket elevator or by a pneumatic conveyor.

The recycle silo is a day bin that stores about 1 hours of material required for recycle at maximum design conditions.. The controls and conveying equipment are quite simple as all of the collected material is conveyed directly to the recycle silo. All of the un-reacted lime is thereby available for reuse.

A simple overflow screw runs continuously dumping unneeded material into the final disposal silo. This eliminates complicated material splitters required by other system designs.

RAP Reactor

The Reactor is able to flash dry rapidly using the heat of the flue gas. The recycle material enters the reactor above the venturi as shown below.



The wetted recycle material enters from the chute and immediately flash dries leaving a dried material that is carried on to the final filter (baghouse or electrostatic precipitator).

By keeping the lime slurry sprays outside of the reactor, we eliminate the buildup on the walls of the reactor, which is a problem with previous semi-dry scrubber designs

In the venturi section an evaporative cooling water spray nozzle is installed. This nozzle can be activated to cool the flue gas during start-up when SO_2 is not being controlled. It also is available for additional cooling during normal operation.

Disposal Material

The disposal material from the chemical reaction of the SO_2 with the lime slurry has been characterized (based on coals with ash less than 10% and with sulfur content of 3 to 4%) and is as follows.

–Ca(OH)2 - 13%
–CaSO3 - .5H2O - 65%
–CaSO4 - 4%
–CaCl2- 1.5H2O - 2%
–CaCO3 - 11%
–Inert - 5%

The disposal material from the chemical reaction of the SO_2 with the lime slurry is as follows.

–<200 Microns 91-98 %
–<100 Microns 70 to 90 %
–<75 Microns 52 to83 %
–<50 Microns 18 to 59 %

–Average of 60 lbs/cuft

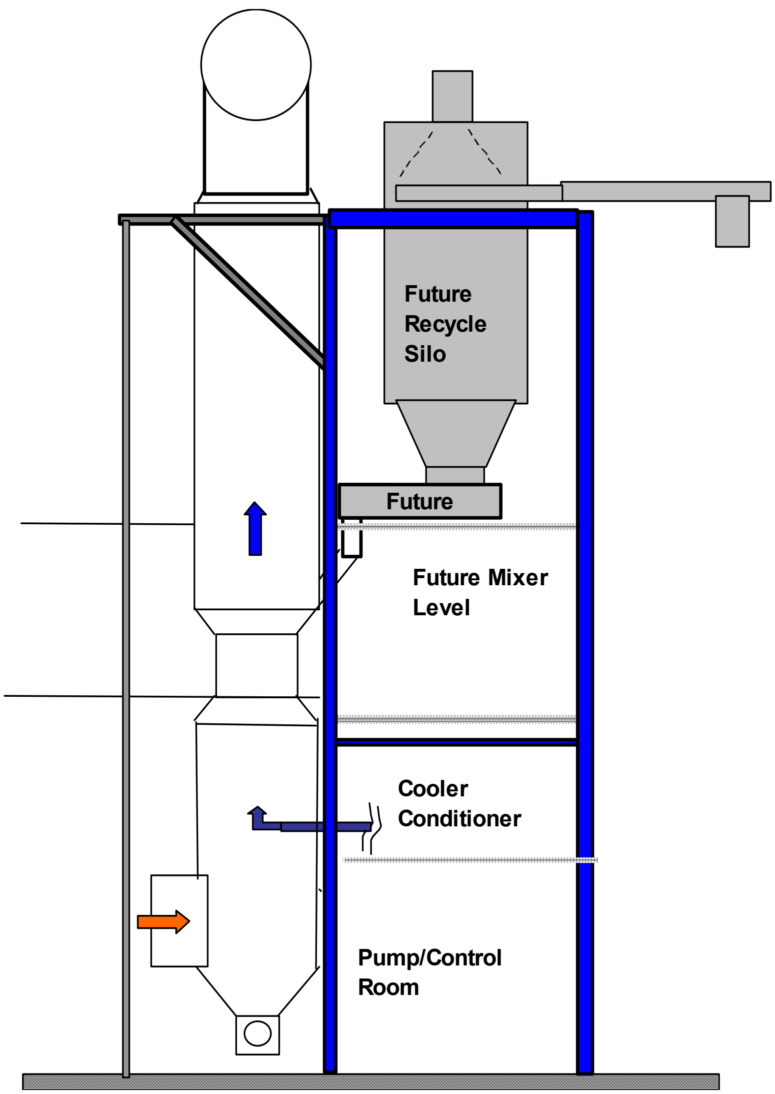
The byproduct material is dry and can be easily moved and transported. It may be necessary to wet the material as it is removed from the disposal silo to eliminate any dusting of the material.

The material, that has been tested does not leach and can be disposed of in existing disposal sites.

The material can be utilized for fill. It is normally pozzolanic in nature but will vary in composition depending on the amount of ash and unreacted lime.

DAP Process

- Uses the RAP Reactor drying design to provide cooling, conditioning and the addition of a dry sorbent.
- For Stoker or CFB Boilers where MACT emission level control is the only consideration we provide cooling only.
- The second level of control would be the addition of a sorbent to stabilize mercury removal.
- Adding a small amount of lime slurry can be included in the cooling water in the lower conditioning zone.
- For a dry sorbent it can be best added at the future mixer level.
- We can also add dry sorbent in the down comer to the Fabric Filter.



Integrating With FGD System

The DAP system can improve the performance of a wet FGD system by converting SO3 and mercury vapor into collectable particles upstream of the existing control device. In addition to significantly improving particulate collection performance by cooling and conditioning., this approach avoids potentially difficult wet FGD enhancements, such as; (1) altering FGD chemistry, (2) adding a mercury oxidation catalyst, or (3) adding a wet ESP downstream (for plume opacity and $PM_{2.5}$ reductions).

The DAP reactor and housing should be sized to accommodate future increases in gas flow and/or upgrading to a full flash dry FGD system capable of 95+% SO2 control. To upgrade DAP to RAP we add the recycle silo and mixer along with the necessary material handling equipment, to convey from the fabric filter to the recycle silo.

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RAP - Sizing Chart Assumptions

Assumptions
Inlet Temperature = 350 F
Outlet Temperature = 200
Height Under Hopper = 12 Ft
Includes Inlet Cooler
ACFM / MWe = 3700

Dia. (ft)	Ht (ft)	ACFM	SCFM	MWe	NCMH	CMH	Ht (m)	Dia. (m)
4.00	73	33,236	22,585	**8.98**	35,639	56,468	22.23	1.2183
4.50	75	42,064	28,584	**11.37**	45,106	71,467	22.84	1.3706
5.00	77	51,931	35,289	**14.04**	55,686	88,231	23.45	1.5228
5.50	79	62,836	42,700	**16.98**	67,380	106,760	24.06	1.6751
6.00	81	74,780	50,816	**20.21**	80,188	127,053	24.67	1.8274
6.50	83	87,763	59,639	**23.72**	94,110	149,110	25.28	1.9797
7.00	85	101,784	69,167	**27.51**	109,145	172,933	25.89	2.1320
7.50	87	116,844	79,401	**31.58**	125,294	198,520	26.50	2.2843
8.00	89	132,942	90,340	**35.93**	142,557	225,871	27.11	2.4365
8.50	91	150,079	101,986	**40.56**	160,933	254,988	27.72	2.5888
9.00	93	168,255	114,337	**45.47**	180,424	285,868	28.32	2.7411
9.50	95	187,469	127,394	**50.67**	201,027	318,514	28.93	2.8934
10.00	97	207,722	141,157	**56.14**	222,745	352,924	29.54	3.0457
10.50	99	229,014	155,625	**61.90**	245,577	389,099	30.15	3.1980
11.00	101	251,344	170,800	**67.93**	269,522	427,038	30.76	3.3503
11.50	103	274,712	186,680	**74.25**	294,580	466,742	31.37	3.5025
12.00	105	299,120	203,266	**80.84**	320,753	508,211	31.98	3.6548
12.50	107	324,566	220,557	**87.72**	348,039	551,444	32.59	3.8071
13.00	109	351,050	238,555	**94.88**	376,439	596,442	33.20	3.9594
13.50	111	378,574	257,258	**102.32**	405,953	643,204	33.81	4.1117
14.00	113	407,135	276,667	**110.04**	436,580	691,731	34.42	4.2640
14.50	115	436,736	296,782	**118.04**	468,322	742,023	35.03	4.4162
15.00	117	467,375	317,602	**126.32**	501,177	794,079	35.63	4.5685
15.50	119	499,052	339,129	**134.88**	535,145	847,900	36.24	4.7208
16.00	121	531,769	361,361	**143.72**	570,228	903,485	36.85	4.8731
16.50	123	565,523	384,299	**152.84**	606,424	960,836	37.46	5.0254
17.00	125	600,317	407,943	**162.25**	643,733	1,019,950	38.07	5.1777
17.50	127	636,149	432,292	**171.93**	682,157	1,080,830	38.68	5.3299
18.00	129	673,020	457,347	**181.90**	721,694	1,143,474	39.29	5.4822
18.50	131	710,929	483,109	**192.14**	762,345	1,207,882	39.90	5.6345
19.00	133	749,877	509,575	**202.67**	804,110	1,274,056	40.51	5.7868
19.50	135	789,863	536,748	**213.48**	846,988	1,341,994	41.12	5.9391
20.00	137	830,888	564,626	**224.56**	890,981	1,411,696	41.73	6.0914
20.50	139	872,952	593,211	**235.93**	936,086	1,483,163	42.34	6.2437
21.00	141	916,054	622,501	**247.58**	982,306	1,556,395	42.94	6.3959
21.50	143	960,195	652,496	**259.51**	1,029,639	1,631,391	43.55	6.5482
22.00	145	1,005,375	683,198	**271.72**	1,078,086	1,708,152	44.16	6.7005
22.50	147	1,051,593	714,605	**284.21**	1,127,647	1,786,678	44.77	6.8528