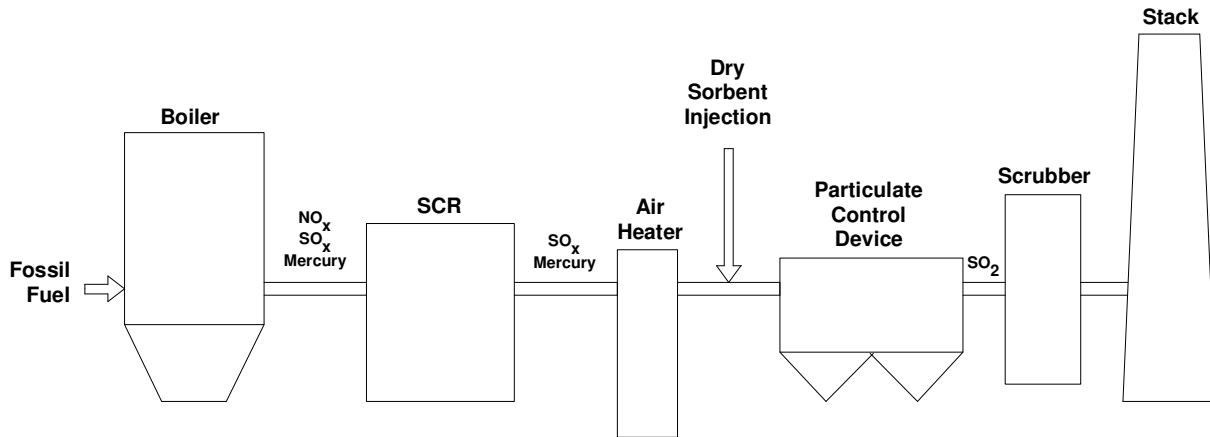


FOREWORD

When coal is burned (oxidized) as fuel, the elemental sulphur that coal contains is converted to SO₂. A percentage of this SO₂ is converted into SO₃ when further oxidization occurs in the boiler (excess oxygen available beyond what is required from combustion). A system that uses a selective catalytic reducer (SCR) to reduce NO_x emissions will further convert SO₂ to SO₃. SO_x combines with flue gas moisture to form vapor-phase (or condensed) sulfuric acid. Creation of sulfuric acid in the flue gas can potentially lead to down stream equipment corrosion, plugging and fouling; duct corrosion; visible plume and particulate emissions from the facility stack. SO₂ and SO₃ escaping the mitigation process can also produce acid rain and ozone depletion. The effects are further compounded with the use of high sulfur coal, which is a more economical fuel, but requires increased emission control.

This paper describes a controlled method of mitigating SO₃ and SO₂ by injecting powdered hydrated lime sorbent directly into the flue gas ductwork between the systems air heater and the particulate control device. Pilot scale testing has shown that hydrated lime reacts with flue gas SO_x to form synthetic gypsum that is collected along with fly ash in the particulate control device. This byproduct can be sold to gypsum wallboard plants worldwide.



Example: **Emission Control System with Dry Sorbent Injection**

DRY HYDRATED LIME SORBENT INJECTION OPERATING IMPACTS

Capitol Equipment Requirements	Storage silos, pneumatic conveying system*
Waste Disposal/Byproduct	Synthetic gypsum, excess hydrated lime mixed with fly ash
Boiler Efficiency Impacts	None
SO ₂ Allowance Impacts	None
NO _x Removal Impacts	None

*See *Typical Equipment List* for further information.



DRY HYDRATED LIME SORBENT INJECTION SYSTEM TECHNICAL SUMMARY

1. General System Concept (Typical for Coal Fired Power Plant):

Nol-Tec Systems, Inc. has designed systems to transfer dry bulk hydrated lime from pneumatic bulk trucks to storage, and from storage to hydrated lime injection ports on boiler furnace flue gas ducts on a continuous basis.

Although the system configuration will vary with each application, a typical project may include four (4) to (6) six storage silos configured to hold a total of five (5) to ten (10) days storage of hydrated lime. For this example a nominal hydrated lime feed rate of 4,000 pounds per hour per duct will be used. A fluidizing silo cone bottom is added as a precaution against creating a funnel flow condition that could result in rat holing, bridging arching of hydrated lime in the storage silos. An air-activated butterfly valve will be located below the fluidizing silo cone bottom. An air activated silo discharge system will be located below the fluidizing silo cone bottom butterfly valve to serve as a refill device for the loss-in-weight [LIW] continuous feed system(s) located under each silo. Please note the entire silo and silo discharge system has no moving parts exposed to material with the exception of the butterfly valves used in refilling the LIW feeders.

The LIW feeders are designed to facilitate continuous flow of the hydrated lime material. In this example each feeder is capable of holding a minimum of 45 cubic feet of material, keeping the number of refills per hour to a minimum. Minimizing the number of refills will in turn maximize the amount of time the feeders spend in gravimetric (LIW control) mode. Each feeder hopper will have its own reverse jet pulse dust filter system. The function of this dust filter system is to trap and return to the process the nuisance dust that would be generated during refill of the LIW feeder. The dust filter will also allow for displacement of air in the hopper as material is metered out or replenished. Each feeder hopper will be mounted on three load cells (three points define a plain therefore there will be no corner to corner tuning of load cell signals, making calibration of the units simple) that will be linked to the control system. A rotary valve will be mounted at the discharge of the hopper and will serve as the metering device for the material. This rotary valve will be run by a variable frequency drive linked to the control system. The metering rotary valve will discharge to a small, vented chute directly into a blow through rotary airlock running at a constant speed. The blow through rotary airlock will serve as the primary seal between the metering system and the pneumatic conveying line with the metering rotary valve serving as a secondary seal.

Transferring and injecting the metered hydrated lime is based on dilute phase positive pressure pneumatic conveying technology. Each conveying line will have a dedicated positive displacement blower. The blower packages will be equipped with a common air dryer that will ensure the air used to convey the hydrated lime material remains dry. The convey lines can also be insulated to prevent condensation from forming inside the conveying lines. Every precaution is taken to assure that the conveying lines will not plug with material. Blowout ports can be added to aid in locating and dealing with any condition that may arise.

Blower packages can also be equipped with flow meters and variable frequency drive controls. Any variation in the steady state operation of the blower could signal the need for maintenance of the conveying lines.

Each of the conveying lines will terminate in a convey line splitter that will distribute the hydrated lime to duct injection lances. Please note line splitters must be oriented vertically to



provide the best distribution possible. Nol-Tec Systems, Inc. has developed a method to analyzing the status of each injection lance provided a way to purge the injection lance automatically should a lance blockage occur.

Nol-Tec Systems, Inc. will supply control of all system components. Nol-Tec Systems, Inc. provides further information on the control system as part of its engineering package.

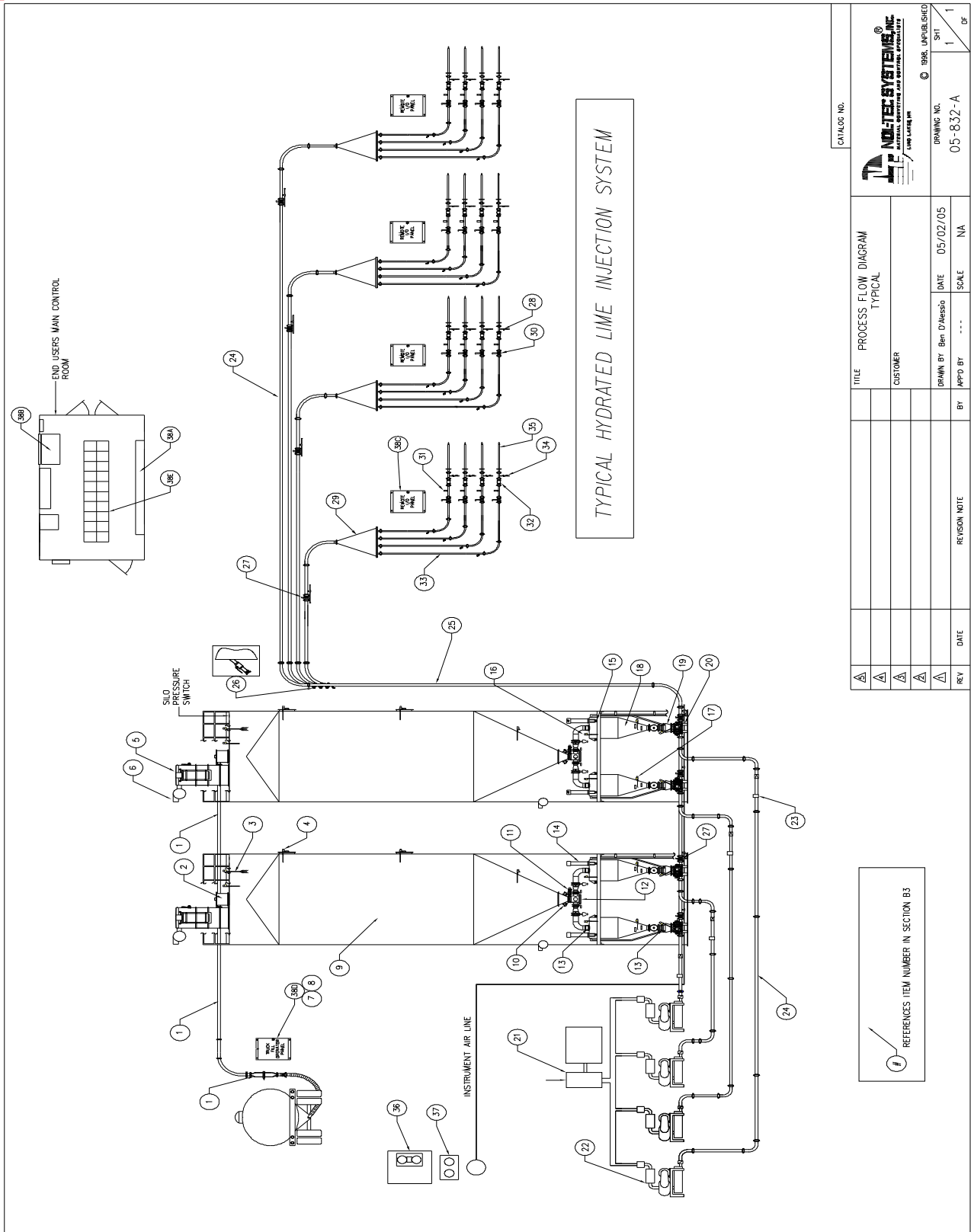
2. Typical Design Criteria:

Product:	Hydrated Lime
Bulk Density:	25-50 Lbs./Cu. Ft.
Particle Size:	325 Mesh
Moisture:	Dry
Temperature:	Ambient
Abrasiveness:	Mildly
System Capacity:	As required by plant flue gas flow rate
Convey Lines:	As required based on number of flue gas ducts

3. Typical Equipment List:

See Nol-Tec Drawing No. 05-832-A (Page 4) Typical System Process Flow_Diagram

- | | | |
|-------------------------------------------------|----------------------------------------------------------------|-------------------------------------------------------------------------------|
| 1. Bulk truck unload line components | 17. Emergency low level indicators | 32. Pinch valves, air operated |
| 2. Silo end receivers | 18. Loss-In-Weight feed systems | 33. Conveying line components from distribution splitters to injection lances |
| 3. Guided radar continuous level indicators | 19. Vent adapters | 34. Solenoid valves for injection lance cleaning |
| 4. Point level indicators | 20. Airlock packages | 35. Injection lances |
| 5. Dust collectors | 21. Air Drying Systems | 36. Rotary screw compressors |
| 6. Exhausters | 22. Blower packages | 37. Compressed air dryer packages |
| 7. Rubber hammer with holster for tuck operator | 23. In-line thermal mass flow meters | 38. Electrical Controls: |
| 8. Sign for delivery instructions. | 24. Air line components from dryers/blowers to rotary airlocks | a. Main PLC Control Panel |
| 9. Storage silos | 25. Conveying line components | b. HMI Workstation to be installed in the Injection System Control Room. |
| 10. Fluidizing bin bottoms | 26. Blowout ports | c. Injection Area Remote I/O Panels |
| 11. Maintenance gates | 27. Knifegates, with manual handwheel | d. Truck Unloading Operator Panel |
| 12. Air activated silo discharge systems | 28. Ball valves | e. Motor Control Center |
| 13. Gravity flexible connectors | 29. Convey Line distribution splitter assemblies | |
| 14. Single cartridge dust filters | 30. Knifegates, with manual handwheel | |
| 15. Load cell systems | 31. Pressure transducers. | |
| 16. Emergency high level indicators | | |



REV	DATE	REVISION NOTE	BY	APPD BY	SCALE	DATE	DRAWING NO.	SHEET
1					NA	05/02/05	05-832-A	1 of 1
TITLE			PROCESS FLOW DIAGRAM			CUSTOMER		
TITLE			TYPICAL			CUSTOMER		

REFERENCES ITEM NUMBER IN SECTION B3

Silos



Silo Bin Vent



**Truck Fill
Line Screeners**

Refill System

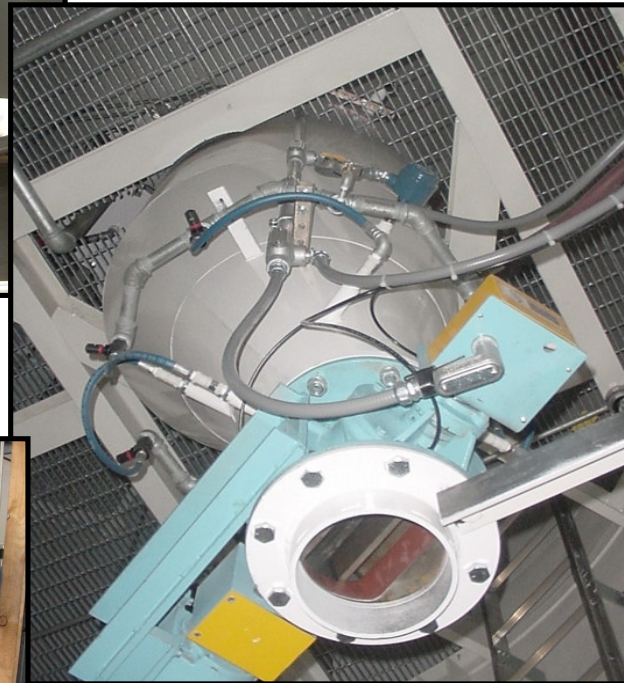


PD Blower Package



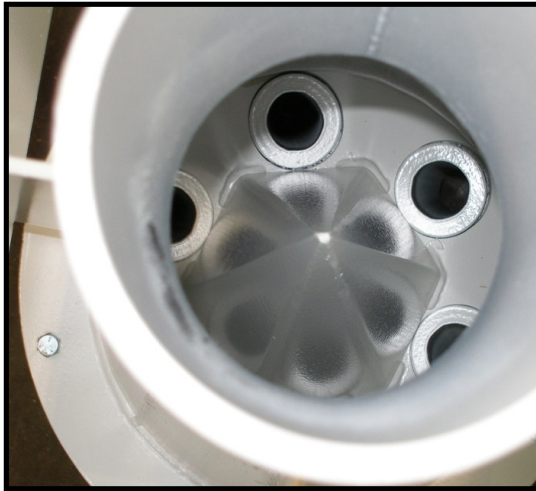


**Loss-In-Weight Feeders
to Convey Line**



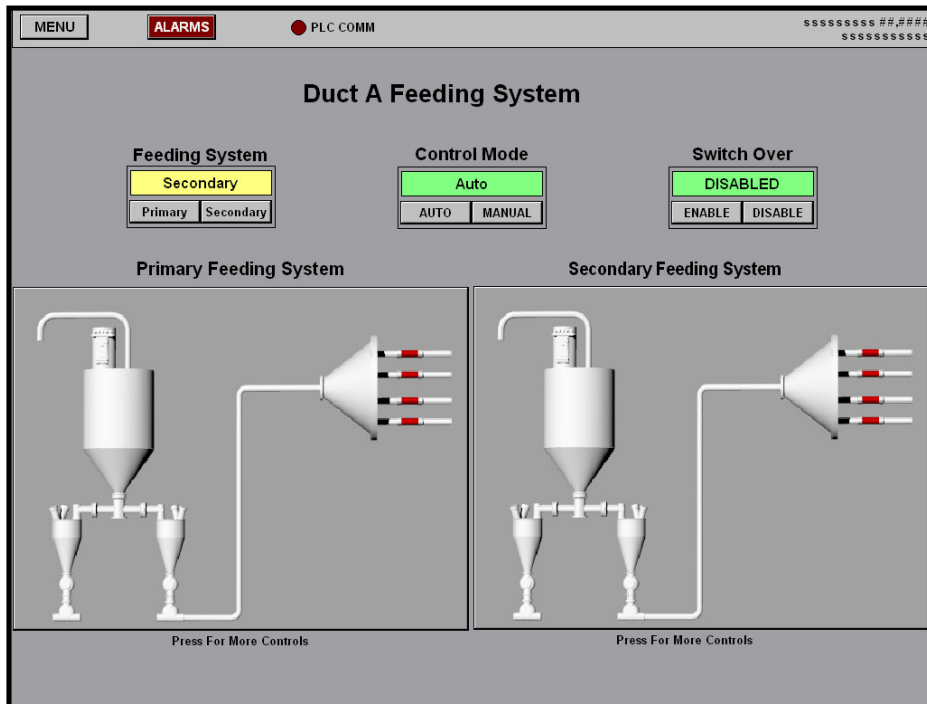
Desiccant Dryer

**Convey Line
Distribution
Assembly**

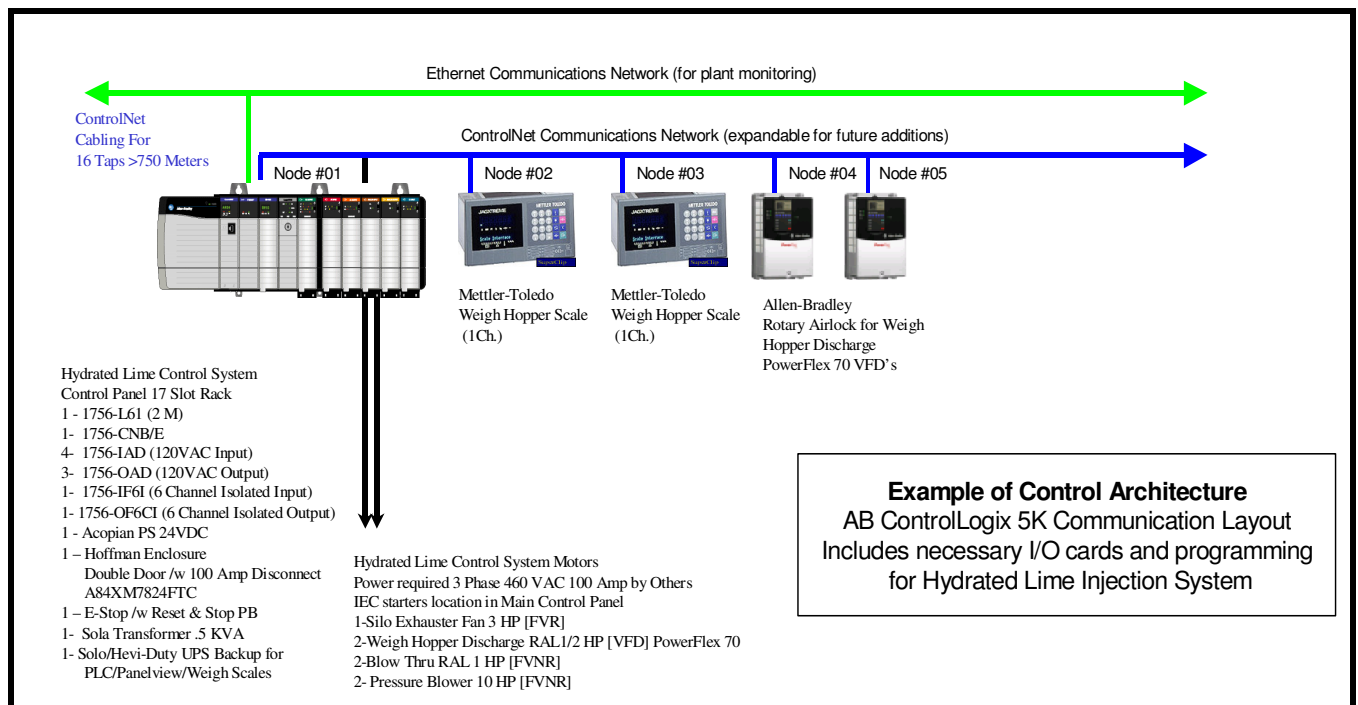


Duct Injection Ports





**Sample HMI
Screen and
Control
Architecture**





DRY HYDRATED LIME INJECTION FOR COAL FIRED BOILER FLUE GAS DESULPHURIZATION (FGD)

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Revision C
August 14, 2006

NOL-TEC EXPERIENCE AND PAST PERFORMANCE WITH LIME

Company Name	State	Type	Rate	Distance	Material	Ship
Holton Water Purification Plant	RI	Dilute Phase	6 TPH	520 ft	Quick Lime	Oct 04
IGT d/b/a Gas Technology Institute	IL	Dense Phase Vacuum	1.5 TPH	45 ft	Glass Batch Ingredients (sand, lime, etc.)	Jul 04
International Fiberglass Producer	TN	Rail Unload to Storage vacuum/pressure			Silica, Clay or Limestone	Aug 04
International Fiberglass Producer	TN	Dense Phase Transfer			Limestone	Aug 04
Gerdau Ameristeel Charlotte	NC	Modify Existing Dilute Phase (volumetric) Feed System			Pebble Lime	Feb 04
International Fiberglass Producer	FR	Equipment Only - Transporters & Bag Dump Stations + Spares			Dolomite/Limestone, Salt Cake	Feb '04
International Fiberglass Producer	MEX	Rail Unload, Dilute Phase	16.5 TPH	575 ft	Limestone	May '04
International Fiberglass Producer	MEX	Truck Unload, Dilute Phase		100 ft V	Limestone	May '04
International Fiberglass Producer	MEX	Blending & Dense Phase Transfer	(8) 4,100 lb batches per hr	600 ft	Batched Material (clay, limestone, dolomite, silica, soda ash, salt cake)	May '04
International Ceramics Company	FR	Air Slides & Bulk Bag Fill Stations			Alumina, Limestone, Boric Acid, Sand	Jul 04
Thermal Ceramics Australia PTY	FR	Batching System - (4) Ingredients	150 cu.ft/hr	68 ft	Dolomite Lime, Wollastonite, Silica	Mar 03
Custom Building Products	CA	Truck Unload System		340 ft	Gray Cement, White Cement, Fondu Cement, Limestone, Sand	
International Fiberglass Producer	FR	Silo Storage/Unloading - Two Silos			Limestone	
International Fiberglass Producer	FR	Dense Phase			Limestone	
International Fiberglass Producer	FR	Limestone Delivery to Emission System			Limestone	
International Fiberglass Producer	FR	Majors Feeder to Scales (3)			Silica, Limestone, Boric Acid	
Taian Taishan Compound	FR	Feeding/Discharge			Pyrollite, Limestone, Borogmaite, Silica Flour, Fluorspar, Salt Cake	Nov, 01
Blue Circle Cement (LaFarge)	GA	Blending			Cement/Lime	May, 01
International Ceramics Company	NY	Bulk Bag Unload, Volumetric Feed	800-2600 pph		Hydrated Lime	Oct 04
Custom Building Products	FR	Truck Unload		360'	Limestone, Gray Cement, White Cement, Sand	Apr 01
Custom Building Products	FR	Dense Phase, Majors Batching	Eight Batches/Hour	100'	Limestone, Gray Cement, White Cement, Sand	Apr 01
Samireg	FR	Injection System - Eductor	10-20 PPH	40'	Pulverized Limestone	Jan, 01
Coastal Chemical, Inc., Div. of El Paso Energy	NV	Bulk Bag Unloading/Dilute Phase Eductor	300 PPH	40'	Magnesium Oxide/Quick Lime	Dec, 00
Interceramic	MEX	Truck Unload/Dense Phase Pressure	35-40 MTPH	120'	Calcium Carbonate, Cement	June, 00
Specialty Minerals	CA	Model 255 Bin Discharger			Calcium Carbonate	Apr 00
Specialty Minerals	CA	Model 255 Bin Dischargers (3)			Limestone	
Power Generating Company	MD	Model 255 Bin Discharger			Limestone	Dec, 99
Johns Manville	TN	Dense Phase - D.A. Retrofit (Silos 5 & 6)	Unknown	233' and 205'	BD Lime and Borax	Jan, 00
Johns Manville	TN	Dense Phase Pressure (Silo 9)	Unknown	184'	Limestone	Jan, 00
Powder Processos (Gessy Lever)	FR	Truck Unload/Dense Phase	15 MTPH/2.75 MTPH	121'/451'	Calcium Carbonate	Nov, 99
Custom Building Products	FL	Truck Unload/Dense Phase Pressure Batching	Eight (8) Batches/Hour	135'	Limestone, White/Gray Cement, Sand	

www.nol-tec.com

901 Blair Hill Road • Suite 500 • Charlotte, NC 28217704 • 529-0123 FAX: 704 • 529-0139

Corporate Headquarters:

425 Apollo Drive • Lino Lakes, MN 55014 • 651 • 780-8600 FAX: 651 • 780-4400



DRY HYDRATED LIME INJECTION FOR COAL FIRED BOILER FLUE GAS DESULPHURIZATION (FGD)

Swan Corporation	IL	Dense Phase/Weighing	5 TPH	200'	Calcium Carbonate	Sept, 99
Swan Corporation	IL	Dense Phase/Weighing	5 TPH	200'	Calcium Carbonate	May, 00
Sandwell (Dravo Lime)	GA	Dilute Phase	15,000 PPH	256'	Lime Fines	May 99
U.S. Intec, Inc.	NJ	Truck Unload		40'	Crushed Limestone	May, 99
U.S. Intec, Inc.	NJ	Dilute Phase	36,000 PPH	195'	Crushed Limestone	May, 99
Powder Processos	FR	Dense Phase	5.5 TPH	260'	Crushed Lime	Apr 99
Major Building Materials Supplier	IN	Silos (6)			Limestone Filler	Jan, 00
Major Building Materials Supplier	IN	Silos - Hot and Cold Filler			Limestone Filler	Jan, 00
Major Building Materials Supplier	IN	Dilute Phase Pressure - Two (2) Systems	58,000 PPH	385'	Pulverized Limestone	Jan, 00
Major Building Materials Supplier	IN	Dilute Phase	2,700 PPH	450'	Pulverized Limestone	Jan, 00
Major Building Materials Supplier	IN	Engineering for three (3) Dilute Phase Systems	40,000 PPH	220'	Limestone Filler	Apr 00
Major Building Materials Supplier	TX	Dilute Phase Truck Unload	Variable	150'	Lime Filler, Fly Ash	Jan 99
U.S. Mix Products	CO	Dense	15 TPH	60'	Cement & Lime Mixture	July 98
U.S. Mix Products	CO	Dense	15 TPH	120'	Sand, Cement & Lime Mixture	July 98
J.M. Huber Corporation	GA	Aeration	n/a	n/a	Calcium Carbonate	Feb 98
J.M. Huber Corporation	GA	Dense	30 TPH	225'	Calcium Carbonate	Apr 98
Nutri-West Granulations (Bepex)	CA	Dense Phase Vacuum	1.8 TPH	40'	Calcium Carbonate	Apr 98
Nutri-West Granulations (Bepex)	CA	Dense Phase	1.8 TPH	100'	Calcium Carbonate	Apr 98
Sika Corporation	OH	Dilute Phase	12,000 PPH	180'	Calcium Carbonate	
Major Fiberglass Producer	CAN	Railcar Unload	6 TPH	125'	Colemanite, Silica, Kaolin Clay, Limestone	Jan 98
Major Fiberglass Producer	CAN	Dense Phase	10 TPH	100'	Limestone	Dec, 00
Lauren International	OH	Truck Unload	n/a	n/a	Talc/Calcium Carbonate	Nov, 97
Lauren International	OH	Continuous Dense Phase	3 TPH	360'	Calcium Carbonate	Nov, 97
TEK Associates, Inc.	FR	Injection System - Eductor	5-8 PPH	40'	Pulverized Lime	June, 97
Petron Corporation	FR	Dilute Phase	.14-.44 CFH	80'	Limestone	Jan, 97
Custom Building Products	FR	System Modification			Limestone	Aug, 98
National Lime and Stone	OH	Dense Phase	.2 TPH	125'	Limestone	Nov, 96
T & C (Asia) PTE Ltd.	FR	Dense Phase	28,250 PPH	125'	Limestone, Cement, Sand	Nov, 95
T & C (Asia) PTE Ltd.	FR	Dense Phase	55,000 PPH	113'	Limestone, Cement, Sand (weighed batch)	
Vortec Corporation	PA	Dense Phase Batching	600 to 6,000 PPH		Lime, soil, soda ash	Nov, 96
Metito International	FR	Dilute Phase	12.5 TPH	231'	Lime, Powder	Feb, 96
Marathon Oil	TX	Truck Unload		40'	Hydrated Lime	June, 95
Marathon Oil	TX	Screw Feeder	5 PPM		Hydrated Lime	June, 95
International Chemical Company	MN	Dense Phase, Non-Purge	1.25 TPH	55'	Silica Flour, Lime, Borax	Sept, 99
Ormet Corporation	OH	Storage Silos	n/a	n/a	Sand, Limestone, Cullet, and SPL	Sept, 95
T & C (Asia) PTE Ltd.	FR	Dense Phase	7.2 metric TPH	63'	Silica, CaCO ₃ , Hydrated Lime	Dec, 95
Custom Building Products	FR	Dilute Phase Pressure and Bulk Bag Unloader	4 TPH	106 ft	Gypsum & Limestone, Cement	Oct 04
OmNova Solutions	PA	Blending	n/a	n/a	PVC Resin/Calcium Carbonate	June 94
Kokosing Construction	OH	Dilute Phase Vacuum System	10 TPH	110'	Pebble Limestone	June, 94
International Fiberglass Producer	TN	Rail Car Unload/Dense Phase	n/a	n/a	clay, limestone, colemanite, flint, Uloxite	Sept, 93
International Fiberglass Producer	TN	Dense Phase, Blending	n/a	n/a	clay, limestone, colemanite, flint, Uloxite	Sept, 93
International Fiberglass Producer	TN	Dense Phase/ Rail Car Unload Expansion	n/a	n/a	clay, limestone, colemanite, flint, Uloxite	July, 96
City of Chicago	IL	Dilute-Vacuum	12 TPH	140'	Pebble Lime	Jan 93



DRY HYDRATED LIME INJECTION FOR COAL FIRED BOILER FLUE GAS DESULPHURIZATION (FGD)

Perfoventas	MEX	Dilute Phase	n/a	40'	Lime	Nov, 92
Manville	OH	Dilute Vacuum/Dense Phase/Rail Unload	15 TPH	114'	Flint and, Limestone	July, 95
Major Building Materials Supplier	MN	Aeration	n/a	n/a	Ground Limestone	Jan 97
Burrell Industries/Spring	OH	Dense - Blend			Cement, Ash, Lime, Aggregates	92
TOSCO Refining	WA	Injection System		75'-100'	Limestone	June, 91
Custom Building Products	NJ	Flop Gate Addition	n/a	n/a	Crushed Limestone	June 98
Custom Building Products	NJ	Addition of destination to existing system			Crushed Limestone	Aug, 00
Custom Building Products	NJ	Dense Phase Weigh & Transfer	32 TPH	125 ft	Limestone	Dec 04
Modern Equipment (JI Case Racine WI)	WI	Dense Phase	2 CFPH	80'	Cement and Hydrated Lime	Apr 91
Modern Equipment (JI Case Racine WI)	WI	Dense Phase	4 CFPH	80'	Cement and Hydrated Lime	Apr 91
Modern Equipment (JI Case Racine WI)	WI	Bin Discharger	9 CFPH		Hydrated Lime	Apr 91
Hoechst Celanese	NC	Model 256 Bag Dump Station (2)			Powder Lime	May, 90
Wyoming Refinery Company	WY	Dilute Phase	5 to 8 PPH	40'	Pulverized Lime	Jan 95
Warner Company	PA	Dense Phase	8.5 TPH	300'	Quick Lime	Sept. 92
Bellefonte Lime Company	PA	Dilute Pressure	8 TPH	203'	Pebble Lime	Sept 89
Inland Steel	IN	Dense Phase	2000 PP 6-8 Minutes	130'	Lime & Calcium Aluminate	Aug, 89
Rhodia, Inc.	TN	Dense Phase System for Hot Lime	2,500 PPH	55'+	Hydrated Lime	May, 95
Rhodia, Inc.	TN	Dense Phase	3,080 PPH	81'	Hydrated Lime	May, 96
Allied Glass Industry	FR	Dense Phase	5 TPH	n/a	Silica, clay, limestone, colemanite	
Southern Fiberglass Products Corp.	FR	Dense Phase			Silica, Limestone, Colemanite	Dec, 88
Major Building Materials Supplier	CA	Truck Unload	50 TPH	95'	Powdered Lime	Mar88
Major Building Materials Supplier	CA	Dense	30 TPH	n/a	Powdered Lime/Stone Dust	Mar88
Major Building Materials Supplier	CA	Retrofit - D.A. System	10-24 TPH	300'	Limestone and Sand	Sept 99
Major Building Materials Supplier	CA	System Retrofit (Silo)			Limestone	Apr 01
Delta Conveying (Delta Ducon)	PA	Blending			Silica, Soda Ash, Feldspar, Dolomite, Limestone, Salt Cake	Mar, 88
International Fiberglass Producer	FR	Dense Phase System(s)			Boric acid, Flourspar, Silica, Clay, Limestone	
International Fiberglass Producer	FR	Dense Phase Systems	17,640 Lbs/Hr	400 ft	Silica, clay, limestone, colemanite	89
Major Building Materials Supplier	IN	Positive Pressure Dulite Phase	30 TPH	76 ft	Hot Filler (ground raw limestone)	Nov 89
International Fiberglass Producer	NC	Furnace 524 dense phase truck fill		400 ft	quicklime	
International Fiberglass Producer	NC	Two-Way Switch			Limestone	Nov 99
Tennessee Valley Authority	TN	Sorbent Injection Systems	4,000 Lb/hr	500 ft	Hydrated Lime	Mar 05



NOL-TEC SYSTEMS, INC. CONTACT INFORMATION

Corporate Headquarters:

Nol-Tec Systems, Inc.
425 Apollo Drive
Lino Lakes, MN 55014
Contact: Mike Weyandt
Phone: (651) 780-8600
Fax: (651) 780-4400
E-mail: MikeWeyandt@nol-tec.com
Web: www.nol-tec.com

Charlotte, NC Office:

Nol-Tec Systems, Inc.
901 Blairhill Road, Suite 500
Charlotte, NC 28217
Contact: Vern Hudalla
Phone: (704) 529-0123
Fax: (704) 529-0139
E-mail: VernHudalla@nol-tec.com
Web: www.nol-tec.com

By: Ben D'Alessio – Nol-Tec Systems, Inc.

With thanks to Mr. Bryan Williams, System Engineer-Chemical, Fossil Fuel Division of the Tennessee Valley Authority.

¹ Blythe, Gary M., Rhudy, Richard G., Aljoe, Bill, "Economic Comparison of SO₃ Control Options for Coal-Fired Power Plants", white paper, November 25, 2003.
Tavoulareas, E.S., Jozewicz, W. "EPA Multiparticulate Emmissions Control Technology Options for Coal-Fired Power Plants", white paper, March, 2005