PROCEEDINGS OF THE 49TH ANNUAL MEETING FERTILIZER INDUSTRY ROUND TABLE 1999



October 27, 28 and 29, 1999 Grosvenor Resort, Walt Disney World Village Lake Buena Vista, Florida

PROCEEDINGS OF THE 49th ANNUAL MEETING FERTILIZER INDUSTRY ROUND TABLE 1999

October 27, 28, and 29, 1999 Grosvenor Resort, Walt Disney World Village Lake Buena Vista, Florida None of the printed matter in these proceedings may be printed or reproduced in any way without written permission of the Fertilizer Industry Round Table.

Copies of Proceedings: (Subject to availability) Plus postage where applicable

Current Year	\$35.00
Previous Year(s)	\$25.00

Please make checks payable to: The Fertilizer Industry Round Table 1914 Baldwin Mill Road Forrest Hill, MD 21050

Table of Contents

Wednesday, October 27, 1999

Morning Session I Moderator: Ken Nyiri

Thursday, October 28, 1999 Morning Session III Moderator: *Kenneth D. Kunz*

	Page		Page
Keynote Address Mary Hartney	1	Granulation At A Point Ronald E. Highsmith	. 57
Outlook for Nitrogen Glen Buckley	4	New Sackett Patented Granulation Process	(2)
Outlook For Phosphate Al Zlobik	9	Nutrient Management & Alternative Fertilizer Sources in the United States	63
Richard Downey	17	The Role of Treated Manure in	0/
Outlook For Sulphur Richard E. Amesbury	19	the Fertilizer Industry in Europe Dick Kuiper	77
Wednesday, October 27, 1999 Afternoon Session II Moderator:		Magplane or Beam Me Up, Scotty Dr. Vaughn Astley	84
Lee D. Hoffmann Real Granular Ammonium Sulfate		Friday, October 29, 1999 Morning Session V Luc M. Maene	
David M. Ivell and Tony Brown	29	Slow Release Methodology William L. Hall	93
A. Ray Shirley, Jr.	37	Soil Methodology Valuation of Slow Release Fertilizer	
Improvements in Fertilizer Application Equipment		Jerry B. Sartain	98
Improved Fertilizer Product Sizing		Charlie Chandler	100
Patrick E. Peterson	44	Fertilizer Risk Assessment Results — New Information	
AAPPCO Regulatory Update Mark Ringler	54	Daniel Woltering	112
		John Dantinne	115
		Financial Report	117

INDEX OF PARTICIPANTS

Mr. Richard E. Amesbury MOBIL SPECIAL PRODUCT Room #3W218 3225 Gallows Road Faitfax, VA 22007-0001

Dr. Vaughn Astley IMC-AGRICO COMPANY P.O. Box 2000 Mulberry, FL 33860-1100

Mr. Tony Brown INCITEC Australia

Mr. Glen Buckley CFI INDUSTRIES, INC. One Salem Lake Drive Long Grove, IL 60047

Mr. Charlie Chandler TERRA MICRONUTRIENTS 25045 I-45 North The Woodlands, TX 77380

Mr. Michael Dang The A.J. SACKETT & SONS 1701 South Highland Avenue Baltimore, MD 21224

Mr. John Dantinne AG VENTURE, L.L.C. 334 West James Street Lancaster, PA 17603

Mr. Richard Downey AGRIUM U.S. INC. 13131 Lake Frazier Drive Calgery, Alberta T2J7E8 Canada

Mr. Ron Dreese The A.J. SACKETT & SONS 1701 South Highland Avenue Baltimore, MD 21224 Mr. William L. Hall, Jr. IMC GLOBAL Inc. 3095 County Road 640 West Mulberry, FL 33860

Ms. Mary Hartney FLORIDA FERTILIZER & AGRICHEMICAL P.O. Box 9326 Winter Haven, FL 33883-9326

Mr. Ron Highsmith ALLIED SIGNAL, INC. P.O. Box 31 Petersburg, VA 23804

Mr. Lee D. Hoffmann FEECO INTERNATIONAL 3913 Algoma Road Green Bay, WI 54311

Mr. D. Kuiper KUIPER PROCESS ENGINERING P.O. Box 11287 2301 EG Leiden The Netherlands

Mr. Kenneth D. Kunz ALLIED SIGNAL INC. P.O. Box 1559 Hopewell, VA 23860

Mr. Luc M. Maene INTERNATIONAL FERTILIZER INDUSTRY 28 Rue Marbeuf 75008 Paris, France

Mr. Ken Nyiri MS CHEMICAL CORP. OC Administration Bldg. 3622 Hwy 49 East Yazoo City, MS 39194 Mr. Patrick E. Peterson CF INDUSTRIES, INC. Salem Lake Drive Long Grove, IL 60047

Mr. Mark Ringler IL DEPT. OF AGRICULTURE P.O. Box 19281 Springfield, IL 62794-9281

Mr. Jerry B. Sartian UNIVERSITY OF FLORIDA 106 Newell Hall Gainesville, FL 32611-0510

Mr. A. Ray Shirley, Jr. APPLIED CHEMICAL TECHNOLOGIES 4350 Helton Drive Florence, AL 35630

Dr. Clifford S. Snyder POTASH & PHOSPHATE INSTITUTE P.O. Drawer 2440 Conway, AR 72033-2440

Mr. Nyle C. Wollenhaupt AG-CHEM EQUIPMENT CO. 5720 Smetana Drive Minnetonka, MN 55343

Mr. Daniel Woltering The WEINBERG GROUP

Mr. Al Zlobik MULBERRY CORP. P.O. Drawer 797 Mulberry, FL 33860

1999 BOARD OF DIRECTORS

FRANK P. ACHORN SE-ME P.O. BOX 493 FLORENCE, AL 35631

B.E. ADAMS CONSULTANT 3509 WOODLAWN STREET HOPEWELL, VA 23860

BOBBY S. AVANT ROYSTER-CLARK, INC. 1611 OAK AVENUE AMERICUS, GA 31709

MIKE BARRY SIMS AG-PRODUCTS, INC. 3795 COUNTRY ROAD 29 MT. GILEAD, OH 43338

LEO BEWER PCS SALES 122 1ST AVE. S. SASAKATOON, SASKATCHEWAN S7K 7G3 CANADA

HAROLD D. BLENKHORN 525 BEACONSFIELD BEACONSFIELD, QUEBEC CANADA H9W 4C8

G. CAMERON BOWEN CAMERON CHEMICAL, INC 1316 SMITH DOUGLAS CHESAPEAKE, VA 23320

JOHN A. BOYD, SR. MORRAL COMPANIES P.O. BOX 26 MORRAL, OH 43337

JAMES C. BROWN SYLVITE SALES (USA) INC. 8 KEYSTONE DRIVE LEBANON, PA 17042

DOUGLAS CAINE CONSULTANT P.O. BOX 491 WHITING, IN 46394 VERNON C. CARLTON WINSTON-WEAVER FERT. P.O. BOX 7366 WINSTON-SALEM, NC 27109

BJARNE CHRISTENSEN KEMIRA AGO OY DRONNINGENS TVAERGADE 9, 3RD FLOOR DK-1302 COPENHAGEN DENMARK

PAUL R. CLIFFORD, PH.D. FL INSTITUTE OF PHOSPHATE RESEARCH 1855 WEST MAIN STREET BARTOW, FL 33830-7718

JAMES C. COOPER RENNEBURG DIVISION HEYL & PATTERSON, INC. P.O. BOX 36 PITTSUBRGH, PA 15230

DAVID CRERAR 6, WESTMORLAND ROAD FELIXSTOWE, SUFFOLK IP119TB U.K.

DONALD P. DAY PCS SALES P.O. BOX 30321 RALEIGH, NC 27622

DALE DUBBERLY FL DEPT OF AGRICULTURE 3125 CONNER BLVD TALLAHASSA, FL 32399

JOHN M. FRENCH BRITISH SULPHUR CORP. 31 MOUNT PLEASANT LONDON WCIX OAD ENGLAND

JAMES GREENE SOUTHERN STATES COOP 2582 SALISBURY HWY. STATESVILLE, NC 28677 WILLIAM L. HALL, JR. IMC GLOBAL INC. 3095 COUNTY ROAD 640 W MULBERRY, FL 33860

MICHAEL HANCOCK OISC, PURDUE UNIVERSITY 1154 BIOCHEMISTRY W LAFAYETTE, IN 47907

G. CONRAD HARDIE, JR. LYKES AGRI SALES P.O. BOX 13989 FT. PIERCE, FL 34979

RICHARD D. HARRELL NU-GRO TECHNOLOGIES 2680 HORIZON DRIVE SE GRAND RAPIDS, MI 49546

MR. LEE D. HOFFMANN, V.P. FEECO INTERNTATIONAL 3913 ALGOMA ROAD GREEN BAY, WI 54311-9707

EDWARD HUBER, JR. THE FERTILIZER INSTITUTE 6615 PHEASANT DRIVE ELKRIDGE, MD 21227

JOHN KLUS AGWAY P.O. BOX 3377 SYRACUSE, NY 13221

K.C. KNUDSEN TOFTEVEJ 9 DK-2840 HOLTE DENMARK

JAMES J. KUHLE LEBANON CHEMICAL CORP. P.O. BOX 180 LEBANON, PA 17042

KENNETH D. KUNZ ALLIED SIGNAL INC. P.O. BOX 1559 HOPEWELL, VA 23860 DAVID W. LEYSHON JACOBS/DORRCO DIV P.O. BOX 2008 LAKELAND, FL 33803

OLE H. LIE NORSK HYDRO A.S. P.O. BOX 2594 SOLLI N-OSLO 2 NORWAY

LUC M. MAENE INTERNATIONAL FERTILIZER INDUSTRY 28 RUE MARBEUF 75008 PARIS, FRANCE

DONALD L. MESSICK THE SULPHUR INSTITUTE 1140 CONNECTICUT AVE. WASHINGTON, DC 20036

G. KENNETH MOSHENEK ROYSTER-CLARK, INC. 10 ROCKEFELLER PLAZA NEW YORK, NY 10020

ED NORRIS THE ANDERSONS, INC. P.O. BOX 119 MAUMEE, OH 43537

KEN NYIRI MS CHEMICAL CORP. OC ADMINISTRATION BLDG 3622 HWY 49 EAST YAZOO CITY, MS 39194

PATRICK E. PETERSON CF INDUSTRIES, INC. SALEM LAKE DRIVE LONG GROVE, IL 60047

PAUL J. PROSSER, JR THE PROSSER COMPANY P.O. BOX 5036 GLEN ARM, MD 21057

JOHN RENNEBURG CONSULTANT 515 BIGHTWOOD CLUB DR LUTHERVILLE, MD 21093

JOSEPH E. REYNOLDS, JR. CONSULTANT 5518 SOUTHWOOD DR. MEMPHIS, TN 38119

ROBERT E. ROBINSON ROBERT E. ROBINSON & ASSOC 50 PICKWICK ROAD MARBLEHEAD, MA 01945

WALTER J. SACKETT, JR. A.J. SACKETT & SONS CO. 1701 S HIGHLAND AVE. BALTIMORE, MD 21224

MARV SAVAGE RENNEBURG DIV. HEYL & PATTERSON P.O. BOX 8438 LONGBOAT KEY, FL 34228 WILLIAM F. SHELDRICK 38 RAVINE ROAD CANFORD CLIFFS POOLE, BH13 7HY DORSET UNITED KINGDOM

SR. ADOLFO SISTO MESETA 200, DEL A. OBREGON 01900 MEXICO, D.F.

MICHAEL D. STEGMANN LANGE-STEGMANN ONE ANGELICA STREET ST. LOUIS, MO 63147

STEVEN J. VAN KAUWENBERGH INTERNATIONAL FERTILIZER DEVELOPMENT P.O. BOX 2040 MUSCLE SHOALS, AL35662

DAVID J. VETERE CREST TECHNOLOGIES P.O. BOX 57 INGOMAR, PA 15127

GLEN H. WESENBERG, P.E. FEECO INTERNATIONAL 3913 ALGOMA ROAD GREEN BAY, WI 54311

PHILLIP W. YELVERTON THE FERTILIZER INSTITUTE 501 SECOND STREET WASHINGTON, DC 20002

OFFICERS

PATRICK E. PETERSON DONALD P. DAY PAUL J. PROSSER, JR. CHAIRMAN VICE-CHAIRMAN SECRETARY/TREASURER

ACTIVE PAST CHAIRMEN

Joseph E. Reynolds, Jr. Frank P. Achorn Harold D. Blenkhorn William F. Sheldrick Paul J. Prosser, Jr. David W. Leyshon Walter J. Sackett, Jr. Ole H. Lie Past Chairman Past Chairman

COMMITTEE CHAIRMEN

Finances Nominating Public Relations International Relations Paul J. Prosser, Jr. Joseph E. Reynolds, Jr. Walter J. Sackett, Jr. William F. Sheldrick



Thomas B. Athey 1905 – 1998

This issue of the Proceedings is dedicated with respect and affection to the memory of our long-time Friend, Director, Supporter and Host Thomas B. (Mr. Hospitality) Athey.

Opening Remarks

Pat Peterson

Welcome to the forty-ninth annual meeting of The Fertilizer Industry Round Table. The Board of Directors of The Round Table has assembled an interesting and informative program for this meeting. My remarks will be brief, as I am sure that you are especially anxious to hear the upcoming outlook papers. This year, 1999, has been a challenging year for agriculture in general and the fertilizer industry in particular. So with that, I again thank you for your attendance and support of The Fertilizer Industry Round Table, and turn the podium over to our moderator, Ken Nyiri of Mississippi Chemical Corporation, to open the first session. Ken the floor is yours.

Wednesday, October 27, 1999

Session I Moderator:

Ken Nyiri

Keynote Address Y2K Challenges for Florida's Fertilizer Industry Mary Hartney Florida Fertilizer & Agrichemical Association

Welcome to Florida, a state with approximately 40,000 farms, 10 million acres of agricultural production and a record-setting \$6.6 billion in sales last year. Welcome to Florida, a place of stunning beauty, a \$48 billion state budget, no state income tax, and a promise that the despised intangible tax will soon go the way of the dinosaur. Welcome to Florida, where Jeb Bush is Governor and whose roles include husband, father, son of a President and brother of a Governor and Presidential contender. And welcome to Florida where the Republicans control the Governor's seat, the House and the Senate for the first time ever since Statehood.

Welcome to the Sunshine State where the fertilizer industry tackles seemingly endless environmental issues such as the implementation of Total Maximum Daily Loads and the end of a voluntary BMP program for bulk fertilizer plants. Welcome to Florida where the fertilizer industry struggles to define the role and value of the Certified Crop Adviser and the continuing pressure to meet the needs of an extremely diverse agricultural community.

Welcome to Florida, where our fertilizer industry will meet these challenges head on and welcome the next millennium with hopes of financial prosperity and a commitment to environmental stewardship. I welcome you on behalf of the Florida Fertilizer & Agrichemical Association's Board of Directors and members. FFAA is the successor of the Florida Agricultural Research Institute, founded in 1932 and originally charged with laying the groundwork for research into fertilization formulas, micronutrients and optimal fertilizer rates under Florida's subtropical conditions and 52-inches of average annual rainfall.

Today FFAA's mission is even broader: To represent the interests of the state's fertilizer and agrichemical companies before the Florida Legislature and state regulatory agencies like the Florida Department of Environmental Protection, the Florida Department of Agriculture and Consumer Services, the five water management districts, and a host of other legislative and regulatory bodies. Our challenges are perhaps even greater today than they were 67 years ago. With less than 2% of this nation's 265 million people actively involved in production agriculture, we struggle to tell our story and present the compelling reasons for national policies to support a strong domestic agricultural sector.

As the nation's fourth most populous state (and soon to be third most populous) and heading toward a population of 20 million people in the next decade, we're going to have to shout our story from the rooftops. And we must work together. Florida's agricultural industry is diverse with over 240 crops grown here. Our production almost literally spans from A to Z. In between, Florida farmers led the nation in production of 18 major agricultural commodities: oranges, sugarcane, fresh tomatoes, grapefruit, bell peppers, sweet corn, ferns, fresh cucumbers, fresh snap beans, tangerines, tropical fish, temple oranges, fresh squash, radishes, gladioli, tangelos, eggplant and house plants.

Industry Challenges in 2000

We face a whole host of challenges in 2000 but I will limit my comments to just a few: the impact of term limits, the TMDL program, Lake Okeechobee and the action we must take regarding the Certified Crop Adviser program

Term Limits: Proposed as a constitutional amendment in 1992, 77% of Florida voters thought "Eight is Enough" was a good idea and passed term limits. Incumbent legislators filed an appeal to stay in office. In early September of this year, the Florida Supreme Court upheld term limits and made Florida the 18th state to impose term limits on state legislative and Cabinet officeholders. We're going to feel the impact with next year's elections. In the House, 53 legislators are ineligible for re-election. In the Senate, 11 legislators are out. Given the jockeying for key seats, at last count, at least 62 House seats were up for grabs.

In Tallahassee, the corridors of power have always been paved by people who knew their way around the system. Thanks to term limits, we now have a situation where lobbyists and legislative staffers may hold more power due to the inexperience of so many new legislators. Even more power will be in the hands of the Senate President and the Speaker of the House. And given the massive turnover, I expect we're going to face some monumental uphill battles in ensuring good legislation is passed affecting agriculture. By 2006, only 4 out of the 40 current Senators will be eligible to run for another term. And in the House, that number is 28% of the current 120 members. Agriculture's old friends won't be with us much longer. And that's a shame as we face some major legislative issues in 2000 and beyond.

Our challenge is great and agriculture is outnumbered in the Legislature when you tally the professions of our elected officials. Only 3 Senators listed their occupation as agriculture and only 8 in the House. The good news, however, is that in 1998 the number of attorneys in the state Legislature reached an all-time low—with only 26 out of 120 House members identifying themselves as attorneys!

A quick look at the characteristics of the members of the Florida Legislature in 1997-1998 shows that almost 75 percent of the 120 House members are men and 83% of the 40 Senators are men. Anglo-Saxons represent nearly 78% of the House members and 80% of the Senators with blacks representing 12.5% respectively in each chamber. Hispanics have a growing representation with 9% of the House seats and 7.5% of the Senate seats. The average age of the House member is 47 and Senators average 50 years old. For the record, the youngest legislator is 25-year-old Adam Putnam from Polk County who is well on his way to winning a seat in Congress representing the 12th Congressional District. I suspect that the 2000 elections will pave the way for even greater diversity in the Legislature.

In 1998, business lobbyists (tort reform was the issue) contributed \$4.25 million to Republican candidates alone, which was just a fraction of the record \$34 million raised by Florida's Republican Party during last year's political campaigns. Business lobbies gave \$2 million to the state Democratic Party which raised over \$13 million for last year's campaigns.

Money is a key consideration in politics and I encourage you to support your local political action committee. Grassroots activism is the other component so I'll also encourage you to get involved in a campaign. Help us elect business-minded legislators who will make decisions regarding Florida's difficult environmental and economic issues based on sound science and logic, not emotion.

Total Maximum Daily Loads (TMDLs): Required under the Clean Water Act, TMDLs describe the amount of each pollutant a water body can receive without violating standards. They are characterized as the sum of wasteload allocations, load allocations and a margin of safety to account for uncertainties. Wasteload allocations are pollutant loads attributable to existing and future point sources, such as discharges from industry and sewage facilities. Load allocations are pollutant loads attributable to existing and future nonpoint sources and natural backgrounds. Nonpoint sources include runoff from farms, forests, urban areas and natural sources, such as decaying organic matter and nutrients in soil. TMDLs take into account the cumulative impact on a water shed rather than simply considering whether each individual discharge meets its permit requirements.

Agriculture's challenge is in ensuring that sound science is used to determine the allocation loadings and that knee-jerk reactions aren't made which make it impossible to continue to farm efficiently and hopefully at a profit.

In Florida, we have 712 water bodies on the 303(d) impaired waters list. Efforts to remove about 200 of those segments failed this summer when the public protested their removal. David Struhs, Secretary of the Florida Department of Environmental Protection, was quoted as saying: "...It has become abundantly clear that Floridians care deeply about clean water and that this state will not tolerate even the perception that a river, lake or stream will be less protected as a result of being removed from this historic list." Struhs then went on to call for better science and data, noting that some of the information used in making the 303(d) determinations was "incomplete and anecdotal" and this "undermines the public's confidence in government".

Of the 712 listed waters in Florida, nearly 2,000 impairments ranging from nutrients and coliforms to mercury, lead, and cadmium have been identified.

Florida is working on a combination of regulatory, non-regulatory and incentive-based action to achieve the desired reduction in pollutant loading. The non-regulatory and incentive-based actions include Best Management Practices (BMPs), pollution prevention activities and habitat restoration or preservation. The regulatory approaches include permit requirements such as effluent limitations or a combination of structural and non-structural BMPs to achieve the necessary pollutant load reduction.

The Watershed Restoration Act of 1999, legislation spearheaded by Rep. JD Alexander and Sen. John Laurent and passed in the last session, establishes the process for listing impaired waters, determines which waters will be subjected to TMDL calculations, adopts by rule those calculations and associated allocations of pollutant loadings and implements the management strategies designed to reduce the loadings and enable the water body to meet water quality standards. Thanks to a funding formula under the Florida Forever Act, our Department of Agriculture and Department of Environmental Protection will each receive \$2.7 million a year to develop the TMDL program. DEP's funds will be used to study nonagricultural nonpoint sources and DACS will use its funds to address water quality impacts associated with agricultural nonpoint sources.

Lake Okeechobee Bill: Proposed by Rep. Ken Pruitt, the House Appropriations Chairman, this bill takes in the watershed from Orlando south to Lake Okeechobee. It would set aside approximately \$30 million to improve the water quality of the lake. The bill proposes a regional water quality treatment construction project, regional water quality monitoring, implementation of a voluntary best management program, and permits for certain activities in the Lake Okeechobee watershed.

Certified Crop Adviser Program: Over 200 people have been certified by the Florida CCA Board yet only 166 have paid their 18-month renewal fee. In Florida, as in many states, we're struggling to find ways to add value to the CCA program. Right now, it's a fantastic professional education tool and demonstrates proficiency when people master the international and state exam, submit their credentials for review and agree to abide by a code of ethics. However, the program is time-intensive (40 ceus over a two-year period) and ultimately costly in terms of time away from work and the cost of the ceus. We have to add value to the program. Opportunities include writing nutrient management plans and making crop protection recommendations. If you have ideas, please give me a call!

Finally, I want to encourage each of you to participate in your local and state organizations, whether it's FFAA or Farm Bureau or an Agribusiness Council. Our numbers are too few not to make the most of what we have. Your expertise, enthusiasm and ties to your local community are needed as we strive to mount an effective grassroots campaign to ensure good representation in our Legislative offices and to protect the future of agriculture in this country. Get involved, you can make a difference!

Outlook for Nitorogen Glenn Buckley CF Industries, Inc.

























	.0. 1			163
	<u>1998</u>	Est. <u>1999</u> (Millior	Fct. <u>2000</u> Acres)	1999-2000 <u>Change</u>
Corn	80.2	77.6	77.6	-
Wheat	65.8	63.0	63.0	-
Soybeans	72.0	74.1	73.0	-1.1
Cotton	13.4	14.6	13.5	-1.1
Other	99.0	98.8	99.5	0.7
Total	330.4	328.1	326.6	-1.5

U.S. N-P-K Consumption

	<u>1998</u> (M	Est. <u>1999</u> Iillion Ton	Fct. <u>2000</u> is)	Change
N	12.3	11.8	11.8	0.1%
P ₂ O ₅	4.6	4.3	4.3	-0.3%
K₂O	5.3	5.0	4.9	-0.4%
Total	22.3	21.1	21.1	0.2%









Nitrogen	Production	Closures
Muogen	riouucuon	Ulugui ça

		000 Tons
Company	Location	Ammonia
Agrium	Redwater, AB	310
Diamond Shamrock	Freeport, TX	155
Farmland	Lawrence, KS	470
	Pollack, LA	510
Miss Chem	Donaldsonville, LA	620
Solutia	Luling, LA	500
PCS	La Platte, NE	210
	Clinton, IA	260
	Geismar, LA	<u>525</u>
Total		3,560



Ammonia Factors

Positives

- + Low U.S. operating rates-Plant closures
- + Declining producer inventory
- + Tightening Yuzhnyy market
- + New phosphate capacity

Negatives

- + Excess capacity
- + High natural gas prices







Outlook for Phosphate Al Zlobik Mulberry Corporation

Before I get into a discussion about the current and near term outlook for phosphate fertilizer, I thought that I would take a few minutes, for the benefit of those who have concentrated more on the technical side of the business, and give a brief review of the marketing side of the U.S. phosphate industry. For reference, all tonnes referred to in the paper are metric tonnes (mt) and all years are calendar years.

Background

The term "change" has been used a lot lately to describe everything from soup to nuts..."This has changed"; "You have to change"; "Be prepared to change". Frankly, the word is beginning to annoy me. Therefore, I will do my best to keep from using it. Let me begin by saying that the U.S. phosphate industry has undergone significant "adjustment" over the past two decades. In 1980 the U.S. had 23 producers of phosphate fertilizer with a total Wet Process Phosacid (WPPA) capacity of 9.7 million tonnes per year. In that year the top three producing companies controlled 3.8 million mt or 39% of U.S. production capacity. As 1999 draws to a close, the U.S. now has 12.1 million mt of WPPA capacity, but only 12 producers. The top three producing companies now control 7.8 million mt or 65% of available capacity.



The next slide shows U.S. P_2O_5 production versus available capacity between 1980 and 1998. As can

be seen, with the exception of period 1982-83, period 1985-87, and 1993, U.S. producers have operated their plants at relatively efficient rates. Even including the poor years, producers have been able to maintain an operating rate of 89% over the review period. Since 1980, U.S. production of Wet Process Phosacid has grown at an average annual rate of 1.2%.



Of the three major phosphate fertilizers produced from Wet Process Phosacid in the U.S., i.e. DAP, MAP, and TSP, DAP is far and away the dominant product. Since 1980, DAP has averaged 73% of the P_2O_5 in major phosphate fertilizer products produced followed by MAP at 14% and TSP at 13%. However, as can be seen, MAP has been increasing in market share over the past few years.



This next slide shows the makeup of U.S. P_2O_5 fertilizer demand over the period 1980 to 1998. Fertilizer demand is divided into domestic appar-

ent consumption and exports. On average, exports makeup the largest portion of U.S. phosphate fertilizer demand averaging 54% over the period. Consequently, what happens in world markets has a significant impact on U.S. phosphate business. Since 1980, domestic fertilizer consumption has averaged 46% of U.S. P_2O_5 demand.



As we know, the primary phosphate fertilizer exported from the U.S. is DAP. Since 1980, DAP has averaged 67% of phosphate fertilizer exports. In more recent years, DAP's average share of U.S. phosphate fertilizer exports has grown even more. Between the years 1990 and 1998, DAP represented 73% of total U.S. phosphate fertilizer exports. However, three other phosphate fertilizer products, MAP, TSP, and merchant grade phosacid (MGA), also play a significant role in U.S. phosphate fertilizer exports.



Analysis of 1999

With this industry background given, the first question is "How are we going to do this year?" Well, the year began on a cautious note. Ag commodity prices were at low levels. Cash prices for the "Big 4" crops, corn, soybeans, wheat, and cotton, were at levels below prices seen the year before. For example, the cash price for corn at the beginning of 1999 was about \$2.15/bu. This was nearly 8% lower than the average price for calendar year 1998. Soybeans were in not much better shape with the cash price around \$5.32/bu, down \$0.81/bu, or 13%, compared to the prior year.



Coupled with low commodity prices were rising grain and oilseed stocks not only in the U.S. but in other producing countries around the world as well. In addition, the Russian and Asian economic crises were dampening the outlook for agricultural trade, and deteriorating economic conditions in Latin America loomed as a threat to fertilizer purchases by that region. So with this general agriculture market condition facing the fertilizer industry what happened?

P₂O₅ Production

The year began on a strong note with U.S. phosacid production through June about equal with production for the same period in 1998. The market began to soften and in August, PCS announced the permanent closure of its 110,000 mt/yr White Springs, Suwannee River Hemihydrate P_2O_5 plant. In September, the company announced an additional closure of 90,000 mt/yr P_2O_5 at the White Springs facility effective in October. The PCS closures reduced U.S. P_2O_5 production by about 70,000 tonnes for 1999. On October 20, Mulberry Corporation took down the equivalent of 160,000 tonnes/yr of P_2O_5 production. Through September 1999, U.S. Wet Process Phosacid production was running about 1.5% behind production levels seen in 1998, i.e. about 940,000 versus 955,000 tonnes P_2O_5 per month. Accounting for capacity adjustments and net changes in DAP, MAP, TSP and Super Phosacid, overall U.S. production of P2O5 is estimated at about 11.2 million tonnes for 1999, 2.6% lower than production in 1998.



Through September, U.S. DAP plants operated at high levels when compared to 1998. The capacity expansion put into operation by Mississippi Phosphates in late 1998; the resolving of rock grinding problems at Cargill's Riverview plant; the bringing up of Mulberry Corporation's Piney Point plant; and various, typical debottlenecking activities done at other producers' facilities, all helped to increase DAP production. However, with a weak domestic market, producer stocks rising and DAP prices falling, IMC Global shut down its Taft, LA plant. In the meantime PCS announced DAP production cutbacks at White Springs bringing the company's DAP shut-in capacity equivalent to 275,000 tonnes/ yr. Subsequently, during the first week of October, Mulberry announced the shut-in of the equivalent of about 330,000 tonnes/yr of DAP production. In addition, on October 15, Cargill announced a reduction of approximately 150,000 tonnes of dry product production for the remainder of 1999.

After accounting for these adjustments, the high level of production earlier in the year puts estimates of U.S. DAP production at about 14.3 million tonnes, slightly higher than the 14.2 million tonnes produced in 1998.



A bright spot that has emerged over the past few years has been MAP. Since 1990 U.S. MAP production has increased from 2.0 million tonnes to 3.7 million tonnes by 1998. However, due to economic conditions and a competitive environment, especially in Latin America, U.S. MAP production in 1999 is estimated at 3.4 million tonnes, a decrease of 9.4% from last year. Even with this estimated drop in production for 1999, growth has still averaged 5.7% over the 1990-99 period.



U.S. Apparent Consumption

USDA estimates indicate that soybean and cotton planted acres were up by a combined total of 3.0 million acres; however, corn and wheat acres were down by a total of 5.6 million acres for a net loss of "Big 4" acres of 2.8 million acres. With low commodity prices and a drop in U.S. agriculture exports, it is no surprise that farmers appear to have reduced application rates of phosphate fertilizer in 1999. Consequently, U.S. domestic consumption of phosphate fertilizer for 1999 should show a significant drop. U.S. apparent consumption, based on TFI reported producer shipments and inventory levels through September, and estimated exports, is forecast at 4.3 million tonnes P2O5, a 6.2% decrease from 1998. This figure appears to fall in line with other published estimates of a 4-10% decrease for the year.



Phosphate Fertilizer Exports

Exports are the lifeblood for U.S. phosphate fertilizer producers with over 50% of total U.S. demand for phosphate fertilizer being exported. Based on current available data through September, estimates indicate that total U.S. P_2O_5 fertilizer exports will be about 6.0 million tonnes, a decrease of 4.0% from total P_2O_5 exports in 1998. This slide shows an estimated breakdown, by product, in P2O5 tonnes, for 1999 versus 1998. As can be seen from the slide, DAP was the only product that appears to have held its own during the year. Estimates of other finished product exports like MAP, TSP, MGA, etc, all show decreases of at least 10% for the year.



As usual, China and India were the big guns for U.S. DAP exports. However, this year purchases by India were more important than usual. Estimates indicate that India will purchase 2.2 million tonnes of U.S. DAP this year. This is an increase of about 890,000 tonnes, or +68.0% from 1998. What makes this so important to the U.S. industry is that total exports to all other destinations are estimated to be down almost 870,000 or nearly 10% from levels seen in 1998.



Outlook for yr2000

Demand

How is next year shaping up? After a couple of pretty good years, a well know phrase probably best sums up the situation, "Well Toto, I guess we're not in Kansas anymore!" Unless you've spent the last few months in the "Land of Oz", you probably have read and heard that "us phosphate guys" could be facing a tough year ahead. Phosphate Outlook for 2000 - Summary

"Well Toto, I guess we're not in Kansas Anymore!"

From a domestic consumption standpoint, U.S. farmers are facing lower crop prices that could translate into less available cash for them to spend on inputs. Recent industry estimates, indicate that U.S. planted acres for the "Big 4", i.e., corn, wheat, soybeans, and cotton, next year could be about 228 million acres. This reflects a decrease of about 1.5 million acres or a 0.6% drop from the "Big 4" acres planted in 1999. Acres planted to corn are estimated near 1999 levels at 77.8 million acres. Soybean acres are estimated to be slightly down to flat compared to the 74.2 million acres planted in 1999. Cotton acres are expected to be down about 0.9 million acres, while wheat acres are expected to be down some 0.6 million acres. If one assumes a modest increase in application rates to make up for leaner application and weather related incidents in 1999, and assuming the recent historical percent of acres fertilized for these crops, it appears that U.S. phosphate fertilizer consumption could be flat to slightly up, maybe 1%, in 2000. This should put U.S. apparent consumption around 4.3-4.4 million mt P₂O₅ in 2000.



On the international side, 1999 estimates of world consumption indicate that demand is expected to show an increase over consumption in 1998; however, the increase will probably only be a modest one at about 150-200,000 tonnes P_2O_5 or +1%. Increases in Asia, primarily in India and China, should be offset by decreases in consumption in the U.S. and Latin America, due primarily to a weak agriculture market, plus, in the case of Latin America, economic and fiscal uncertainty.

For next year, I think that world P₂O₅ consumption will recover somewhat, with consumption increasing about 700,000 tonnes P₂O₅ from 33.5 million tonnes to 34.2 million tonnes P_2O_5 . This represents an increase of about 2.3%. While U.S. consumption of phosphate is forecast to remain relatively flat, Asian consumption is expected to continue to grow with an increase of about 2.8%. This rise is led by China with consumption expected to grow 2.5% and India with growth forecast at about 3.0%. The forecast anticipates continued modest improvement in the Asian economies thus spurring some improvement in agriculture trade. Some stabilization in the regional economic situation coupled with some increase in "ag" trade should help improve fertilizer demand in areas like Latin America. Therefore, I look to see phosphate demand in Latin America increase about 4.0% or 120,000 tonnes P_2O_5 to 3.2 million tonnes P_2O_5 .



Supply

The challenge for phosphate producers next year is on the supply side. The bottom line is there appears to be too much new capacity chasing too little new demand. According to producers' announcements, approximately 1.9 million tonnes of new P_2O_5 capacity could become available in yr2000. Major world P2O5 additions/expansions include: WMC's Phosphate Hill project in Australia at 500,000 tonnes/yr; the Oswal Chemical & Fertilizer complex at Paradeep, India at 875,000 tonnes/ yr; the Indo Maroc Phosphore project at 330,000 tonnes/yr in Morocco; and several smaller projects in China and other locations. While these projects will not reach "normal" operating rates immediately, it appears that the market is already factoring in their impact. However, a delay in their startup, a very possible situation, would be favorable for U.S. suppliers.



The two projects that have attracted the most attention recently are the Phosphate Hill project with DAP capacity of 1.0 million tonnes/yr and the Oswal project with 1.5 million tonnes/yr DAP capacity. Both of these projects are expected to have a significant impact on the DAP market, because of their size and location. The effects will especially be felt by U.S. suppliers.

In the case of the Australian project, DAP production from that facility, possibly 1.0 million tonnes per year, is reported to be split about 50-50 between domestic use and export. In 1998, Australia imported approximately 780,000 of DAP of which the U.S. supplied about 600,000 tonnes. The 500,000 tonnes of DAP supply from the new WMC operation that will enter the domestic market represents 64% of Australia's total 1998 DAP imports and 83% of the amount that the U.S. supplied. Cargill Fertilizer, who has the offshore marketing rights to the product, controls the remaining 400-500,000 tonnes of production from the operation. The availability of these export tonnes, in the back yard of the Southeast Asian market, will put additional pressure on DAP exports from the U.S to that region.



The other project that is expected to have a significant impact on U.S. DAP exports next year is the Oswal Chemical & Fertilizer project in India. This project is reported to have an annual DAP capacity of 1.5 million tonnes plus an additional 420,000 tonnes of NPK products. There has been conjecture about this plant throughout our industry since its inception; however, the project is nearing completion of the construction stage. There are still questions to be answered as to the plant's performance, especially since it is supposed to be using rock from various "non-mainstream" sources such as China, Syria, and Algeria. An additional problem for the facility is that all of the plant's raw material inputs must be imported. Excluding sulphur and ammonia, just the rock supply, estimated at over 3.0 million tonnes per year, will require the use of over 50 Panamax size vessels each year for the facility to operate near claimed capacity. In addition, finished product needs to move from the plant to various distribution points. According to company reports there are no plans to keep large amounts of finished product in inventory. Product is to be moved immediately by truck and rail to distributors throughout the country. This raises the question of whether the local infrastructure can support such large movements of material. With the huge amounts of raw material needing to be imported plus distribution of finished product, it is obvious that logistics will play a key role in the performance of this operation.

U.S. DAP Exports

An added complication facing suppliers next year is that it appears that India overbought DAP this year. Estimates indicate that inventories in the country could range between 1.3 and 2.0 million tonnes. This stock level represents India's average annual imports of DAP over the last several years. Consequently, with the large Oswal capacity addition forecast to come onstream, even at a modest rate, plus high in-country stocks, one would not expect India to be in the market for a lot of DAP tonnes in yr2000.



With a recent 450,000 tonne DAP capacity addition in Pakistan, the new capacity additions just discussed in Australia and India, plus potentially high stock levels in India, U.S. DAP exporters, are going to be facing a challenging yr2000. Assuming that the new capacity comes onstream as cited by various industry reports, plus the other items just noted like stock levels, estimates have U.S. DAP exports possibly falling 850,000 to 1.3 million tonnes next year. This translates into a potential drop in U.S. DAP exports of between 9-13% from the estimated level of 9.9 million tonnes in 1999. As previously noted, some U.S. producers have already responded in a pro-active manner to this potential export drop.

Future Outlook

I thought I would take a quick look at what the industry is facing over the next few years. It is difficult to forecast the next few years because the industry is undergoing a structural adjustment; however, I will give it my best shot.

From the Demand side I see overall world growth in phosphate fertilizer consumption increasing at an average rate of about 2.2% per year from an estimated 33.5 million tonnes P_2O_5 in 1999 to 36.5 million tonnes P_2O_5 in 2003. If you assume the new plants come onstream as reported, at this growth rate it will take about 1.5-2.0 years for demand to absorb the new capacity additions. However, if the new plants come on at a slower rate, as some reports indicate, the additional production would be absorbed more smoothly.

In terms of overall P_2O_5 tonnes, Asia remains the dominant region over the 1999-2003 review period, with consumption expected to grow by an additional 1.7 million tonnes P2O5. As usual, China is the driving force within the region with consumption forecast to increase by an additional 850,000 tonnes of P_2O_5 . This would put China's annual consumption at 9.8 million tonnes P2O5 in 2003 reflecting an average P_2O_5 growth rate of about 2.3%. I see India's consumption growing at an average rate of about 2.8% per year over the 1999-2003 review period. This rate adds about 500,000 tonnes of P₂O₅to this country's consumption thereby putting total consumption somewhat over 4.7 million tonnes P_2O_5 . However, while the country recognizes its need to improve its NPK application ratio, I think that fiscal and incessant bureaucratic uncertainty will continue to overshadow sound market policy.

Latin America is a positive area for phosphate fertilizer consumption with growth forecast to average 4% per year reaching 3.6 million tonnes P2O5 by 2003.

Consumption of phosphate fertilizer in East Europe and the FSU should increase over the 1999-2003 period; however, economic conditions in these areas, while expected to improve somewhat, will most likely not have a major impact on P_2O_5

consumption over the review period. Consumption in Africa is forecast to reach 1.1 million tonnes by 2003, an overall increase of about 100,000 P_2O_5 . Middle East tonnage is predicted to rise approximately 100,000 tonnes to reach nearly 950,000 tonnes P_2O_5 .



Use of phosphate fertilizer in West Europe is expected to remain flat to slightly decrease over the next few years with consumption forecast at 4.2 million mt P_2O_5 in 2003. Consumption in Oceania is expected to rise modestly by about 2.2% per year reaching 1.6 million tonnes P_2O_5 by 2003. The U.S., being a mature market, is forecast to grow at less than 1% per year over the 1999-2003 time period.

On the Supply side, as I have already pointed out, the biggest problem facing the industry is the incremental capacity scheduled to come onstream over the next year or two. World production capacity of Wet Process Phosacid, the basis for high analysis phosphate fertilizers, is forecast to increase from 37.9 million tonnes P_2O_5 in 1999 to nearly 40.0 million tonnes P_2O_5 by 2001 an overall increase of 2.1 million tonnes, or 5.5%. As previously discussed, the operation of some of this new capacity is open for discussion. The Oswal project appears to face some operating and logistical difficulties; however, I do believe that discounting its impact would put you on dangerous ground.

After yr2000, the projects that I would classify as "firm" begin to flatten out thus allowing demand to start absorbing the new incremental capacity. Barring unforeseen events, I see the U.S. industry beginning to return to "normal" between yr2001-02.



While we are looking ahead, a question arises regarding future DAP production in India. How long and at what level will the Indian government continue to subsidize high cost domestically produced DAP versus cheaper imported product? For example, the current subsidy levels are \$108.00/mt for domestic product versus \$75.00/mt for imported product. Assuming the Oswal project produces at capacity, i.e. 1.5 million tonnes per year DAP, and that the plant's production displaces the equivalent amount of imports, the subsidy cost to the government, just for this project alone, is \$162 million per year. This is almost \$50 million per year more than the subsidy that would be paid out for the equivalent volume of imported DAP.

Closing Comments

As an analyst I try to envision, on a qualitative level, what the fertilizer business is facing in the long term, say 10 or 15 years from now? It would be nice to be able to just rely on one of the industry maxims, "More people; more mouths to feed; more food needed; less arable land available; therefore more fertilizer required." To a large degree that is a true statement, at least in the near term. However, as with a lot of things associated with this business it is just not going to be that simple in the future. Like it or not, there is going to be more attention given to agriculture's impact on the environment. We read and see about how Precision Agriculture is developing. We hear about companies like Monsanto, DuPont, and Dow, etc. investing "big bucks" in Ag biotech/genetic engineering. Guess where they think the future of agriculture is heading.



Currently there is concern and debate about the safety and environmental effects of genetically modified crops. A couple of weeks ago it was announced that the world's population reached 6.0 billion people, a doubling of the population since 1960. According to U.N estimates the world will reach 7.0 billion people by 2013, only 14 years from now. With agricultural land being a finite resource clearly the "old" methods of growing food will need to improve. Therefore, I believe that in the long term, good science, economics, and necessity will advance the use of biotech commodities.

These developments should alert us, that as an industry, we need to be prepared for what I see as future "adjustment".

> Outlook for Potash Richard Downey Agrium U.S. Inc.

The following slides were presented to the Fertilizer Industry Round Table October 27, 1999.

Potash Outlook

- Potash is the most straight forward nutrient to understand
 - MOP accounts for 95% of K20 use/production
 - Canada, FSU, and Germany account for 75% of production, 80% of this is exported
 - . US, China and Brazil account for half of world use
- Potash has the most stable short and medium term outlook of the three nutrients,
- ... there is always potential for unexpected surprises (eg. Asian, Brazil & FSU supply/demand)



Factors Influencing Potash Prices







World Potash Trade/Use

- The lower international grain prices negatively impacted potash use in US (- 8% in FY98/99), Brazil imports (-10% to 20% in CY99) and EU imports (-3% in CY99).
- Asian potash demand (India) is higher in 1999 and in other regions little change is expected.
- 1999 world potash trade is expected to be unchanged, to slightly lower.

World Potash Production & Trade

	Million tonnes K2O				
	<u>1993-96</u>	<u>1997</u>	<u>1998</u>	<u>1999</u>	
Capacity	34.5	35.4	35.5	36.0	
Production	22.4	25.1	25.4	25.2	
Oper. Rate	65%	71%	72%	70%	
Trade	17.2	20.4	19.2	19.0	

Sources IFA, Natural Resources Canada, Agrium

U.S. Consumption of Potash 1975-1999

• US potash use was < 5mst/yr only 4 times in the past 25 years
• 8% decline would = 0.8 mmt potash (0.42 mmt of K20)









1998 World Potash Production



Source: IFA

US Operating Rates





Canadian & CIS Potash Operating Rates

<u>Canada</u>	<u>1996</u>	1997 1998 (million tonnes K20)		<u>1999(f)</u>	
Capacity	13.4	13.4	13.4	13.4	
Production	8.0	9.0	9.2	8.6	
Operating Rate	59%	67%	69%	64%	
<u>FSU</u>					
Capacity	11.9	11.9	11.9	11.9	
Production	5.4	6.7	7.0	7.3	
Operating Rate	45%	56%	59%	61%	

Source. IFA, Natural Resources Canada, British Sulphur PPI, Agrium



Source IFA. Natural Resources Canada. British Sulphur, Agrium

Potential Changes in World Capacity

- New Asian mines under consideration??
 - 2 in Thailand (Somboon 1.2mmt K20/yr, Udon Thani 0.7mmt/yr)
 - China, Qinghai mines (DSW 0.5mmt/yr)
- Jordan expansion
- IMC small expansion within 2-3 years (<0.4 mmt).
- French mine closures of 0.6 mmt 2002-04,
- Belarus reserves depletion??

Medium Term Potash Outlook

- Recent IFA supply/demand balance forecasts indicate a tightening in the surplus capacity:
 - from 4.9mmt in 1999 to 3.2mmt in 2003
- IFA projects increase in world demand (2.8%/yr) will outpace supply growth (0.8%/yr).
- If half of proposed Asian projects were operational by 2004 the annual growth rate in supply would still be less than 1.5%/yr.

Potential Market Shocks

- Major political/economic strife in CIS
- Y2K problems (FSU, Asia)
- Faster growth in demand: due to higher crop prices & better Asian/LA nutrient balance
- Mine closures, depletion of Belarus reserves. Potential new mines or expansions?
- Will China join WTO? (minimal impact on K)

Outlook for Sulphur Richard E. Amesbury Mobil Oil Corporation

The world market for sulfur in all forms has been in surplus since the early 1990's, and will remain in surplus well into the next decade. Current world sulfur inventories total about 20MM. This surplus will grow to greater than 30MM metric tons by the middle of the next decade, despite steady growth in the consumption by phosphate fertilizer producers and other industrial users.

North America will remain the world's largest sulfur producing and consuming region well into the next millennium. North American sulfur supply will continue to grow, almost entirely in gas recovered sulfur in Canada and oil recovered sulfur in the U.S. Supply will considerably exceed demand, and most of the surplus will continue to be exported by Canada into the world market. Canada will maintain its role as the swing supplier in the international market.

The U.S. market will be supplied more and more by oil recovered sulfur from U.S. producers. This recovered sulfur production will displace U.S. imports. U.S. sulfur inventories will remain at today's working level of one-half million tons (less than three weeks supply), having declined from 1.5MM tons since the mid 1990's. The low level of working inventories in the U.S. will require close producer/consumer relationships, and may necessitate significant supply chain changes in the market to ensure secure, orderly product movement.





World Supply and Demand Balance Sulfur in All Forms

Supply

Approaching 60MM metric tons in 1998, world supply of sulfur in all forms will exceed 72MM metric tons by 2007

Assuming:

Frasch Production will expand by less than 1mm metric tons, as Iraq production grows

Gas recovered sulfur production will grow by 6mm metric tons, primarily in the FSU and West Asia

Oil recovered sulfur production will grow by 6mm metric tons, with the biggest increase in North America

Pyrites production will decline modestly

Unless:

Sulfur values do not support Frasch mining costs

Economic/political instability or logistical constraints in the FSU prevents development of Caspian Sea petroleum reserves

There is further substitution of brimstone for pyrites in China

Sulfur In All Forms World Supply and Demand Balance

Demand

Current demand of approximately 58mm metric tons will grow to about 71mm metric tons by 2007

Assuming:

World phsophate fertilizer consumption of sulfur will grow by about 2.5% per year, primarily in Africa and West Asia, and East Asia.

World sulfur consumption in the Industrial sector will grow by 1.5% per year.

Unless:

Political/Economic conditions prevent substitution of brimstone for pyrites.

Instability in the FSU prevents economic recovery.

Anticipated Copper, Nickel, and Cobalt leaching projects are delayed.



NORTH AMERICAN SULFUR SUPPLY AND DEMAND

22




Non Fertilizer demand for sulfur in the U.S. will grow very modestly.

U.S. Fertilizer sector for sulfur will drop in 2000, will recover over the subsequent three years, and will slightly exceed 1998 levels by 2007.

US SULFUR CONSUMPTION BY SOURCE (MM Metric Tons)



North American sulfur supply will undergo significant structural changes.

Frasch production will remain constant at 1.8mm to 2.0mm tons per year.

Consumption of SOF (U.S. production plus imports) will remain constant at 2mm tons per year.

U.S. recovered production will grow to +8mm tons by 2007.

U.S. Sulfur imports must decline to balance US S&D.



U.S. PRODUCTION & CONSUMPTION OF SULFUR IN OTHER FORMS (MM METRIC TONS)

Virtually all U.S. production of SOF is consumed domestically.

The reduction in production U.S. SOF may generate additional brimstone demand.

or

The recent reduction in production of U.S. will be replaced by additional imports.

"Make versus Buy" economics will determine the volume of U.S. SOF imports.

U. S. ELEMENTAL SULFUR IMPORTS



U.S. imports of Mexican and "Other" recovered liquid sulfur should continue to grow modestly.

Canada will remain the swing supplier into the U.S.



U.S. Sulfur inventories have been dramatically reduced over the last ten years. Remaining inventory is virtually 100% liquid, and represents approximately two weeks consumption. Economic (remelting costs, dumping concerns) and logistical constraints (rail car supply) may limit the short term availability of Canadian stockpiles.





North American and U.S. Sulfur Market Outlook

Outlook

US Sulfur supply will exceed demand for the foreseeable future.

Growth in U.S. recovered sulfur production will displace U.S. Sulfur imports.

The decline of the U.S. Frasch industry, accompanied by a decline in U. S. sulfur inventories, means U.S. liquid inventories are no longer adequate to absorb supply disruptions of +15 day duration.

Imports, primarily Canadian, are the swing sulfur supply to the U.S.

Concerns

The decline of U.S. imports from Canada diminish the ability of Canada to act as the swing supplier to the U.S.

Current U.S. sulfur inventory capacities put consumers and recovered producers at risk in times of demand surges and declines.

Wednesday, October 27th, 1999

Session II Moderator:

Lee Hoffmann

Real Granular Ammonium Sulfate at Fertinal, Mexico

David M. Ivell Jacobs Engineering Tony Brown Incitec

Summary

Incitec license unique technology for the granulation of ammonium sulfate through Jacobs Engineering. The process utilizes feeds of sulfuric acid and ammonia to a pipe reactor. Ammonium sulfate does not granulate readily and an additive, which is readily available in most countries, is used to promote granulation. Standard MAP/DAP plants can normally be fairly easily retrofitted to allow ammonium sulfate to be produced.

Incitec are fertilizer producers themselves and produce granular ammonium sulfate on their own plant at Gibson Island in Queensland, Australia. The technology has previously been licensed to Esso (now Agrium) at Redwater, Canada in 1986. This paper describes the conversion of the MAP/DAP/ TSP plant operated by Fertinal at Lazaro Cardenas, Mexico to allow granular ammonium sulfate to be produced.

Engineering work on the project started at the end of January 1998 and the revamped plant started up on July 22, 1998. Phase 1 of the project aimed for a production rate of 40 mtph. By July 27 rates of 50-55 mtph were being achieved and the guarantee test was easily passed.

The product quality is far superior to any other ammonium sulfate claimed as granular in the mar-

ket. Granules are identical in size & shape to any other products manufactured in a granulation plant. The size range is usually a 2-4 mm granule compatible with other granular products for bulk blending or for direct application. The size is limited only by the plant screening. The product granules are hard (4.3 kg per granule), dense (bulk density 1.07 t/m^3) and free flowing. No anti-caking treatment is necessary.

The second phase of the project is to debottleneck the plant to enable the rate to be increased to 70 mtph. Engineering work for the debottlenecking has been completed and implementation is expected by the end of the year.

2.0 Background

2.1 Real Granular vs. Crystal

Ammonium Sulfate is a crystalline salt, which does not normally steam granulate when fed to a traditional drum granulation plant.

The vast bulk of the ammonium sulfate produced world wide and consumed largely as fertilizer, comes from processes making ammonium sulfate as a byproduct, such as methyl methacrylate, caprolactam, coke oven gas washing and metallurgical industries, such as nickel processing. The bulk of this is produced as a fine crystal looking similar to sugar grains and about the same size i.e. SGN of approximately 100. The process used is vacuum crystallization and the size of these crystallizers is limited to approximately 20 mtph production capacity per vacuum unit. Some use multistage evaporation to reduce energy costs. The pressure from the customer is to increase the size of the material to be blend compatible with other fertilizers so the development of crystallizers has seen a progressive increase in SGN. The current limit of the largest crystals seems to be approximately 220 SGN. The technical problem is that the size of crystallizers becomes capital limiting and, as the residence time (and hence volume of the crystalliser) is increased to allow more crystal growth, the processes of attrition also accelerates.

Most of the large crystal manufacturers now screen off a small proportion of their total make with an SGN of 220 and sell it as super crystal or "granular". But an SGN of 220 is very marginally blendable with other fertiliser ingredients with an SGN averaging 240 - 300. The rest of the sugar grade material is either dumped on a reluctant market or used as feed stock for compound granulation plants. The sugar grade ammonium sulfate is aggregated together with ammonium phosphates to produce compound fertilisers using the ammonium phosphate component to bind the granules together to produce fertilizer grade sizing.

Ammonium phosphates and NPKs from drum granulation plants tend to have a 240 - 300 SGN size range. There is no limit on the sizing from this granulation process but it is simply determined by the screening sizes used on the plant.

There are other processes, such as compaction, which also do not have this size limit but because of the extreme chemically aggressive nature of ammonium sulfate the compaction equipment tends to have high maintenance costs. In addition, the pellet produced is not well rounded like a granule.

In 1975 Consolidated Fertilisers (which later changed name to Incitec) invented a method for producing granular ammonium sulfate using a traditional drum granulation plant. The product was invented for CFLs own use in its own market. The granular ammonium sulfate, called Granam, had an immediate and spectacular effect on the market with market size growing from an originally envisaged 15,000 mtpy to 80,000 mtpy in under 5 years. The product is identical in appearance and sizing to other fertilizer NP and NPKs normally produced from such plants. The ammonium sulfate is made from sulfuric acid and ammonia at Incitec's Brisbane plant in Australia and is specifically made for the fertilizer market. This plant was commissioned in early 1976. In 1986 this process was licensed to Esso Chemicals at Redwater Canada (now Agrium). Both the Brisbane and Agrium plants are still producing at maximum plant capacity and various uprates have progressively shifted tonnage's up over the years.

2.2 Incitec Granulation Technology

Incitec is a manufacturer of fertilizers and industrial chemicals located on the Eastern coast of Australia, with head office located at Brisbane on one of the manufacturing sites. It operates two ammonia plants, an ammonium nitrate plant (producing both explosive and fertilizer grades), a urea plant and two granulation plants. The granulation plant at the Brisbane site was recommissioned in 1974 to make DAP and was one of the first plants in the world to manufacture DAP with a pipe reactor which was retrofitted into that plant. This pipe reactor technology was extended in 1976 to produce ammonium sulfate.

For many years the plant produced MAP, DAP and ammonium sulfate together with some mixed acid runs making 15:20:0 before the production or even import of phosphoric acid at the Brisbane facility became uneconomic and the plant reverted to making 100% Ammonium Sulfate.

Currently a range of new products is generated on the plant including a Zincated MAP and a granular urea produced from prilling fines using an extension to the ammonium sulfate granulation technology. Like ammonium sulfate, solid urea fines will not usually granulate on its own and this technology allows urea fines to be granulated to produce blend compatible product. The process and products are world unique and have been subject to further patents.

Because of the industry interest in this granulation technology Incitec has continued to license both ammonium phosphate and ammonium sulfate technology world wide on a low-key basis. The DAP technology has been licensed in Germany, Australia, and India and the ammonium sulfate technology in Canada and now Mexico.

2.3 Jacobs Engineering

Jacobs is one of the largest Engineering and Construction companies in the world with offices on four continents and over 20,000 employees. The Jacobs office in Lakeland, Florida specializes in the fertilizer industry and has a long list of successfully completed projects for phosphate rock mining and beneficiation, phosphoric acid, and DAP/MAP/TSP and NPK granulation plants. In 1998, Incitec were looking for a partner with experience in fertilizer design and engineering to partner with, to better exploit their licensed process for granular ammonium sulfate. Jacobs had the necessary experience that Incitec were looking for and, as Jacobs had no competing process for ammonium sulfate, the match seemed well made. A license agreement was signed which gives Jacobs exclusive rights to the Incitec process for granular ammonium sulfate.

2.4 The Customer, Fertinal

Grupo Fertinal, S. A. de C. V. emerged from the privatization of the fertilizer industry by the Mexican Government in a process which took about two years. Fertinal acquired the Lazaro Cardenas fertilizer complex and the Rofomex mine in December 1992.

The Lazaro Cardenas fertilizer complex (now Agroindustrias del Balsas, S. A. de C. V.) is located in the south of the country on the Pacific coast. The complex was originally started up in 1986 under the management of Fertimex, a government owned company. Following privatization Fertinal started up the first granulation plant producing DAP in January 1993. This was followed by a phosphoric acid plant, the second granulation plant, the second phosphoric acid plant and the nitric acid and ammonium nitrate plants. In 1998 units producing SSP ROP and TSP ROP and the GAS (Granulated Ammonium Sulfate) retrofitting in Complex Plant II came on stream.

The installed capacity of the plants is follows:

Sulfuric acid I 660,000 mt/y

Sulfuric acid II 660,000 mt/y

Phosphoric acid I 250,000 mt/y

Phosphoric acid II 250,000 mt/y

Complex Plant I (making only DAP) 577,500 mt/y

Complex Plant I (making only MAP) 577,500 mt/y

Complex Plant II (making only DAP) 577,500 mt/y

Complex Plant II (making only MAP) 577,500 mt/y

Complex Plant II (making only GTSP) 388,000 mt/y

Complex Plant II (making only GAS) 316,800 mt/y

SSP ROP Plant (making only SSP ROP) 165,000 mt/y

SSP ROP Plant (making only TSP ROP) 165,000 mt/y

Nitric acid 215,000 mt/y

Ammonium Nitrate 275,000 mt/y

Rofomex (Roca Fosfórica Mexicana, S. A. de C. V.) is the other site operated by Grupo Fertinal and is located in the northwest of the country in the Gulf of California and the Baja California Peninsula. At this site, phosphate ore is mined and concentrated in a beneficiation plant to obtain a 64 % concentrate, which is shipped to the Lazaro Cardenas Complex in a two-day voyage. Current concentrate production capacity is 1.0 million metric tons but a revamping to 2.0 million metric tons is under construction to be in operation in July,

1999. This will improve the integration of the mine and the Lazaro Cardenas Complex with respect to phosphate rock.

The final products are then Phosphate fertilizers such as DAP, MAP, GTSP and GSSP and Nitrogen fertilizers such as Ammonium nitrate agricultural and low-density grade. TSP ROP is incorporated during production of GTSP in Complex plant II.

Phosphate fertilizer products are dedicated approximately 50 % to the domestic market and 50 % to the export market including countries such as India, Australia, New Zealand, Philippines, Vietnam, Chile, Brazil, Guatemala, Argentina, and Uruguay. Brazil appears as a potential market for GSSP although no shipments have been made to that country so far.

Approximately 16 % of the total P_2O_5 complex throughput is sold domestically as a special grade of phosphoric acid for detergents.

Agricultural grade Ammonium nitrate is sold entirely in the domestic market, whereas 35% of the low-density Ammonium Nitrate is exported to countries such as Chile, and Peru.

A cargo of GAS amounting to 50% of last year's production has been sold to New Zealand under the license agreement with Incitec.

3.0 Modifications

The granulation plants were originally designed to make NPK grades based on ammonium nitrate in addition to these products but these grades are no longer produced. The two plants are almost identical – the one difference is that only one of the two has the TSP processing capability. It was this plant that was to be modified to allow ammonium sulfate to be produced.

The objectives of the retrofit were to install the Ammonium Sulfate Pipe Reactor process into the Fertinal granulation plant as soon as possible, with minimum down time and while still being able to produce MAP, DAP and TSP on the same plant in the same way as previously. So the project was broken into 2 phases. The first phase being simply to install the pipe reactor with minimal equipment to produce at what was achievable without uprating any other section of the plant. Phase 2 would involve more extensive modification at a later, more convenient date to maximize plant rates.

A simplified flowsheet of the plant is shown in Figure 1. The throughput of the plant is limited to 440 mtph by the capacity of the elevators and drag flight conveyors. The granulator is 4.1m dia x 7.6m long and the dryer is 5.1m dia x 33.5m long. The drums are generously sized because of the original intention to produce NPK.

The production capacity of DAP and MAP is 73 mtph but TSP rate is limited to only 49 mtph. Fertinal wished to have the modified plant capable of the same kind of rate on ammonium sulfate as achieved on MAP/DAP. This was however a considerable increase over the maximum rate that Incitec had achieved, either on their own plant or the licensed plant at Agrium. The Incitec plant at Gibson Island produces around 28 mtph and the Agrium plant around 37 mtph. Of particular concern was the design of the pipe reactor for what amounted to almost double the maximum demonstrated rate.

An agreement was reached whereby Incitec would design two pipe reactors. One for at least 50 mtph (of which 40mtph would be guaranteed), and one for 70 mtph.

In Phase 1, the two pipe reactors would be supplied, together with all the feed systems. The feed systems would be designed for the 70 mtph that was to be eventually targeted but with the capability of being able to operate at the 40 mtph rate that was guaranteed.

Phase 2 was to be concerned with debottlenecking the plant to enable the 70 mtph to be achieved. It was decided to delay the implementation of Phase 2 until after the Phase 1 guarantee test runs had been completed so as to be able to better ascertain where the bottlenecks lay. However, the granulator venting rate was identified at this early stage as being almost certain to be a limitation. The Phase 1 modifications were relatively simple and consisted of the following:

- New sulfuric acid storage facility and feed pumps to supply both the pipe reactor and the scrubbing system.
- New storage facility and feed pumps for the granulation additive.
- New pipe reactor feed pumps for scrubber liquor.
- New ammonia sparger for the granulator.
- Pipe reactor with feed control systems for sulfuric acid, liquid ammonia and scrubber liquor.
- Granulator duct flushing facilities.

The most difficult challenge was to locate the pipe reactor, as the internal arrangement inside the granulator was already very congested. This was mainly because the very large 800mm diameter support pipe for the ammonia sparger and the slurry line was designed to double as a duct for introducing forced draft air through a slot along its length.

It was decided to reduce the size of the support pipe from 800 to 350mm and to locate the existing MAP/DAP/TSP slurry line inside the new support pipe. This freed up valuable space inside the granulator and enabled the pipe reactor to be located. A new air inlet arrangement was constructed at the inlet end of the granulator. The inlet duct terminated at the inlet seal plate.

The original plant was designed with only a short platform at the back of the granulator in the area where the slurry pipe entered. The two bays between this platform and the next platform (for the dryer cyclones) were open. These two bays were therefore floored in to enable the pipe reactor and the feed lines to be supported and accessed. The area under the pipe reactor and acid feed pipework was fashioned into a trough to collect any leaks.

The heat of reaction involved in producing a tonne of ammonium sulfate is approximately 1.4 and 2.3 times that generated when producing DAP and MAP respectively. Very large volumes of steam are therefore generated in the granulator requiring good granulator venting.

Liquid ammonia was used during ammonium sulfate production to limit the steam generated. A special ammonia sparger was designed to allow either liquid or gaseous ammonia feed depending on the grade to be produced. The pipe reactor discharge and the sparger technique are critical to the successful production of granular ammonium sulfate.

The Pipe Reactor reaction conditions are very severe – hot and highly corrosive – and selection of the correct materials of construction for the various sections of pipe is crucial. Nevertheless, the cost of the reactor is relatively modest.

The original plant was controlled via a conventional control panel. Fertinal specified a PLC for the new pipe reactor. The use of a PLC makes it very easy to program the controllers so that ratio controllers can be used where appropriate.

Variable speed pumps were selected for the feeds of sulfuric acid, scrubber liquor and the additive. Variable speed pumps were chosen rather than control valves because not only were they cheaper but there were significant maintenance and safety advantages in avoiding the use of acid valves.

A small fraction of the sulfuric acid (<10%) is used to acidify the scrubber water. The scrubber pH is controlled to minimize ammonia loss. The feeds of sulfuric acid, scrubber liquor and the additive each have a recycle line back to their individual tanks to make it operator-friendly during start up and shutdown of the system. The pipe reactor is fitted with an automatic steam purge. The exhaust duct from the granulator was originally flushed with scrubber liquor but this had been abandoned many years previously due to problems of plugging the inappropriately selected nozzles. In view of the relatively dusty nature of ammonium sulfate a new flushing system was installed.

4.0 Start Up

The modified plant was started up on July 22, 1998. A combined Incitec/Jacobs team supervised the start up. Incitec supplied two experienced operators & a process/design engineer from their own plant in Australia to work on shifts with the Fertinal operators. In view of the very special nature of the operating techniques required for ammonium sulfate, this proved to be a distinct advantage.

The plant was initially started up using fine crystalline ammonium sulfate to establish the solids circuit operation. This material was "granulated" with granulation additive and steam and water. The additive is crucial to the successful granulation of ammonium sulfate. If the supply is lost for any reason the plant will fill with dust within a short period of time. The additive is readily available in most countries and costs about \$6-8 per tonne of ammonium sulfate. Costs can be reduced considerably by manufacturing the additive on site, even in-situ on the plant.

About four hours after starting the feed of the crystal to the plant, the pipe reactor was brought online. The smaller pipe was installed initially for the purpose of proving the guaranteed capacity. Rates of 40 mtph were produced from the pipe reactor immediately and production was stabilized, after a series of mechanical difficulties, within the first 16 hours of operation.

Some of the problems encountered during the first days of operation, which in some cases were interrelated included:

- Non function of the automatic control systems.
- Build up inside the granulator on the ammonia sparge pipe and support arms.
- Maintaining consistent granulation and overloading of the screens.
- Product color.

Most of the control problems were sorted out within the first few days. The only control loop that did not function properly was the automatic control of the sulfuric acid to the scrubbing system. The major problem was an unsuitable valve for the service. A globe valve was specified but, because of delivery time problems, a plug valve with a noncharacterized plug was installed. This meant that automatic flow control was a problem. When attempts were made to put the loop into cascade with the pH, the flow cycled wildly.

There were no problems with the on-line measurement of the pH however. The pH was relatively stable and could be quite easily controlled by making manual adjustments to the sulfuric acid flow. In fact the quantity of acid required to control the pH was lower than had been anticipated (<5% of the total flow) indicating that both the pipe reactor and the ammonia sparger in the granulator were performing efficiently.

The problem with the build up inside the granulator was traced to malfunctioning of the sparger. The sparger fabrication had been in error, allowing leakage and accumulation of liquid ammonia and consequent build up on the sparger and sparger supports.

The problem was temporarily corrected by adding steam to the sparger to minimize the leakage. Operation at higher rates also noticeably improved the situation. The importance of correct operation of the ammonia sparger quickly became apparent. During the first few days of operation when sparger build up was a problem, the granulation was poorer than when the sparger was clean. Granulation was orders of magnitude better than when it was built up.

Granulation of ammonium sulfate is unlike almost any other fertilizer. The granulation does not look like that experienced with other materials and operators require special training to learn the difference, and the techniques in optimizing granulation. The natural tendency for ammonium sulfate is for the granulation to go dry and dusty. This is where the Incitec operators were most valuable to teach the Fertinal operators and at the same time to react quickly to avoid the worst of the inevitable start up upsets.

In addition to the locations of the pipe reactor and the ammonia sparger, major controls are the split of ammonia between the pipe reactor and the granulator, the quantity of scrubber liquor fed to the pipe and the control system for the dryer. When the process is in steady state, a minimum of product-sized material is recycled (compared with, say, DAP production). The recycle of productsized material is used simply to steady the feed to the granulator. Under optimum conditions the exit dryer stream contains about 30% between 2 and 4 mm. Deviation from the optimum conditions can result in deterioration in the size distribution of the circulating load. These upsets can lead to overloading of the primary screens, which in turn overloads the polishing screens.

However the operator learning curve was very rapid and the performance test started on July 27, 1998, only five days after the pipe reactor was brought on stream for the first time. Production rates of 50 - 55 mtph were easily maintained throughout the guarantee test period. The limit was found to be around 55 mtph, when venting from the granulator became a problem.

In all, in the 72 hour test a total of 2880 tonnes was produced in approximately 55 operating hours, including a series of plant shutdowns due to mechanical problems unrelated to the operation of the plant on ammonium sulfate. Typical operating conditions are shown in Table 1.

The product quality is significantly better compared to any other "granular" product produced by crystallization or other methods. Typical product quality parameters are given in Table 2.

The one remaining problem after the commissioning period was the color of the product. Ammonium Sulfate is normally pure white and Fertinal's marketing people had hoped that this would be the case with their product.

In the event the commissioning product turned out to be pale gray. At the time there were many divergent theories put forward as to the cause of the gray color, including TSP from a previous run, the color of the sulfuric acid or granulation additive, or the deterioration of the rubber linings in the scrubbers. It became clear eventually that the cause was improper combustion of the Bunker C oil being used for drying. This caused carburization of the unburnt fuel, which was scrubbed out in the dryer scrubber and recycled via scrubber liquor into the product. Fertinal switched to diesel as a check and as anticipated the product became white. In the longer term Fertinal plan to switch to natural gas.

In all Fertinal produced around 40,000 tonnes of granular ammonium sulfate in 1998 selling 14,000 tonnes to New Zealand.

5.0 Future Plans

Following the very successful start up, the engineering for the debottlenecking of the plant was immediately put in hand. The following items were identified as bottlenecks that required correction to enable the design rate of 70 mtph to be consistently achieved:

Increase in granulator venting capacity. This is to be achieved by increasing the size of the granulator exhaust duct. Cooler airflow will be slightly reduced from current levels. The effects of an increased production rate on achievable cooling will be partially mitigated by reflighting of the cooler (existing flights are much too small). It is anticipated that the increased product temperature will have little effect on the Ammonium Sulfate storage or handling characteristics..

Increase in solids handling capacity of the plant by 10%. Although not necessary for steady state operation it was decided to increase the capacity of the elevators and drag flight conveyors by increasing their speed. New motors will be required. This is perfectly feasible in this case because the rotary drums are very generously sized and currently operate with very low fill rates.

Convert the two single deck screens to double deck machines. The original plant was laid out with six sets of primary screens. Two were single deck machines with all of the material being fed to these screens passing to the recycle. This arrangement is fine for TSP and DAP but not for ammonium sulfate.

Although some product-sized material is recycled in steady state operation it is minimal to stabilize recycle. In addition, during upsets it is necessary to extract all the product-sized material that is available for a short time to prevent the recycle load from increasing. For this reason, the two single deck screens were bypassed during the start up period. This was one reason that the screens became overloaded at times.

At the time of writing, the final modifications had not been completed. However, given the success of the initial operation, everyone is very confident that 70 mtph will be achieved once they have been implemented. This would certainly cap off a very successful project. Bearing in mind that brand new technology was installed in the plant, it is quite remarkable that the guarantee test was passed within ten days of start up.

Table 1		
Production Rate	•	52 mtph
Pipe Reactor		
H ₂ SO ₄ Feed		35.4 mtph
NH, Feed		10.0 mtph
Scrubber Liquor	r Feed	49.0 mtph
Granulator		
NH ₃ Feed		2.7 mtph
Dryer		
Air Inlet Temp		322°C
Air Outlet Temp)	98°C
Size, +4 mm	l	18%
	2-4 mm	24%
	-2 mm	58%

The quality of the product is so good compared to the traditional "granular" (large crystalline) ammonium sulfate that it will dominate in markets where product quality is of prime importance.

This project marks the second granulation plant to be retrofitted with Incitec granular ammonium sulfate technology. Incitec and Jacobs look forward to collaborating on many more similar projects in the future once this quality product begins to impact ammonium sulfate markets.

Table 2				
	%N			20.3
	%H ₂ O			0.15
	pH (1% solution)		5.1
	Free Acid			<0.2
	Size +4mm			5%
		+2mm		90%
		+1.4mm	8%	
		-1.4mm	2%	
	Bulk Density			1.07 t/m ³
	Crushing Streng	th		4.3 kg on
			a 2.5 mr	n granule



Product Quality With Air Separation A. Ray Shirley, Jr. P.E. Applied Chemical Technology, Inc.

Air is a size classifier of like material because of the various resistance air offers to various size particles. For example, if one takes a handful of dry sand and gravel and throws it with a horizontal pitching motion in still air, the gravel will travel further than the sand before hitting the ground. Should one be able to do the same thing in a vacuum, both the sand and the gravel would travel the same distance before hitting the ground. The difference is the resistance of the air. The small sand particles have more profile surface area per unit of weight than the larger gravel, thus their horizontal velocity is slowed much quicker by the resistance to motion imparted by the air.

Now suppose one just drops the handful of gravel and sand in a stiff breeze; then the air movement would carry the sand further before it hits the ground than it would the gravel.

Both of the air examples, 1) where the air is still and the particles are moving and 2) where the air is moving and the particles are only falling due to gravity are examples of air classification.

In our discussion today, we will talk primarily about systems where the air moves and carries particles with it. I will show that air is an effective low cost size classifying means.

At this point, it should be pointed out that air is also a good way of separating same size materials of different specific gravity's. In some applications of air classification this is good, in other cases it is bad because it causes segregation of blended materials by material density as well as by size. Sometimes this gets complicated, so today we will only discuss the classification of like materials, whether they be one chemical or a homogeneous blend of chemicals in each particle.

So everyone can follow the following discussion, just a quick review on sizing terminology. When products are classified, they are separated into desired sizes. Usually this means a size which is too large, we call oversize; a size too small, we call undersize, recycle, or fines; and one or more inbetween sizes which may be additional products or intermediate cuts. We usually denote the sizes of a group of particles by a screen mesh size. The mesh designation is based on the standard used to test the size of the particles. The two most important test standards in the U.S. are the U.S. Sieve Series and the Tyler Standard Screen Scale Sieve Series. The size openings in the standard screens are specified by their wire count to the inch, which is called mesh, but actually it is the opening size between the wires which is the standard. A table has been included (Figure 1) designating the sizes as published by the U.S. Tyler Company in their publication entitled "Industrial Wire Cloth Woven Wire Screens", p. 71, 1970 edition.

An example of screen terminology follows: A sample, which was tested when the largest test screen was a 6 mesh, would have a designation of +6 mesh = x% of the sample for material which did not pass through the screen. For material which passed through the 6 mesh screen, but which was too big to pass through the next screen, say a 8 mesh screen, the designation is -6+8 = y% of the sample. If these were the only two screens used, the material passing through the 8 mesh screen would be -8 = z% of the sample.

Sizing in a plant operation, however, is not as simple as putting standard sieve screens onto a screener and running material across them. Screens can be inefficient, and their efficiency varies with through-put rate, and their through-put rate is very sensitive to material size. As the size of the materials to be separated goes down, the screen area required for screening goes up for a given rate. For example, it is very easy to visualize that several tons of very large rock can be screened on a very small screen, if that screen has 6" openings, but as that rock is crushed into smaller gravel, say 1" or smaller, and separation of various sizes of gravel occurs, the area of screen for screening the rock becomes much greater for the same rate. In fertilizer, when screening -6+8 mesh product, you can achieve much more through-put for a given area screen than when screening fine cuts such as -16+20 mesh material or -20+35 mesh material. As some of you know, the later cuts might be a customers special request for product, if you are supplying certain parts of the specialty fertilizer market.

Can air separation help cut costs? Yes, but as all technologies, it has its areas of most effectiveness and that is with smaller sized products and in special services such as complete dust removal from the product.

As materials get smaller and smaller, screening starts to get very impractical such as separation of fine milled face powder products from that needing additional milling. This is done almost exclusively with air classification just as much as vibrating heavy duty grizzlies and screens are exclusive with rock and gravel sizing.

When using air to separate typical fertilizer sized particles, fluid-bed style air separation systems are the most useful. Figure 2 depicts a fluid-bed system in recycle air mode. Air can be recycled, pulled, pushed, or pushed and pulled through a separation chamber consisting of a bubbling bed of solid caused by air passing through them. The bubbling bed acts as if it was a liquid behind a dam with the height of the bed controlled by the height of the dam. Below the bubbling solids is a distribution plate to make sure the air passes through the bed evenly or unevenly as the design may specify. Now the important part, as air flows upward through a bubbling bed of solids, the velocity of the air will not only suspend, but will also lift and carry material out of the vessel. The size carried depends on the velocity of the air flow and the specific gravity of the material.

There is a well known law in Chemical Engineering called Stokes Law. It defines the drag force exerted on a particle which is free falling in a gas or liquid. When this drag force just matches the gravitational pull on the particle, the speed of the falling particles reaches what is called its terminal velocity. One thing which is important is that in air it makes no difference whether the particle is falling in the air or the air is blowing past the particle, the effect is the same. If the force of air is greater than the gravitational pull, the particle will move up with the air; if it is less than the gravitational pull, it will stay down.

Stokes Law, written in the terminal velocity form is:

$$U_{t} = \underline{gD_{p}}^{2}(\rho_{p}-\rho) \quad \text{ft/sec}$$

$$18\mu$$

where U_t is the terminal velocity of the particle; D_p is the diameter of the particle; P_p is the density of the particle; P is the density of the gas; N is the viscosity of the gas. It is important to note that the terminal velocity is directly proportional to the square of the particle diameter.

A true fluid-bed is based on this technology. To be truly fluidized, a particle must be subjected to air at or above its terminal velocity. Air moving through a fluid-bed essentially reaches terminal velocity for all granules fluidizied, because the granules themselves act as area restrictors thus causing air to have a high superficial velocity within the bed area. After the air leaves the bed, the air velocity reduces. Therefore, the air does not carry the granules out of the unit unless they are of a size where the air velocity above the bed is above their terminal velocity.

Based on this very simplified explanation of how a fluid-bed works, it is easy to see if air flow rates are maintained just above the terminal velocity for the size of particle which is to be removed, that size particle will be carried out and the larger size particle will be retained.

To determine how effective a fluid-bed can be at classifying fertilizer size material, we set-up the following experiment. We took a laboratory fluidbed like we at Applied Chemical Technology build and sell, and set it up in a manner where we could vary, control, and measure the air flow rates passing through the apparatus. Figure 3 is a picture of the fluid-bed with a 4" diameter fluidizing tube in operation. In the upper right hand side of the unit the air velocity can be seen as 316 ft/minute. A closer view, Figure 4, shows the undersize being blown up and into an expansion chamber for disengaging and separation from the air. In this case, we were trying to remove all particles less than U.S. Sieve 40 mesh (.42mm) from a sample of particles which were essentially -18 mesh (1.00mm) and smaller.

Separation of larger mesh material was done using a 2" diameter separation tube so we could achieve higher air velocities in the lab unit. See Figure 5. In Figure 6, the small separated particles are shown leaving the separation tube and entering the disassociation and expansion zone.

For our test we used granules discharging from the drum of a falling curtain granulation pilot plant which was operating at ACT. The material was a polymer with a true density near that of urea. Based on using the very same sample in each set of tests, we achieved excellent separation. Four sets of material were sized at different true air velocities. The following graphs, Figures 7, 8, 9, and 10, show how well separation occurred at various velocities. The graphs show the amount of each size left in the bed after being exposed to various air flows. Note on Figure 7 that when making a -6+8 mesh U.S. Sieve Series separation with a air velocity of 1020 ft/min, the test left 99% of material -6+7 in the bed; 90% of the -7+8 mesh material, 65% of the -8+10 mesh, 22% of the -10+12 mesh, and 0% of material less than 12 mesh. Of course, as the graph shows, the complimentary percentage was removed. By an increase of about 10% in air flow, all of the -10 mesh and most of the -8 mesh particles was easily removed while still retaining most of -7+8 mesh material and essentially all of the -6+7 mesh material. Similar results were seen when using sets of smaller size materials. Figure 8 shows similar results when looking for a - 8 + 12mesh cut, Figure 9 gives excellent result with a -12+16 mesh cut, and Figure 10 gives exceptional results with a -20+35 mesh cut with air velocities now in the 350 to 390 ft/min range.

In general, the fluid-bed area to replace a screen for most applications is about $1/10^{th}$ of the screen area.

Fluid-beds give many advantages. The undersize which is the material air-lifted from the fluid-bed can continue to be air-veyed to anywhere in the plant before being released from the air by either passing it through a simple disengaging device such as a soft handling expansion chamber, a cyclone, or many other specifically designed devices, depending on the material and what is being done with it. ACT has an urea plant where -35 mesh material is being removed to leave a -20+35 mesh material. About two tons per hour is being separated with excellent efficiency at about 1:1 oversize to undersize in a 5 ft² fluid-bed with the undersize being air-veyed to a wet cyclone where it is put into solution.

Listed are some of the major advantages of air classifying.

- Size distribution is immediately adjusted by adjusting air flows through dampers or blower speed control. Thus no screen changes to change product size or to slightly vary the product cut to avoid too many fines, etc.
- No screen wear-out and replacement cost.
- The area and volume required for equipment allows easy, low cost installation for both an initial installation or a retrofit. (Headroom and conveying considerations are not as serious as with screens.)
- Air classifying allows gentle handling of product which will be completely dust free.
- Air classifiers can do double service; material can be cooled or heated by the air at the same time classification is occurring.

There is one important disadvantage to using air classification of material. It is difficult to obtain a true upper limit cut of product where near size oversize is involved. Usually this is achieved by air separation of the undersize and then screening the product on a scalping screen. Since scalping screens are much more efficient, than undersize screens, overall cost and plant flexibility are improved. ACT is working on a system to solve the oversize problem without screening, but we don't know the answer yet. Fluid-bed technology has come a long way in the last twenty years, and will continue to improve.

We at ACT know we are on the leading edge of fluid-bed technology, having built a myriad of specialty units of all descriptions and uses. We not only heat, cool, and dry granules, but react gas and solids to form granules, granulate liquids into solids, coat and impregnate solids, and yes, now even replace screening with air classification. At ACT, we do all kinds of chemical engineering, and fluidbed technology is one place we excel.

Figure 1.			
TYLER SCRE Tyler Mesh Designation	EN SCALE Opening (inches)	U.S. Mesh Designation	U.S. SIEVE SERIES Opening (mm)
$ \begin{array}{c} \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\$		1.06 in 7/8 in 3/4 in 5/8 in .530 in 7/16 in 3/8 in 5/16 in .265 in No. 3 No. 4 No. 5 No. 6 No. 7 No. 8 No. 10 No. 12 No. 14 No. 16 No. 18 No. 20 No. 25 No. 30 No. 35 No. 40 No. 45 No. 50 No. 40 No. 45 No. 50 No. 60 No. 70 No. 80 No. 100 No. 120 No. 120 No. 100 No. 120 No. 200 No. 200	26.9 22.6 19.0 16.0 13.5 11.2 9.51 8.00 6.73 5.66 4.76 4.00 3.36 2.83 2.38 2.00 1.68 1.41 1.19 1.00 841 micron 707 micron 595 micron 595 micron 595 micron 500 micron 420 micron 354 micron 250 micron 250 micron 177 micron 149 micron 125 micron 149 micron 125 micron 88 micron 74 micron 53 micron 53 micron 53 micron 53 micron 53 micron 53 micron 53 micron
325 400	0.002 0.002	No. 325 No. 400	44 micron 37 micron

This is taken from the U.S. Tyler Company's publication entitled "Industrial Wire Cloth Woven Wire Screens", p. 91, 1970 edition.





Figure 3.

Applied Chemical Technology Laboratory Fluid Bed Model N-100. Operating with 4 inch diameter air classifying tube particle separation at -20+35 mesh U.S.



Figure 4.

Close-up of 4 inch air classifying tube and disengaging chamber in operation, with -35 mesh particles entering chamber.



Figure 5.

Two inch diameter air classifying tube operating with particle separation at -6+10 mesh U.S.



Figure 6.

Close-up of 2 inch disengaging chamber in operation with -10 mesh particles entering chamber.



Figure 8 Fluid-bed Particle Seperation Utilizing Air Classification (-8+18 Mesh Granules, SpG = 1.3)







Improved Fertilizer Product Sizing Patrick E. Peterson

CF Industries, Inc.

I will begin with a quote by George Hoffmiester, formerly of TVA circa 1973:

"A bulk blend of top quality is characterized by a number of desirable qualities. It is granular and free flowing. Its components are present in the correct plant food proportions and are mixed to a high degree of homogeneity. It is non-segregating to a high degree, and therefore can be handled without a loss of homogeniety and can be spread in a uniform manner. Because of its homogeneity and non-segregating character, analysis of any reasonable sample shows the desired analysis. Finally, it is non dusty and free of fines and lumps."

This statement is as true today as it was those twenty-six years ago. It addresses the three main ingredients in providing good blended material. Firstly, the fertilizer materials must be blended properly to affect homogeneity and the desired (guaranteed) analysis. Secondly, the blended fertilizer must be placed in a uniform manner so that nutrient avilability is spread evenly across a field. And, thirdly, that the materials used for blending be of good quality and compatible size.

First, let us examine the improvements in the areas of the blending and application of these mixed fertilizers.

Blending

In this area we have seen great improvements in equipment over the past years. The industry has progresses. (see the following Blending graphics).

Application

Similarly, many improvements have made the agequipment industry. Improvements such as: (see the following Applications graphics).

Now let us look at the area of fertilizer materials as to their sizing and quality. As innovative and revolutionary as the afore mentioned improvements to the blend and application equipment have been, they still only mix, and apply, and rely, on materials that lend themselves to efficient mixing and application. And as the equipment has become more sophisticated, better fertilizer materials are needed.

Through improvements in sizing and uniformity these materials are available in today's market.

Recall from Dr. Hoffmiester's quote the requisites for a good blended material. It must be *free flowing, homogeneous and free of dust, fines and lumps*. Free flowing is a given (acknowledged). The others will be considered.

Segregation

As bulk blending replaced ammoniation-granulation studies were made by TVA scientists to determine what affected segregation. Particle shape or density had little or no effect. The basic finding was that to minimize segregation the materials to be blended should be in a range of +/-10% in their various size portions. It was also found that segregation was greater when the larger particles were in the minority rather than when they were in the majority.

In the 1980's, new concepts of identifying fertilizer materials size and uniformity to combat segregation were conceived, Size Guide Number (SGN) and Uniformity Index (UI). Size Guide Number being a number representing the average particle size in millimeters at which one half of the material is larger and half is smaller. The SGN is calculated by multiplying this average size by 100 and rounding to the nearest unit of 5.

Uniformity Index is the ratio of the size of small particles to large particles expressed in percentage. More precisely UI is the ratio times 100 of the two extreme size in the range of particles retained at the 95% level and the 10% level.

Size Guide

For the past 10—15 years the influence of these two concepts have a great effect on the sizing and quality of fertilizer materials. Overall size (SGN) and uniformity have increased and improved. Let's compare some size ranges of fertilizers available in 1973 to present day materials. (see the following Size graphics).

Note the uniformity of the newer materials. Most of the particles are in two tyler mesh sizes. The +8 mesh and the +10mesh. The smaller particles, the +14 and the +20 mesh sizes have been reduced significantly.

This has contributed to the lessening of the second area of concern, that of fines and dust. Tests have



shown that smaller particles are softer that larger ones and will more readily fracture or pulverize during handling to produce fines and dust.

So with their improvements in the overall sizing and uniformity, the problems of segregation and fines and dust have been lessened. This leads to better blending and application of blended fertilizers. In conclusion, the fertilizer industry has kept pace with the requirements of the equipment used to blend and apply it.















Ύεμ



























S G N SYSTEM OF MATERIALS IDENTIFICATION

A concept in materials identification established to assist in the selection of compatible materials for blending by providing a common basis for size comparison.

This program has been developed by the Canadian Fertilizer Institute. Involvement in the program or use of the concepts outlined herein is totally VOLUNTARY.

WHAT IS IT?

The SGN is the Size Guide Number.

Simply, it is a number representing the average particle size in millimeters, which is the size at which 1/2 the material is larger and 1/2 is smaller. The SGN is calculated by multiplying the average particle size by 100 and rounding to nearest unit of 5.

Technically, the Size Guide Number is defined as the median size (millimeters to three significant digits) determined by the 50 per cent cumulative point on a curve of particle size distribution plotted per cent cumulative by mass vs millimeter diameter. multiplied by 100 and rounded to the nearest increment of '5'.

WHY USE SGN

A necessary element of fertilizer quality is the ability to meet a specified guaranteed autrient analysis. Of the many factors affecting this element in mixed fertilizers, raw material particle is generally considered as the most important because of its direct affect of segregation.

Several recent reports (1-8) have demonstrated this relationship and the significance of this important factor. The SGN provides a simple means of product identification by particle size which will assist in the selection of size compatible materials.

Using the SGN system ...

"The closer the SGN of the raw materials, the lower the probability of segregation in the blended product."

... hence enhancing the ability to meet specified nutrient analysis.

UI - WHAT IS IT?

UI stands for Uniformity Index. UI is the ratio of the sizes of "SMALL PARTICLES" to "LARGE PARTICLES" in the product, this ratio being expressed in percentage. More precisely, UI is the ratio, times 100, of the two extreme sizes in the range of particles retained at the 95% level and at the 10% level. UI is best determined by a mathematical method which is described in Appendix C.

A uniformity index of 100 would mean that all the particles have the same size (perfectly uniform). Blend materials in Canada typically have a UI of about 50 (the small particles are half the size of the large particles in the sample), although some materials may be as low as UI 35 or as high as UI 60.

Moch			•	-	-
IMESH	8	Ē	Ē	ň	E
+6	1.5	0.3	0.1	.07	3.7
+8	33.0	33.3	14.9	27.4	22.2
+9	•		-	64.4	45.2
+10	81.9	85.3	73.7	82.6	70.2
+14	96.7	97.7	97.1	95.9	95.4
+16	98.9				97.9
+20	100.0	100.0	99.6	98.9	
UI	40	42	46	40	39
SGN	215	215	200	215	195
Amongana	120-			Contraction of	

		IFI	Survey	1973		
DIAN	имо	NIUM	РНО	SPHA	TE (DAP)
	Mesh	E	E	G	Н	
	+6	0.3	0.2	0.4	1.1	
	+8	24.5	13.4	7.6	44.5	
	+9		46.4	41.0		
	+10	79.0	78.9	81.4	95.2	
	+14	98.3	96.8	98.0	99.7	
	+16			99.2		
	+20	99.5	99.4		100.0	
	UI	43	47	55	54	
	SGN	205	195	190	230	
100	attend to be					
Servit 1754		Contract of the	Sec.	Der.	ANDIN	
I States				Marine Property		

	S. A. C. M.	TFI	Survey 1	973		
DIAN	лмог	NIUM	PHO	SPHA	TE (DAP)
	Mesh	A	в	c	D.	
	+6	0.2	2.2	0.4	1.8	
	+8		20.4	49.3	33.7	
	+9					
	+10		68.0		85.4	
	+14	99.1	92.7	98.9	97.5	
	+16		96.9			
	+20	100.0		99.8	100.0	
	UI	41	37	40	42	
	SGN	225	195	235	215	
1998	Notesta States					
	Const 17	Star Star	1000	te.	AGRICAT	
		11.54				

	GRAN	ULAR P	OTAS	H
TYLERMESH	IMC-KALIUM CARLSBAD	MISS. CHEM. NEW MEXICO	PCS LANIGAN	PCS <u>NEW BRUNSWICK</u>
+6				
3.35 MM +8	10	16	36	26
2.36 MM +10	45	60	96	73
1.70 MM +14	80	90	98	95
1.18 MM +20	95	98	99	97
0.85 MM	99	99	100	99
SGN	225	255	315	285
			ite and the second	Service States St

TYPIGAL PRODUCT SIZE SPECIFICATIONS, CUMULATIVE PERCENTAGES AND SGN

TYPICAL PRODUCT	SIZE SPECIFICATION	NS, CUMULATIVE PI	REENTABES AND	SGN
C	RANULA	AR POTA	SH	
TYLERMESH	IMC-KALIUM BELLE PLAINE	PCS ROCANVILLE	PCS ALLAN	
+6				
3.35 MM +8	8	16	20	
2.36 MM +10	54	75	65	
1.70 MM +14	88	95	95	
1.18 MM +20	98	99	97	
0.85 MM	100	100	99	
SGN	245	275	270	
	in the second second	Carlotter De		
			Scot of the second	
March 1998	Col and the second			Star Star

TYLERMESH	IMC-KALIUM COLONSAY	AGRIUM	IMC-KALIUM ESTERHAZY
+6			
3.35 MM	19	15	14
2.36 MM +10	67	80	65
1.70 MM	97	95	95
1.18 MM	99.5	99	99
0.85 MM	100	100	100
SCN	275	275	270

TYPICAL PRODUCT SIZE SPECIFICATIONS, CUMULATIVE PERCENTAGES AND SGN

	0	OAR	SEP	973 DTAS	H	
	Mesh	A	B	c	D	
	+8	9.6	2.0	1.2	2.5	
\$60 ZS 65	+10	34.1	29.3	23.2	33.8	
	+14	69.0	75.5	79.8	73.7	
5.000	+20	93.7	96.5	97.4	93.6	
	+28	98.1	99.0	99.2	97.9	
	UI	33	40	43	35	
	SGN	155	160	160	160	
			1. Carlo and			

	c	TFI S	urvey 197	3 Tash	
	Mesh	E	E	G	
	+8	11.6	5.0	9.7	
	+10	35.1	26.6	34.2	
2.1.1.1.1.1.1	+14	67.7	69.6	76.3	
	+20	93.6	97.0	95.0	
	+28	98,4	99.1	97.8	
	UI		40	28	
	SGN	155	155	165	
	distance.				
		CONTRACTOR	Carlotte.		CT 1010 770100
110.00	1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1	and the second		Service of the	

TYPICAL PRODUC		ATIONS, DUMUS	ATIVE PERCENT	ABES AND SGN
	GRAN	ULAR	UREA	
	CF	IMC	BOBBEN	
ITLERMEON	INDUSTRIES	AGRICO	DORDEN	ASKIUM
+6 3.35 MM +8	4	1	1	2
2.36 MM +10	60	59	49	75
1.70 MM +14	98	95	90	98
1.18 MM +20	100	99	100	100
0.85 MM		100		
SGN	255	240	235	270
A LONG TO STATE		2 States and		ATTEN 2012-1112
			Second and Second	
ch 1298	aler Alexan		and the second second	a far a start

TVI COMESU	FARMLAND	CIMBI AT	EXEVEEDOO
T TEMPLIFIC OTT	FUIN	STATEDI	ONORPERCO
+6			
3.35 MM +8		2	1
2.36 MM	40	70	60
+10			
1.70 MM	96	96	93
1.18 MM	100	99.9	99
+20			
0.85 MM		100	100
SGN	225	260	250
North States			

TYPICAL PRODUCT SIZE SPECIFICATIONS, DUMULATIVE PERCENTABES AND SGN

Typical Problict Size Specif	ICATIONS, CL	INULATIVE PERCENTAGES AND SEN
GRAI	VIII A	RIIREA
UNA		
TYLERMESH	UNOCAL	TERRA
+6		
3.35 MM	2	1
2.36 MM	75	45
+10		
+14	93	30
1.18 MM	98	99.5
0.85 MM	100	100
SON	270	210
		200
	1.1.1.77	Same Hand Street

	TYPICAL PRODUCT SIZE SPECIFICATIONS, CUMULATIVE PERCENTAGES AND SGN							
			G	TSP				
		IMC		CF		PCS		
	TYLERMESH	AGRICO	CARGILL	INDUSTRIES	SIMPLOT	PHOSPHATES		
	+6							
	3.35 MM +8	20	20	7	1	5		
	2.36 MM	70	88	65	55	49		
	1.70 MM	90	97	95	90	93		
	+14							
	1.18 MM +20	97	99	99.5	99	98		
	0.85 MM	99	100		100	99.5		
	5GN	280	300	260	240	230		
				Contract of the local division of the local				
					ALCONT OF STREET			
200	Maren 1998							

TYPICAL PRODUCT	SIZE SPECIFIC	ATIONS, CUMULA	TIVE PERCENTA	GES AND SON
		DAP		
TYLERMESH	FARMLAND	MULBERRY	AGRIFOS	AGRIUM
+6				
3.35 MM +8	10	4	8	3
2.36 MM +10	65	29	67	55
1.70 MM +14	85	BQ	84	76
1.18 MM +20	98	92	98	98.5
0.85 MM	100	98	99	99.9
SGN	250	205	255	245
1.2.5				
larch 126			4.7	

TYPICAL PRODUCT SIZE SPECIFICATIONS, CUMULATIVE PERCENTAGES AND SGN							
	DAP						
TYLERMESH	MISSISSIPPI PHOSPHATES	SIMPLOT	PCS PHOSPHATES				
+6							
3.35 MM	1.5	2	5				
2.36 MM +9	25	60	48				
2.00 MM +10	60						
1.70 MM	90	95	90				
1.18 MM +20	96	99.5	99				
0.85 MM		99.8	100				
SGN	215	255	230				
STR.	1100						
		10000					
Mareh 1398							

TYPICAL PRODU	CT SIZE SPEDIFI	CATIONS, DUM	ULATIVE PERCEN	TABES AND SGN
		DAP		
TYLERMESH	CF INDUSTRIES	IMC AGRICO	CARGILL	US AGRI-CHEM
+6				TARALLECOPER
3.35 MM +8	7	8	16	2
2.36 MM +10	65	40	82	31
1.70 MM +14	95	90	98	91
1.18 MM +20	99.5	98	100	99.5
0.85 MM	100	100		
SGN	260	240	300	215
		and the		and the second
March Toll				and the second

TYPICAL PRODU	OT BIZE SPECIFIC	ATIONS, CUNU	LATIVE PERCENTA	BEE AND BON
		МАР		
TYLERMESH	PCS PHOSPHATES	FARMLAND		AGRIFOS
+6 3.35 mm +8	5	10	7	30
2.36 MM +10	33	65	65	65
1.70 MM +14	78	85	95	96
1.18 MM +20	99	98	99	98
0.85 MM	100	100	100	
SGN	230	250	260	260
Marth 1996				

TYPICAL PRODUCT	TYPICAL PRODUCT SIZE SPECIFICATIONS, CUMULATIVE PERCENTAGES AND SON					
		MAP				
TYLERMESH	AGRIUM	CARGILL	SIMPLOT	IMC AGRICO		
+6 3.35 mm		20	1	10		
+8 2.36 MM +10	57	88	50	58		
1.70 MM +14	95	98	95	93		
1.18 MM +20	99	100	99	99		
0.85 MM	100		100	100		
SGN	250	300	240	260		
			- A9			
March 1768						

Mesh	A	В	<u>c</u>	D
+6	3.4		0.4	
+8	36.9	40.2	25.5	36.2
+10	74.0	87.3	79.9	82.0
+14	93.7	96.2	97.4	95.5
+20	97.8	98.4	99.3	97.3
+28		99.1	99.7	98.8
UI	34	-	42	
SGN	215	220	205	215

Mesh	E	E	G	Н
+6	3.6	22.3	8.1	
+8	37.1	76.2	56.2	28.9
+10	73.7	98.6	87.8	78.9
+14	93.3	99.0	95.5	97.3
+20	97.8	99.6	97.9	99.2
+28				
UI	34		37	
SGN	210	284	250	210

Mesh	1	Ţ	ĸ	L	M
+6	7.2	1.3	1.1	12.2	2.5
+8	49.2	38.8	40.7	36.3	30.6
+10	89.5	86.1	85.6	75.7	65,5
+14	98.3	96.0	97.7	94.5	89.0
+20	99.6	98.3	99.0	97.4	96.3
+28					
UI	42	39	41		29
SGN	235	220	220	215	200

TYPICAL PRODU	TYPICAL PRODUCT SIZE SPECIFICATIONS, DUMILATIVE PERCENTAGES AND SON						
	GRANU	LAR P	OTASH				
TYLERMESH	PCS PATIENCE LK.	PCS MOAB	PCS LANIGAN	PCS			
+6 3.35 MM +8	12	10	3	4			
2.36 MM +10	70	55	48	50			
1.70 MM +14	95	87	80	87			
1.18 MM +20	98	98	97	97			
0.85 MM	100	99	99	89			
SGN	270	245	235	235			
March 1968							

TYPICAL PRODUCT BIZE EPEDIFICATIONS, DUMULATIVE PERCENTAGES AND BEN COARSE POTASH						
TYLERMESH	IMC-KALIUM BELLE PLAINE	IMC-KALIUM COLONSAY	AGRIUM	IMC-KALIUM CARLSBAD		
+6 3.35 MM +8	3	21	10	12		
2.35 MM	28	49	45	43		
1.70 MM	68	86	88	74		
1.18 MM	95	99	88	95		
0.85 MM	98	99.5	99	98		
0.60 MM	99.5	100	99	100		
+35 0.425 MM			100			
SGN	200	230	230	220		
and the second second		Children and		- in the second		

TYLERMESH	MISS. CHEM. NEW MEXICO	PCS CRYSTALLINE	PCS ROCANVILLE	PCS PATIENCE LE
+6				
3.35 MM		12	5	0
2.36 MM	15	43	30	7
1.70 MM +14	50	74	70	77
1.18 MM +20	85	92	94	95
0.85 MM +28	98	95	97	88
0.60 MM +35	99	98	98	99
0.425 MM				
SGN	170	220	195	195

AAPFCO Regulatory Update

Mark Ringler Illinois Department of Agriculture

On behalf of the American Association of Plant Food Control Officials, I would like to express my appreciation for the opportunity to address this group at the Fertilizer Industry Round Table. Although this is my first opportunity to attend this meeting, it doesn't feel like my first time since I see many familiar faces who I have worked with in the past or other staff within your companies. As indicated by the program, my topic is an update of regulatory activities of AAPFCO. During the past two years, production agriculture and in particular, inputs that go into production agriculture have been scrutinized by the media, state and national legislators, national regulators and any other group that has an issue concerning fertilizer. From the use of ammonium nitrate in the Oklahoma bombing, to heavy metals in fertilizer which escalated in the state of Washington, to the theft of anhydrous ammonia from agricultural storage facilities for the use in manufacturing drugs, to the current issue regarding perchlorates, the term that best describes a regulatory update is "constantly changing".

My remarks today will pertain to AAPFCO, its philosophy and approach to the regulations of fertilizer and related materials. As most of you are aware, my one term appointment as President is strictly a privilege that I have been given to represent the Association of American Plant Food Control Officials. Whatever accomplishments and progress the Association has made in the past and will make in the future can be directly contributed to the Board of Directors, committees, task forces, and all the chair persons who devoted their resources in accomplishing the goals and objectives of that committee. Since the committees are made up of fertilizer control officials and liaisons from the fertilizer industry, most of the work and accomplishments are done outside our meetings throughout the year. As I just mentioned, industry liaisons that provide input and work on these committees are extremely valuable and essential to the development of a good regulatory structure. The Association appreciates the time, hard work, and resources which you contribute.

One of the primary purposes of this Association is to develop and encourage state regulatory programs to adopt recommended uniform laws, rules, terms, definitions, labeling requirements, and laboratory methods. The Association's philosophy has been and will continue to be that uniformity is extremely important for the industry, ag production, and the economy by providing movement of fertilizer in commerce without maintaining separate labels, products, or advertisements on a per state basis. It is the philosophy of the Association that a good regulatory program, which will protect the consumer and provide a level playing field for industry, can be maintained without placing a hodge podge of regulatory requirements on industry. Within our group the Association strives to promote uniformity from its members when new state regulations are proposed, adopted, and administered. As many from this group know, it is always challenging and sometimes difficult to obtain uniformity.

Following the theme of uniformity, the Association's Uniform Bills Committee is one of many active committees within our group. This committee's function is to address issues of concern by soliciting input from control officials and industry alike. The in-depth review and analysis of each statement of a rule or law assures that both industry and control officials can support and recommend adoptions of the committee's work. Since joining the Association, I have seen the completion of the Uniform Soil Amendment Bill, Model Chemigation Bill, Primary and Secondary Containment of Fertilizer Rules, and the Uniform State Ammonia Bill. In addition, the committee has continually updated long time model legislation such as the Model Agricultural Liming Materials Bill and the Uniform State Fertilizer Bill which was recently expanded to cover adulterated products in the environment. Currently, this committee is working on the development of a Model Compost Bill, developing "directions for use" criteria for the Model Bill, and reviewing material concerning lawn care requirements.

In the past two years, some states have adopted heavy metal guidelines which are not consistent with one another. During the past year, states such as Utah, Virginia, and even Illinois have seen legislation discussed or introduced to address the heavy metals issue in fertilizer. Although the Association has adopted a statement of uniform interpretation and policy regarding heavy metals while research was being conducted, it is sometimes difficult to adopt or defeat proposed laws based upon a policy not supported by research or placed in the recommended uniform bill. It is my desire that the Association review all data now available concerning heavy metals and make a recommendation to the Uniform Bills Committee to prepare and submit heavy metal guidelines as part of the uniform bill or rules and regulations.

The Label and Official Terms and Definitions Committee continues to be one of the most active within the Association. During our past August meeting in Omaha, the Association adopted over 75 new definitions and terms with more being considered for future review. These actions taken by the Association are a pro-active approach to the possible requirements for a "derived from" statement or "ingredient" statement being required on future labels. Today's consumers want and need to know information concerning the products used to determine if that material is appropriate for their operations or desired outcome. In agricultural input products, we already see labeling ingredients for ag chemicals, animal feeds, and even genetically modified products. Can fertilizer be far behind?

^oProbably the most single issue that has a wide range of ramifications is a term that we use in production ag called "nutrient management". Over the past few years the Nutrient Management Subcommittee of our Environmental Affairs Committee has been actively monitoring nutrient management plans proposed by various agencies in trying to determine where AAPFCO's role will be. Since this issue concerns surface water, ground water, and hypoxia in the gulf, a number of federal and state agencies are involved with fertilizer products and application, which traditionally have been areas for state fertilizer control officials and the Association. For example, the USDA and EPA worked together in developing a strategy for animal feeding operations in addressing the application of manure to fields as a fertilizer product. The National Association of State Departments of Agriculture has published a comprehensive resource management planning guide to determine the direction for nutrient management. The Natural Resource Conservation Services has a document for nutrient management related to technical program assistance, such as soil tests, plant tests, field goals, nutrient sources, methods, and application timing. Currently, the Wisconsin Department of Agriculture is working with other agencies within the state to put together a nutrient management program based upon a voluntary compliance aspect that ties nutrient management practices as a prerequisite to participate in federal and state programs. It is imperative that the Association and the fertilizer industry participate in the development of nutrient management plans in both the national and state level programs. Whether it is a voluntary or regulatory conception, these groups should be active in developing issues such as recommended rates, application timing, method of application, qualification of nutrient resources, and promoting the use of technical people such as extension or certified crop advisors.

As nutrient management plans become developed, the use of precision agricultural application will play an important role. As technology advances in G.P.S. monitoring systems and variable rate application, a larger portion of production ag will be dependent on this information system. It will be the role of the regulatory community to help the farmer in determining that he is getting the services and products that he is paying for. The Precision Agricultural Committee has been working with industry groups in developing methods for validating equipment, programs, and sampling techniques to assure that fertilizer material is being mixed and distributed properly. Whether fertilizer materials are mixed at the plant, transported to the field and spread consistently throughout the field, or whether the mixing occurs on the go, per field, on an acre by acre basis, the consumer should know that safeguards are in place to assure that the products are applied to meet specifications.

Another important aspect of the Association is to provide information and education to its members and the fertilizer industry. The Seminars Committee is responsible for ongoing education and developing uniform sampling procedures for field inspection. Through the hard work of the industry liaisons and control officials on the committee, a new inspection manual is now available that provides comprehensive material for inspection staff to assure uniformity in obtaining fertilizer samples and information. In addition, with the help and commitment of industry personnel an inspection and sampling video was produced which is available to any interested party. The Seminars Committee continues to arrange and provide inspector training seminars on a regional basis. Similar to an inspector's training, the fertilizer administrator's seminar offers a form for fertilizer control officials to discuss current issues within the industry. The Association sponsors this meeting for members to provide an understanding of the association's philosophy on uniform bills, to receive comments on new actions such as changes to definitions or model bills, and to get uniform consensus concerning problems and remedies. This form allows both new and some of the older control officials to spend time together sharing ideas, philosophies and knowledge about the fertilizer industry and the administration of regulations. The discussions and sharing of knowledge at these seminars have provided the committees and members of the Association better ways to administer and develop fertilizer regulations.

One of the cornerstones for fertilizer regulatory work is the ability to analyze accurately products or adulterations. In order to promote uniformity in fertilizer laboratories, the Association appointed a new committee over a year ago to develop uniform guidelines. The charge of this committee is to determine methodology needs and to help develop new methods for analysis which can be supported and approved by AOAC International. In conjunction with laboratory methodology, the Magruder Check Sample continues to be a vital program for laboratory and analytical review. The Association encourages laboratories to participate in this exchange of information and sample analysis as we encounter issues that involve analytical work of more than traditional N, P, or K analysis. With the current pace of advancing technology and as the public perception of fertilizer grows, credible laboratory methodology and science based facts need to be in place and recognized.

As part of the Association's informational material, an updated version of the uniform tonnage reporting system software is in the final stage of development and should be available in approximately four weeks. Like many other programs, the old version was not Y2K compliant. On another computer note, AAPFCO is developing a web page which will provide a description of the organization, committees, investigators, and the area that they work. It is anticipated that the site will be constructed and have established appropriate links sometime after the new year. And finally I would suggest that the Association's yearly official publication be part of your reference library. It contains information concerning committee activities, uniform bills, definitions, and current issues that are pertinent to fertilizer regulations and the industry.

In closing, on behalf of AAPFCO, I would like to thank TFI, and the industry members who support and work with the Association in the development and implementation of activities that produce viable fertilizer regulations and programs.

Thursday, October 28, 1999

Session III Moderator:

Kenneth D. Kunz

Granulation At a Point Ronald E. Highsmith Allied Signal, Inc.

Introduction

AlliedSignal is the largest single source producer of ammonium sulfate in the world. Ammonium sulfate is the most important source of plant-available sulfur and has grown in importance in the last few years as electricity producers continue to eliminate more and more sulfur emissions from flue gas. Over the years AlliedSignal has been interested in various granulation processes as a means of increasing the value of small particle grades of AS.

We wish to report a unique granulation process where granules are formed one-at-a-time at the tip of a small hollow tube such as a hypodermic needle. The process consists of continuous injection of certain viscoelastic polymers into a moving stream of fine particles. The critical parameters are the rate of injection and the velocity of the particles. For a given system, the velocity determines two dependent but very important variables: particle momentum and flux. The particles stick to the polymer as it continues to emerge from the tip of the tube (a syringe needle was used in the laboratory experiments) to form a granule. These granules are homogeneous and not a coating of particles on the surface of a polymer ball. The particles in the granule are closely packed together because for every bit of fresh polymer emerging there are thousand of impacting particles. The granule continues to grow at the tip of the tube until the impact of the particles exerts a force on its cross-sectional area sufficient to overcome the viscoelastic forces. A liquid having a low and simple Newtonian viscosity would be sheared off a little bit at a time as each particle contacted the polymer resulting in no granulation. Viscosity has little to do with granulating properties of the polymer in this process granulation depends more on the elastic properties above a certain minimum. Ureaform and other polymers can impart slow release properties to the granules making the resulting fertilizer more valuable.

This process forms granules one-at-a-time in con-³⁷ trast to other processes where many granules are formed instantaneously (bulk processes). This allows study of the primary variables in the process such as particle velocity, temperature, and polymer properties which in turn allow control of the size of the granule as it forms.

The relationship between the polymer flow rate and the particle velocity is obvious at the extremes. If the particles are resting (particle flux is zero) and polymer is continuously injected the result is a large ball of polymer with a coating of particles on the ball. On the other extreme, if the particles have a very high momentum (high velocity and/or high density) the granules will be very small or nonexistent. The following data helps to define the applicable range of these primary variables. The result is the ability, in some degree, to control the size of granules being produced thereby reducing recycle and consequently capital cost for this granulation process.

Polymers having high elastic properties can be used for granulation in this process but not those with low elasticity. In this paper elastic properties were measured through the recoverable elastic compliance (J_e) which has units of Pa⁻¹. This is a measure of the tendency of a material to return to its original shape when slightly distorted by an external force. The minimum elasticity appropriate for this process is about 3 Pa⁻¹ for most polymer-particle combinations.

Ureaform polymers are a special case. Ureaform polymer having a low elasticity will not granulate inert particles such as sand but will granulate acidic particles such as ammonium sulfate. Ureaform polymers exhibit a sharp increase in recoverable compliance upon contact with acidic particles. Ureaform polymers having high elasticity will granulate both types of particles.

The granules produced by this process are homogeneous and many types of fertilizer particles can be incorporated including micronutrients, potash, etc.

This process was scaled up several times using small nozzles and tubes with numerous holes as small as 0.031 inches and eventually in continuous process equipment designed for about 6-7 ton/ hour. An advantage to this process is that dust emissions are virtually eliminated upon introduction of the polymer. The process appears to be consistent with a low capital smaller volume production facility. The process has other advantages, particularly for ammonium sulfate; however, AlliedSignal has decided not to commercialize the process but rather offer it for license.

The Ammonium Sulfate–Ureaform Polymer Syatem

The ammonium sulfate – ureaform polymer combination is of particular commercial interest. A low cost viscous ureaform polymer commonly used in hundreds of thousand of tons per month as a wood adhesive, i.e. Borden's CR-583, is useful in this invention. This polymer is relatively non-hazardous and can be easily handled without extraordinary precautions. No heat is necessary for the combination of CR-583 and ammonium sulfate but sufficient time must be allowed for the polymer to cure and harden the granules. Polymer curing is faster if the ammonium sulfate is heated. Photographs taken under magnification show that the particles of sulfate are not only bound together but are also coated by the polymer. This accounts for the decrease in moisture pick-up by the granules versus that of ammonium sulfate crystals.

The following table lists some of the property measurements for granules prepared using Borden's CR-583 and small particle ammonium sulfate provided by AlliedSignal. Similar properties were obtained for granules prepared in largescale continuous equipment.

Ureaform—Ammonium Sulfate Granules

Starting Particles:

SGN = 85, 100% passing a Tyler #10, ~10% passing a Tyler #28 Opening size: Tyler #10 = 1.70mm, Tyler #28 = 0.60mm

Typical Granular Product:

Crush strength: 3.5 - 7.0 lbs for granules between 2.80 and 2.36 mm in diameter

Critical humidity: 75%RH @ 30°C (5-10° higher than that of ammonium sulfate) ureaform polymer = 4.5% ammonium sulfate = 95.5%

Granule Analysis
%N = 21.7
%S = 23.2
% Controlled Release N <u>≈ 2.2%</u>
SGN = 180-240; ~5% retained on
a Tyler #6 sieve, ~4% passing a
Tyler #28

Experimental–Granulation in the Laboratory

The data reported herein were obtained in the laboratory using a 9.5 inch diameter by 2 inch deep
rotating pan tilted at about 40 degrees from the horizontal and between one and four syringe needles. The needles were typically Number 16 or 22 which have inside diameters of 1.19 mm and 0.41 mm respectively. No relationship could be found between granule size and needle diameter, perhaps because of data scatter. The needles were fed using a manifold into which the liquid polymer was pumped. The pan was loaded with between 400g and 200g of particles and heated to the desired temperature with infrared lamps (usually between room temperature and 90°C). The tips of the needles were positioned near the bottom of the pan so that they were in continuous contact with the tumbling bed of particles. In this position it was noted that the granules pop up to the surface of the tumbling bed of particles leaving the unreacted particles on the bottom where they preferentially contact the fresh polymer emerging from the tip of the needle. This same phenomenon was observed in 36 inch diameter rotating drums. The starting particles were typically run of pile with the largest particles being removed by screening (greater than 1.4 or 1.7 mm). Starting particles composed solely of very small dust-like particles have been found not to be satisfactory in this process because the particle momentum is too low. However, the incorporation of some dust (not more than 20%) was found useful in achieving adequate crush strengths. The polymer was injected at rates between 1 and 6 ml/minute per needle while the pan rotated at speeds of 10 to 45 rpm. Polymer injection continued in this batch process until almost all of the individual particles were converted to granules. Typically 20 to 45g was used but the optimum dry polymer content was about 4.5%. If the polymer was not completely cured or dried at the end of the injection some additional rotation time was allowed. The granules have desirable properties such as crush strength and abrasion resistance.

The following table lists some of the polymer-particle combinations examined.

Polymers used with ammonium sulfate

Hide glue Poly-dimethyldiallyl ammonium chloride Melamine-formaldehyde condensation polymer Epichlorhydrin-dimethylamine polymer Polyvinylalcohol Ureaformaldehyde polymer Ureaformaldehyde polymer modified with furfuryl alcohol Ureaformaldehyde polymer modified with glutaraldehyde

Particles used with ureaformaldehyde polymer

Ammonium sul	fate		
Ammonium sul	fate + potass	ium ch	loride
Ammonium sul	fate + melan	nine	
Steel mill calcin	ne dust		
Ammonium sul	fate with sev	eral di	fferent
micronutrient ra	aw materials		
Aluminum oxic	le		
Ammonium	sulfate	+	urea

Experimantal–Measurements of Particle Velocity

Since this process depends critically on the particle velocity it is desirable to measure that velocity. However, it is not possible to measure particle velocity in a tilted rotating pan because of the wide variation in motion of particles. Therefore the pan was turned horizontal to eliminate three-dimensional movement. The pan was filled to the top with run-of-pile particles and the surface leveled. No extra dust was added. One hypodermic needle was used to inject the polymer about 1/4 inch below the surface. Heat, when desired, was provided by infrared lamps. The polymer was not heated. The pan rotational speed, r, was set and the needle was positioned at a set distance (b) from the center. The velocity of the particles is therefore the product:

 π b2 r = particle velocity example: 3.14 x 4inches x 2 x 20 rpm = 502 inches per minute

The polymer was injected for either one revolution or 15 seconds depending on the desired objective. The needle circumscribed a circle in the particles as the pan rotated. At the end of the injection a small number of granules rested in the bed of particles in the near vicinity of the circle. The granules were separated from the ungranulated particles by sieving the top inch or so of the pan contents through a sieve having an opening through which all particles had previously passed. A #10 Tyler sieve that has an opening of 1.70 mm was typically used. The separated granules had somewhat of a "popcorn" appearance since they experienced no tumbling as would occur if the pan was tilted. The needle was moved to a different position and/or the pan rotational speed was changed to generate samples at a different velocity. No unexpected differences were found whether polymer was injected for one revolution or for 15 seconds. The only significant difference was the amount of polymer injected. One revolution occurs in 0.75 seconds at 45 rpm and hence the amount of polymer injected and the amount of granules is very small under those conditions.

Discussion of Attached Figures

- Figure 1 This figure is an illustration of a granule being formed at the tip of a narrow tube in a flowing bed of particles. The polymer is pumped continuously down the tube and emerges at the open tip that is immersed just below the surface of a moving bed of particles. The granule continues to grow until the total impacting force of the particles overcomes the viscoelastic forces.
- Figure 2 This data on average weight of granule was obtained using a horizontal pan as explained above and illustrates the relationship between particle flux and polymer flow rate. Average granule weight is proportional to size and measurements are more precise. A large increase in average size of granules is observed for the 4 ml/min polymer flow rate at particle velocities of less than about 30 ft/min . An excess of polymer present in the granules was confirmed by measurement of the percent carbon in the granules. This is the result of insufficient flux of particles for that flow rate of polymer. Similar results are not seen for the lower flow rate of 1 ml/min and therefore the particle flux is adequate for that flow rate.

The aspect ratio of the granules is even more sensitive to excess polymer. Excess polymer makes the granule more easily distorted by the fresh impacting particles. More than 1200 measurements of aspect ratios shows insufficient particle flux for the 4 ml/min polymer flow rate at even higher velocities (50 ft/min). Similarly, aspect ratio data shows that excess polymer occurs at particle velocities less than about 20 ft/ min for the 1 ml/min flow rate.

The average weight data does not show the expected decrease in granule size at higher velocities because the change in size distribution is not reflected in the average size number. The following figure shows the change in distribution resulting in smaller granules as the particle velocity increases.

- Figure 3 Figure 3 shows data for change in size the C-309 granule for (diallyldimethylammonium chloride polymer) and sand system. The bar graphs show that about 60% of the granules formed at a particle velocity of 1 ft/min are larger than the holes in a Tyler #6 sieve (3.35mm). That number drops down to about 10% at a particle velocity of 12 ft/min and down to 0% at a particle velocity of 100 ft/min. Similar results are observed at a higher temperature (90°C). However, the granules overall tend to be larger at higher temperature perhaps because the rate of curing and elasticity of the polymer increases.
- Figure 4 The data in Figure 4, obtained using a rotating tilted pan in the laboratory, shows that granulation is a function of elasticity and not viscosity of the polymer. Ureaformaldehyde (UF) polymers present an unusual case. Low viscosity UF polymers do not granulate inert particles such as sand but will readily granulate acidic particles such as ammonium sulfate, calcined dust from steel mills, and certain aluminum oxides. This is explained by the observation that UF polymer elasticity increases rapidly upon contact with acidic particles.
- Figure 5 The granule shown in this photograph was obtained using a rotating tilted pan

and ureaform polymer injected through a syringe needle where the ammonium sulfate particles and granules were allowed to tumble freely. The photograph shows the particles bound together by the polymer in a close-packed configuration with a neat coating of polymer over the entire granule.

Conclusion

A unique granulation process has been described in which granules are formed one-at-a-time at the tip of a small hollow tube such as a hypodermic needle. The process consists of continuous injection of certain viscoelastic polymers into a moving stream of fine particles. The particles stick to the freshly emerging polymer to form a highly compact granule when there is sufficient flux of particles. The critical control parameters are the rate of injection at a point versus the velocity of the particles. Within limits, controlling one or both of these variables can produce granules of different size and different polymer content. The flux of particles can be below the minimum required to satisfy the fresh polymer flow rate (low particle velocity). Thus it has been shown ureaform polymer and ammonium sulfate system has critical velocity of about 20 ft/min when the flow rate through the tube is 1 ml/min. At velocities less than 20 ft/min the granules contain excess polymer. Likewise it has been shown that at a polymer flow rate of 4 ml/min the critical velocity is about 50 ft/ min.



61



		Figure 4		
HIGH COMP PROCES	LIAN <u>CE</u> SS IS FAI	POLYN RLY IN cp	<u>IERS</u>	PRODUCE GRANULATION NDENT OF VISCOSITY
POLYMER	PARTICLES	VISCOSITY	COMPLIANCE	% CHANGE IN SGN
HIDE	AS	3700	7.9	340%
DADMAC	AS	3900	7.6	320%
UF *	AS	1050	2.6	330%
PVA	AS	4900	1.5	0%
UF	SAND	1100	2.6	0%
HIDE - HIDE GEUF DADMAC - DIALLYEDIMET UT = POLYMER OF URLA &	HY LAMMONI FORMALDEH	EM CHI ORI YDE	01 0	AS = AMMONIUM SULFAIT STARTING SGN = <100 PVA - POLYVINYL ACETATE

<section-header><caption><section-header><section-header>

New Patented Granulation Process: The Sackett Process

Roon Dreese Michael Dang The A. J. Sackett & Sons Company

Abstract

A recent development in granulation technology has resulted in improved granulation techniques utilizing a dispersed liquid clay binder. The Sackett Liquid Clay Granulation Process incorporates an aqueous solution of binding clay fibers with a full granulation system. The full system includes mixing, agglomerating, drying, cooling, and particle sizing resulting in a high quality finished granular product.

Introduction

The utilization of granular fertilizer in the agriculture is preferred because of its inherent chemical and physical characteristics. Each individual granule is chemically similar to one another, as opposed to bulk blending methods where processed granules of different nutritional values are mixed together. Therefore, a homogenous product can be attained to provide more uniform distribution of nutrients to the soil. Moreover, these granular particles possess properties that reduce caking and are generally dust free and free flowing. Hence, storage, transportation, and distribution of products to the crops are simplified.

Granulation of fertilizers can be performed in many different ways. These include compaction, extrusion, and agglomeration, among others. Of these methods, agglomeration has been the most popular. This is due to such factors as initial capital costs, operating and maintenance costs, and the flexibility and ease of operation associated with agglomeration methods.

In the newly developed liquid binder granulation process developed by Sackett, high-speed agitation and rolling, or tumbling, are utilized to produce a high quality granule generally in the 2-4 mm size range. This, however, can be adjusted to suit the specific needs of the client. Agglomeration of fertilizers and soil amendments with the use of binding agents is not new to the industry. Many previous applications of binders in fertilizers have involved the use of dry binding materials. For instance, Smith developed a process in which binders are added to dry ammonium nitrate.

A major problem involving the application of clay as a binder is tendency for the product to shrink upon drying. This shrinking causes the product to crack; thus, making it unusable. However, there are several types of clay on the market today that are classified as non-shrinking. This constitutes less than 10% of the various types. Therefore, selection of the particular type of clay binder is the key first step in successful clay granulation

In addition, clay binders have found their way into liquid fertilizers, particularly salt suspensions. Utilization of bentonite as a suspending agent has been researched in Japan. However, problems with high viscosity and salt incompatibility problems were reported.

The granulation process developed by the A.J. Sackett & Sons Co. is unique in that it utilizes the dispersed clay as the liquid phase in granulation. The Sackett Process consists of five distinct stages of operation, each with a specific and important role in the Sackett granulation process.

- Liquid clay binder preparation.
- Incorporation with the dry portion of the fertilizer and/or soil amendments.
- Agglomeration of aggregates.
- Drying and cooling.
- Classification

A schematic representation of the full liquid binder granulation system is shown in *Figure 1*.

The Importance of the Liquid Phase

Agglomeration of aggregates of multinutrient fertilizers requires the presence of a liquid phase. The simplest way of introducing this liquid phase is with the addition of water and/or steam to dry fertilizer and amendments. Thus, a liquid phase is formed from the aqueous solution produced by contact between the water and soluble salts present in the fertilizer. The quantity of liquid phase is dependent on factors such as temperature, saturation of ionized salts, and quantity of water added. This quantity is important in the formation of high quality granules because it is the medium in which particles of the developing aggregate are attracted by capillary forces.

In practice, however, use of only water in the liquid phase is not generally practiced. This is partly due to the limited solubility of the salts in water and the inability of water to provide a sufficient proportion of liquid phase without extensive drying. Therefore, there is not enough capillary attraction within the aggregate and the plasticity of the granule is severely starved. Upon drying of such aggregates, intersitials develop within the crystalline lattice and weaken its mechanical structure. The result is a granule lacking sufficient crush strength and attrition resistance.

Hence, additional components are added to increase the liquid phase. Normally acids such as sulfuric, nitric, and phosphoric acid are added to the raw materials in the granulator to provide for additional liquid phase. These acids react more readily with the salts; but, in turn, need to be neutralized with the use of anhydrous ammonia.

Use of these caustic chemicals poses many potential dangers for those individuals who must work in the granulation plants. Furthermore, on a larger scale, they pose as hazards to the surrounding environment and communities. Also, the availability of these chemicals may be limited in many developing countries and the cost of importing them would be uneconomical. Granulation with a liquid binder serves as an alternative to using acid and ammonia. It poses no potential environmental hazards, is readily available, and features lower capital and maintenance costs.

Development

The development of the Sackett Granulation Process begins with an understanding of the properties of aqueous slurries of binding fibers and an understanding of granulation techniques. These sciences are then integrated and a model of granulation with liquid binders can be developed.

These inorganic mineral binders, which are high in magnesium and silica, are of special interest in granulation because of their inherent fibrous structure. When combined in an aqueous solution with a surfactant, the forces holding the fibers together are weakened and the fiber bundles can be separated from each other when a mechanical force applied (*Figure 2*). The aqueous slurry will remain suspended for several days without considerable precipitation.

Agglomeration of the aggregate begins after the liquid slurry is injected into the system. High agitation levels that can be introduced by various means homogenize the mixture and cause the free fiber particles to coalesce to the fertilizer amendments. In addition to the capillary forces produced by the liquid films, there is also probably a high degree of hydrogen bonding caused by the large number of hydroxide constituents and polyhydrate structure of the fibers. Moreover, because of the chemical structure of the fibers, these particles tend to possess a net negative charge and will attract the cations of the aqueous salts. As a result, a great deal of cation exchange will occur on the colloidal surfaces of the particles. These additional Van der Waals forces created by the binding agent produce an aggregate with a high level of plasticity. Hence, voids within the substructures of the aggregate will more readily be filled by equilibrating particles and a dense granule can be formed.

Upon drying of the aggregates, the structure of the crystalline lattice developed by precipitating ionic salts is reinforced by extensive crosslinking of the inorganic fibers. This crosslinking forms an immense structural network within the crystalline lattice, bridging voids and intersitials. The result is a granule that possesses enhanced physical characteristics that are harder and more resistive to compression and attrition.

The recently patented liquid binder granulation process developed by Sackett incorporates these ideas with drying and cooling methods that have long been used in the fertilizer industry. This has served as a stable basis for developing the process over the past several years.

The process was developed as an alternative to present day methods of fertilizer granulation. In the past many different materials such as NPK's, soil amendments, and organics have been difficult to granulate using traditional methods. Also, these traditional methods may be too costly or the necessary reagents may be unavailable in the local markets. In some instances, the materials were disposed of in landfills. By utilizing the Sackett Process, these components may be converted to a viable and profitable product; while, at the same time, it reduces the impact on the environment.

The Sackett Process is a relatively dust free and clean process. There is no appreciable particulate exhaust; nor are there effluents that cannot be recycled into the process loop. The Sackett Process does not promote the use of corrosive chemicals such acids and ammonia. Therefore, special corrosive resistant materials are not required for storage or handling of these materials. As a result, both, capital and maintenance costs are greatly reduced. Granulation with liquid binders serves as an environmental and economic alternative to chemical granulation. In addition, it can be used to supplement steam granulation to create higher quality granules.

Scale-Up

All prospective candidate materials for the liquid binder granulation process are extensively researched prior to full-scale production to determine feasibility of the venture. The proceedings involve a three part scale-up process to determine effectiveness of the binders with the raw materials.

The first step is bench top lab testing of the materials in small batch systems. This initial stage serves the purpose of observing how the particular materials in question react, both chemically and physically, to the liquid slurry. The resultant products are tested for compression resistance, attrition levels, and chemical composition, among others.

If satisfactory results from the bench testing occur, the materials are then tested in the Sackett pilot plant facility. Pilot plant production capacity is approximately one-half ton per hour. These conditions closely resemble those of a full-scale production facility. Therefore, final engineering modifications and requirements can be determined. Product quality and characteristics are representative of the full system, guaranteeing a satisfactory final product.

The recently commissioned Sackett Pilot Plant is a state of the art facility designed as a research aid for granulation with liquid binders. The system utilizes 18 inch diameter rotary equipment and can operate up to one-half ton per hour capacity. The system is nearly identical to the full-scale version and utilizes extensive process control equipment to ensure precise control of all process parameters. This includes accurate proportional batch mixing of raw materials and full ratio control of the liquid binder with a dual loop controller employing the PID loop algorithm.

Applications for the pilot facility range from single to multinutrient formulations, organics, micronutrient fertilizers, as well as incinerated or gasified materials. The wide range of applications available for testing in the facility is due to the flexibility of the Sackett Process and the variability of the process equipment and available process parameters.

The goal of the A.J. Sackett & Sons Co. is to provide specially engineered systems for each individual application. This can only be achieved through the extensive research previously mentioned. Current areas of customer research include agglomeration of single and multi component fertilizers, gasified ashes, and effects of micronutrient additions. Further success has been achieved in granulation of highly organic materials (up to 50%), which have been extremely difficult to agglomerate in the past.

The Sackett Process can be developed as a complete granulation system and as an addition to an existing granulation plant. Currently, there are several systems operating under license. These include one operating in South Korea and two in the United States. Furthermore, several international and domestic facilities are currently being studied for feasibility.

More information concerning commercial testing of materials with the Sackett Process is available through the A.J. Sackett & Sons Co. in Baltimore, MD USA.

REFERENCES

- Humphries, Dan et al. Sackett U.S. Patent. Issued 1998.
- Ludwick, Albert E. Western Fertilizer Handbook. Interstate Publishers, Inc, Danville, IL, 1995.
- Nielsson, Frank T. Manual of Fertilizer Processing. Marcel Dekker, Inc, New York, NY, 1987.
- Slack, A.V. Fertilizer Developments and Trends. Noyes Development Corporation, Parkridge, NJ, 1968.
- United States Department of Agriculture and Tennessee Valley Authority. *Superphosphate: Its History, Chemistry, and Manufacture*. U.S. Government Printing Office, Washington, D.C., 1964.

Figure 1

Schematic diagram of granulation with inorganic mineral binder



Figure 2

(a) Dry clay fibers arranged in rigid bundle formation.

(b) Addition of suffactant in aqueous solution effectively distributes fibers.

(c) Fibers are free to interlock with each other as with aggregate materials.

Nutrient Management and Alternative Fertilizer Sources in the United States

Cliff Snyder Paul Fixen Potash & Phosphate Institute

Water quality issues and low crop prices have intensified the focus on improved crop nutrient management and environmental stewardship. Issues like hypoxia in the Gulf of Mexico and Pfiesteria in the Chesapeake Bay have heightened the attention on agricultural non-point source pollution. The Environmental Protection Agency (EPA) and state water quality authorities have been compelled, by litigation, to intensify water quality monitoring and to develop Total Maximum Daily Loads (TMDLs) for nutrients and other potential water contaminants for all water bodies on the 303(d) impaired waters lists. A TMDL sets the amount of pollutant(s) that may be present in a waterbody and still assure that the water quality standards are attained or maintained. These standards will differ depending on the designated use(s) decided by each state water quality authority.

Proposed revisions to the EPA TMDL program were made public in August 1999 as part of the effort to intensify the cleanup of out nation's waters.(The EPA has extended the public comment period to December 22, 1999). One of the objectives of the proposed revisions is to create a more comprehensive list of waterbodies impaired or threatened by pollution or pollutants.

Animal Feeding Operations (AFOs) have come under the scrutiny of the public, EPA and the U.S. Department of Agriculture (USDA). In March, 1999, the USDA and EPA issued a Unified National Strategy for Animal Feeding Operations. The issuance of President Clinton's Clean Water Action Plan in February 19998, helped propel the EPA from its traditional focus on point source pollution and the national Nonpoint Source Pollution Discharge Elimination System (NPDES) toward nonpoint sources. The AFOs, and especially the concentrated AFOs (CAFOs are operations with over 1000 animal units confined) became the new target of the EPA and state water quality authorities because of their potential threat to water quality and public health. New NPDES regulations and effluent limitation guidelines are to be disseminated jointly by EPA and USDA beginning in 2001. An estimated 2000 to 6000 AFOs may be designated as CAFOs. The EPA will adopt the stance that CAFOs, under mandatory regulations, will ordinarily qualify for the Clean Water Act (CWA) agricultural stormwater exemption for land application of manure, if the manure is applied according to an approved Comprehensive Nutrient Management Plan (CNMP). If the CAFOs do not comply, they may be subject to mandatory regulations and the NPDES permitting process. The total number of CAFOs that could have priority coverage under NPDES permitting is estimated to be in the range of 15,000 to 20,000. Approximately 450,000 agricultural operations nationwide confine animals.

Between 1987 and 1992, the number of animal units in the U.S. increased by about 4.5 million. During this same period, the number of AFOs decreased, indicating a consolidation and concentration of larger AFOs with greater production. There is concern that many AFOs and CAFOs do not have sufficient land area to apply the animal waste or biosolids over a sustained period without risk to surface and ground waters from nitrogen (N) and/ or phosphorus (P) overenrichment. The pollution concerns extend beyond just N and P and include pathogens, heavy metals, antibiotics, and hormones. As a result of these concerns, the national joint goal of USDA and EPA is that all AFOs have comprehensive nutrient management plans (CNNIPs) to minimize the threat to water quality by 2009. A CNMP will have to fit into the total resource management objectives of the entire farm. The CNN4P is to address, "as necessary, feed management, manure handling and storage, land application of manure, land management, record keeping, and other utilization options". The National Resources Conservation Service (NRCS) Field Office Technical Guide (FOTG) is the primary technical reference for development of CNNIPs for AFOs, The FOTG at individual NRCS field offices is localized to address particular geographic areas.

The largest CAFOs are to develop and implement CNMPs by 2003 and all other CAFOs by 2005. Most (95%) of the AFOs will be expected to voluntarily develop nutrient management programs by 2009. The EPA expects that all AFOs will have a certified person who works with the operation. The new policy directs the NRCS to start developing plans by April 19, 2001. These plans will be developed as landowners request technical and/or financial assistance from NRCS. Certification of the plans must be by NRCS employees or NRCS-approved third-party vendors. There will be a need for private certified specialists because the public sector does not have the resources to develop and implement all the needed CNN1Ps. Certified Crop Advisers (CCAs) were approved as third-party vendors in 1998.

The EPA plans to use a phased permitting approach for those operations that will be regulated, according to the following: a nationwide general permit will be issued by January 2000; guidance to states will be issued by 2002 for bringing all AFOs within the program; a review and revision of existing regulations will be conducted, including the effluent regulations by 2002 (court-ordered revisions to feedlot effluent guidelines are required by December 2001 for poultry and swine operations, and by December 2002 for beef and dairy); a new definition of CAFOs is to be issued by 2001; and there will be increased enforcement with all CAFOs inspected by 2001 and all AFOs inspected by 2002. Penalties will be issued in accordance with the authority provided under the Clean Water Act.

Where does all this leave commercial fertilizer in the big picture? The EPA and USDA are supposed to "estimate by January 2000 a baseline of nutrient loads to watersheds with potential excess nutrients from animal manure and wastewater using watershed adjusted data from fertilizer sales, USGS/EPA nutrient load analysis, Census of Agriculture, permit limits, and other estimates". So in watersheds with CAFOs and AFOs, fertilizer dealers and commercial fertilizer users are likely to be impacted by any TMDLs that are developed. Any CAFO, falling under a NPDES permit, and requiring technical or financial assistance from the NRCS, will be required to develop a CNMP.

In some states, land applications of animal waste require a nutrient management plan, record keeping, and in some instances a state permit. For example, since 1992, the Arkansas Department of Environmental Quality (ADEQ) has issued permits for liquid animal waste disposal operations. The ADEQ: restricts liquid animal waste applications to slopes less than 15%; requires setbacks from streams, ponds and other waters and property lines; requires records of all land applications (date, weight, destination and acreage spread on); requires periodic (at least yearly) analyses of waste/ wastewater to be land applied; requires annual soil sampling and testing prior to waste application; and annual reports must be submitted with all the above information. Each facility is required to have an ADEQ-approved waste management plan for the farm and a site management plan for each application site. These plans are effectively nutrient management plans.

Maryland developed one of the most far reaching requirements of any state. The Maryland Water Quality Improvement Act (WQIA) of 1998 required that all agricultural operations with annual incomes greater than \$2,500 or more than eight animal units (one animal unit equals 1,000 pounds live weight) must have and implement a nitrogen and phosphorus-based nutrient management plan by a prescribed date. The Act requires that anyone "who, in operating a farm, uses chemical fertilizer" must have a <u>nitrogen and phosphorus-based</u> plan by December 31, 2001 that must be implemented by December 31, 2002. Persons using sludge or animal manure must have and have implemented <u>nitrogen-based</u> plans by the same dates as those using commercial fertilizers. Those using sludge or animal manure have until July 1, 2004 to get a <u>nitrogen and phosphorus-based</u> nutrient management plan, which must be implemented by July 1, 2005. Other states may have similar guidelines/regulations in place or under consideration.

Nutrient management plans should be considered an essential component of all modern farms. Not just because of water quality concerns, but because they can help improve the profitability and efficiency of crop production systems. While the attention has been on CAFOs, and the public perceives the entire agricultural community as "bad actors", the reality is that excesses of N and P are localized. Recent North American soil testing summaries indicate that 46 percent of the sampled soils are medium or lower in P and 44 percent are medium or lower in K. These results suggest that there is considerable opportunity to raise productivity and to improve crop nutrient use efficiency with improved P and K fertilization.

Crop removal of P in the top ten corn/soybean states is roughly in balance with the amount of P applied to these crops as fertilizer and manure combined. Nutrient budgets in some states show there has been an increasing trend for greater harvest removal of P than is input through fertilizer and manure. In Illinois for example, Dr. Bob Hoeft calculates that from 1992-1996, the removal of P exceeded P applications by 17%. In Wisconsin, the ratio of P removed in crop harvest: P applied as fertilizer or manure, increased from 50% in 1970 to 84 percent by 1984. In other states, where animal numbers have increased, the removal of P is less than the inputs from fertilizer and manure: the ratio in Maryland is 46%, for example.

The National Agricultural Statistics Service data show that crop yields have been increasing over the last several decades. With improved varieties and hybrids, improved farm management and biotechnology, yields are likely to continue to increase. The data show that N fertilizer use efficiency by corn has increased by 32%: from 0.76 bushels of corn/ pound of N in 1980 to 1.0 bushel of corn/ pound of N in 1998.

In general where manure is not used, it appears that the fertilizer N use by farmers is similar to the N rates recommended by most Land Grant universities. When manure is used, farmers can improve their fertilizer N use efficiency with greater accounting for the manure N (based on personal communication with M. Duffy at Iowa State University). According to other university manure specialists, there has been an improvement in manure N crediting by swine, dairy, poultry, and beef producers in the last five years, however.

There are many opportunities for improved nutrient management planning. More nutrient management tools are available, or being developed, today than ever before. The more traditional tools, soil testing and plant analysis, are still valuable but are being "upgraded" with the advent of new technologies such as Global Positioning Systems (GPS) and Geographic Information Systems (GIS). Yield monitors, variable rate applicators, and remote and contact sensing of land and crop characteristics are being increasingly used in site-specific precision farming applications with the aid of more powerfW and portable computer hardware and software. The new tools in and of themselves are not the solution to nutrient management challenges and water quality issues. Used appropriately, with a good research foundation, the tools can refine nutrient management from a gross farm scale to an improved field scale. The newer tools can improve the way we consider the land resource, nutrient levels and the potential for losses from the targeted soil and crops.

Some have advocated large-scale transport of manure from nutrient "surplus" areas to "deficit" areas, either with or without public subsidy. Others have suggested composting, pelletizing and incineration alternatives to direct land application of animal wastes. These ideas are worthwhile, but not really that new. Even with the transport to lower fertility soils, manure nutrients can still pose a threat to water quality if applications are not based on sound nutrient management plans with a local component of practicality and flexibility.

Summary

Water quality concerns have been the recent driving force behind nutrient management planning policy, guidelines, and regulation by governmental agencies. From a farmer perspective, nutrient management can help improve the agronomic, economic, and environmental impacts of manure and fertilizer applications. Nutrient management is but one component of a total framing system. Other Best Management Practices (BMPs) should also be considered in the development of profitable nutrient management plans.

Effective nutrient management is a process and requires time, observation, and experimentation. Nutrient management plans must be flexible and practical, and consider the opportunity for increased crop yields. To quote Scott Maple, an Indiana farmer, "We need to balance agronomic soundness and economic advantage with environmental responsibility. The most important piece of the balancing scale, however, is the fulcrum, which must be molded using the metal of common sense".

Nutrient Management & Alternative Nutrient Sources in the U.S.

Cliff Snyder Midsouth Director Potash & Phosphate Institute



Paul Fixen Senior Vice President - North America Director of Research Potash & Phosphate Institute

Nutrient Management

NRCS definition: managing the amount, source, placement, form, and timing of nutrients and soil amendments to ensure adequate soil fertility for plant production and to minimize the potential for environmental damage

Nutrient Management

Localized excesses of N and P

A critical part of profitable and efficient crop production systems

- 1/3 of crop yield attributable to fertilizer use
- Yield rapidly declines when N rate drops below optimum

Soil test summaries

- 46% medium or below in P
- 44% medium or below in K

Percent of Soils Testing Medium or Lower in K



Manure Nutrients Relative to Commercial Fertilizer Use in the U.S.



Tom Bruulsema, PPI, 1998

Trends in Nutrient Use and Management

Cropping system nutrient balance Nutrient use efficiency trends Manure N crediting trends

Percent of Soils Testing Medium or Lower in P





(IL, IN, IA, MI, MN, MO, NE, OH, SD, WI)

3

Illinois P Budgets, 1982-1996.

Removal				Rem/		
Years	Crop	Animal*	Fertilizer	Manure	Human	inputs
		Shor	t tons, thou	sands		%
82-86	517	8	466	112	16	88
87-91	498	8	385	106	16	100
92-96	574	8	381	101	16	117
* Meat,	* Meat, eggs, milk. R. Hoeft, U. of				U. of Illin	ois.

Wisconsin P Budget in 1995

9

Removal			Rem/		
Crop	Runoff	Fertilizer	Manure	Total	inputs
	Shor	t tons, tho	usands		%
182	3	109	111	220	84

L. G. Bundy, U. of Wisconsin.

Histor	ical P Rem	oval/inputs	for WI
<u>1970</u>	1980	<u>1991</u>	<u>1995</u>
	0	6	
50	59	66	84

Maryland Eastern Shore Agricultural P Budget

Output	Inputs	Output/inputs
Short tons,	thousands	%
4.3	9.2	46
R. Brinsfield, U. of	Maryland	· · · · · · · · · · · · · · · · · · ·

Crop Yields Are Increasing



E			_		- [i]		
-	8	10	100				
1936	1945	1994	1945	1975	1985	1 *** #	1997
		1	Ric	e			
		1	Ric	e	8		1
	5		Ric	e	Date: Second		
			Ric	e	100000000000000000000000000000000000000		

11

12

Fertilizer on Corn has been Constant or Declining for 20 Years



Fertilizer N Use Efficiency on Corn has Increased 32% since 1980



Nitrogen Use on Corn in Iowa 1996

	Manure used				
Parameter	Corn/corn	Corn/soybean			
Corn yield, bu/A	142	143			
N fertilizer use, Ib/A	121	119			
ISU recom., Ib/A*	0-90	0-90			
	<u>Manur</u>	<u>re not used</u>			
Corn yield, bu/A	131	142			
N fertilizer use, lb/A	135	129			
ISU recom., Ib/A*	150-200	100-150			
*Iowa State U 1997 recomm	endation, N applie	d pre-emergence.			

Data source: M. Duffy, ISU, personal communication with P. Fixen

Trend of Manure N Crediting by Producers in Previous Five Years

(as perceived by university manure specialists)



Schmitt, et al., 1999

Nutrient Management Tools

Soil testing & plant analysis Nutrient management planning Manure analysis

P Index

Site-specific precision technologies

- GIS (geographic information systems)
- Yield monitors
- Intensive soil sampling
- Variable rate fertilizer/manure application
- Crop and soil sensors (remote and contact),

Nutrient Management Process Components

Farm scale

Determine on-farm nutrient sources ID vulnerable water resources & potential problems Develop cropping plans

Field scale

Estimate current nutrient supplying capability of the soil Estimate supplemental nutrient requirements for optimum yield & quality Determine source(s), placement, & timing Evaluate effectiveness



Nitrogen Input/Output Balance in the Mississippi River Basin, 1980-1996





107 counties out of 3065 (~ 3.5%)

Perdue/Agri-Recycle Joint Venture



Pelletizing plant in Sussex Co., DE Use 120,000 tons of litter/yr Produce 95,000 tons of product/yr Operating by the end of 1999

24

Rail cars bring grain in and litter out



Sources and Fate of Soil Nutrients



Source: Doug Beegle, Penn State U.



Estimating Current Soil Nutrient Supplying Capability



Steps in the Soil Testing Process

Soil sample collection from the field Sample preparation - drying, grinding Chemical extraction

Determination of nutrient concentration in extract

Interpretation of the results

Recommendation development

Factors Influencing Fertilizer Recommended

Soil test calibration Yield potential Fertilizer placement Farmer financial circumstances Land tenure Soil test buffer potential Goals of the farmer





Balanced Nutrition Improves Efficiency



Effect of N and P on Corn Yield



 Schlegel, Dhuyvetter, and Havlin. 1996
 Com \$2.30/bu, N \$0.15/lb, P_O. \$0.24
 32

 JPA 9:1
 other costs \$2.40/A
 32

28

27



Some Factors that can Influence Response at a Given Soil Test Level



Variability within the area represented by a sample influences interpretation

As variability within the area sampled increases, fertilizer response or need may increase

Example: Corn in Ontario; K = 135 ppmVariabilityOptimum KVery low0High60 lb/A

Kanchonoski, U of Guelph





Profitability of P Recommendation Approaches for Soybeans

Recommendation	Field average	Increased
Site-specific	65	48
optimum Site-specific U of	57	28
MN rec.	0,	
Uniform rate	50	20
Uniform rate	100	39

Malzer, U of MN

Windom, 1998





Proper nutrient management planning has a local component

Can not be done properly from: a laboratory a state capital D.C.

A 1998 Corn Fertilization Program

456 lb N/A

- o Fall: 50 as urea
- o Pre-plant: 300 ammonia w/ Field cultivator
- D Starter: 15 GPA 4-10-10
- D Post w/ herbicide: 50 as UAN
- Side-dress at 4 ft with high-boy: 50 as UAN

180 lb P2O5/A; 120 lb K2O/A

Soil tests: 1200 ppm P; 1800 ppm K sampling depth 14"

42

Francis Childs - Manchester, IA Two-time National Corn Growers Assoc. Champion





"Managing Nutrients is a Process" Lance Murrell



Effective Nutrient Management

Must have a local component Must be flexible to match local soil and climate conditions grower management style and ability Must eventually boil down to a practical, executable plan Based on a mix of: science based knowledge and

science based knowledge and experience, intuition or art



Scott Maple - Indiana Farmer InfoAg99 Conference



*We need to balance agronomic soundness and economic advantage with environmental responsibility. The most import piece of the balancing scale, however, is the fulcrum, which must be molded using the metal of common sense."

47

46



The Role of Composted Manure in The Fertilizer Industry in Europe Dirk Kuiper D. Kuiper Process Engineering

The development of agricultural activities in Europe during the past three to five decades has resulted in specialized activities such as large areas of mainly arable farming, areas of mainly cattle production and certain areas of highly concentrated pig and chicken production on relatively small pieces of land. The problems created by animal manure and from the use of mineral fertilizers throughout Europe are illustrated by the current situation in the Netherlands, which is described hereafter, together with its inherent limitations and possible solutions.

The pig farmers have significantly expanded their production during the past decades - there are now nearly as many pigs in the Netherlands as human inhabitants (15 M).

The arable farmers need to use animal manure because it contains organic matter which is essential for the soil fertility and as a soil amendment. The NPK-ratio of the manure can be tailored to the requirement of each type of crop by the addition of mineral fertilizers.

Pig farming is currently concentrated in certain geographical areas of the Netherlands with arable farm land some distance away. The concept of using pig manure for arable farming is deeply rooted in history, and has been traditionally applied by the farmer on his own land; however, current concentrated and intensified farming practices present a number of economical and environmental problems. These are:

- The manure has to be transported, while 90% of it is water.
- According to regulations of the European Community, the nitrate concentration of the groundwater may not exceed 50 ppm, because the water might be used for the production of drinking water and a higher nitrate concentration may

cause health problems. (The US drinking water limit for nitrate is 10 ppm). This regulation limits the amount of nitrogen compounds to be added to the soil as fertilizer to about 200 kg per ha (178 lb/acre) per year.

- According to Dutch national legislation, the annual amount of phosphate added to the soil is limited to 110 kg per ha (98 lb/acre). The reason for this limitation is that the run-off to canals and rivers (non point-source pollution) can result in eutrification and impairment of the surface waters.
- The manure is not homogeneous and the mineral concentration can differ considerably in each load. In order to meet the rules for the maximum dosage of phosphate and nitrogen, each load has to be checked, and excessive application of these chemicals can result in a fine.
- The transportation of manure in concentrated pig farming areas can increase the risk for infectious diseases such as swine-plague.
- The emission of ammonia during the spreading of manure on the land is related to acid rain and should be avoided.
- In addition to the above mentioned problems associated with present arable farming, livestock farming encounters difficulties as well. These are specifically the emission of ammonia and offensive smell from the buildings and the insalubrious atmosphere inside the production buildings.

These problems are presently recognized throughout all of Europe; however, the national legislations are still basically insufficient, and the EC regulations are still limited. In many areas, partial solutions are already applied, but these address just one or two of the most urgent problems.

For the past several years, we have been involved in the development of a complete, integrated manure processing system which addresses all the above mentioned problems and which is economically feasible, at least for the situation in the Netherlands. This system is described in the addendum. It consists of a combination of existing processes which are specifically adjusted to manure treatment. The manure cellar of the production building is periodically flushed and the resulting liquid containing manure is separated into liquid and solid fractions. The latter is composted and the liquid fraction aerated, which produces a nitrification/denitrification process, by which a certain part of the nitrates is removed as non-hazardous nitrogen gas. The treated liquid fraction is used again as flushing liquid for the manure cellar. The excess liquid is evaporated, using the warm ventilation air from the building. The remaining 10% of the liquid is a brine which can be used as fertilizer, although it is preferable to combine it with the solid fraction and compost them together.

As a result of this design, the ammonia emission is reduced to less than 5% and the ammonia concentration inside the building is less than 10% of original values. The composted material contains no ammonia, its weight is less than 10% of the weight of the raw material and as a result, the cost of transportation is also decreased by 90% or more. The composted material is not infectious, as it has been kept for a suffiently long time at a temperature above 60 °C to result in pasteurization. It is a homogeneous material, and can be spread on land very accurately.

The composition of the composted material of both porker manure and sow manure is presented in the two tables. Data are given for the brine, the final solid fraction without brine and the final solid fraction with brine.

The final product consists of N, P and K and stable organic material (NPKO). It can be considered as an NPKO-fertilizer, which is just what the arable farmer wants. The organic material is stable and it represents about 50% of the organics of the raw material. The balance is decomposed during the composting process. The NPK-ratio of the product can be tailored to the requirement of each type of crop by the additon of N, P or K. The product is actually an attractive raw material for a range of NPKO-products. The nitrogen in the product is present as nitrate and in an organic form, but not as ammonia. When the product is spread on land, there is no ammonia emission with its associated odor. This is true even when it is raining. When dried manure is used instead of the composted material, ammonia and strong odors are intensively released during rainfall.

The NP-ratio of the product is about 50% of that of the raw material. The arable farmers in the Netherlands consider this an advantage, because they are limited to the application of only a certain amount of N and P per year per acre. They want to apply phosphate and organic material in the autumn and nitrogen fertilizer in the spring. If they use raw manure in the autumn, they reach the nitrogen limit and no more nitrogen can be applied in the spring. If they use the compost product in the autumn there is still capacity left for the nitrogen fertilizer in the springtime.

In most parts of the world, the importance of soil viability is well recognized. In addition, the environmental concerns of arable farming and of livestock farming are increasing. Therefore, it can be expected that after a number of these systems have been operated for some time under practical conditions, the good results will become the standard in many countries, probably supported by legislation. This represents an attractive opportunity for the fertilizer industry. Several pig farmers in the Netherlands have already expressed an interest in purchasing a system, and two fertilizer companies, a producer and a wholesaler, have expressed interest in obtaining, modifying and distributing the products from the pig farmers.

According to a rough estimate, the economics look attractive for the fertilzer industry. The cost of purchasing the NPKO from the farmer is low and subject to market forces. The transportation cost of the NPKO from various farmers to a central storage facility is similar to the transportation cost of the separate N, P and K fertilizer components. The cost of mineral modification is similar to the mixing of the normal N, P and K. But finally, the price of the NPKO product can be higher than the price of NPK, because it is a substantially better product with the addition of the organic fraction.

The question now is: what is the market potential in terms of product capacity? We believe that the market in Western Europe will be a replacement market; the presently supplied NPK will be partially replaced by NPKO. The total market will expand to a certain extent, but not dramatically. The replacement will specifically take place in areas with concentrated pig farming and arable farming at a certain distance. Specific areas include Denmark, parts of Finland, the Netherlands, Belgium, Brittany in France, Bavaria in Germany, the river Po delta in Italy, Catalonia in Spain, and parts of the United Kingdom.

The existing farming in Eastern Europe however will expand considerably over the next years as a consequence of increasing wealth. Most of the new farming activities will probably be based on NPKO. Typical areas are the whole Danube delta, from Austria to Romania, and parts of the Czech Republic and Poland. In these countries, people are very aware of the environmental problems and they want to operate under the same standards as in Western Europe.

Outside Europe, attractive markets are in Asia, where the wealth of people is growing rapidly, which stimulates the consumption rate. China, for example, has 1.5 billion inhabitants and 400 million pigs. The Netherlands has 15 million inhabitants and 14 million pigs, of which about 8 million are for national consumption. Thus, if China reaches the same consumption rate as the Netherlands, the number of pigs could rise from 400 million to 800 million.

The greatest potential future markets are arid areas in Asia, the Middle East countries and Africa. These are desert areas, and plans are already underway to explore these extensive areas for vegetable and animal food production. Some partially composted manure is already exported from Europe to the Middle East.

If the market forces of economics, environmental legislation and quality production all come into play, the potential opportunities for the fertilizer industry to obtain NPKO material from pig farmers, modify the mineral content to meet the specific requirements of the local arable farmers and sell the product to them are substantial indeed.

Addendum

1-Advantages of the system

This manure treatment system offers a complete solution for the growing problems of the excess pig and cattle manure in many parts of the world. This is evident from the following summary of the advantages of the system:

Ecology: • The emission of ammonia from the production buildings is reduced to less than 5%, most likely 2%.

• There is no ammonia emission when the produced compost is used on land as fertilzer.

• The NP-ratio of the compost is lower and better than that of the raw manure.

• The compost can easily be exported, thus limiting the (excess) minerals in the country.

Well-being: • The concentration of ammonia and other hazardous gases in the production building air is reduced to less than 10%, possibly to about 5%.

• The system allows for increasing the space available to the animals.

Health: • The outside air is not contaminated by dust and, as a consequence, not by viruses which adhere to dust particles, such as the swine plague virus.

• The manure is composted over a period of several weeks, at a temperature of about 60 °C, resulting in a compost that is free of pathogens, including the swine plague virus.

• There is no more transportation of the possibly contaminating raw manure.

Economy: • The system offers a certain outturn resulting from the valuable compost; in addition,

it offers some savings in the operating costs of the production facility.

• The total cost to the farmer is less than the cost of transportation of the maure to remote agricultural areas.

2–Introduction

Pig and cattle farming are being more and more intensified and concentrated in several designated regions in Europe and other parts of the world. The large production buildings in these areas produce a strong emission of ammonia (a cause of acid rain) and offensive odor. The atmosphere inside the production buildings is insalubrious for both farmers and animals: in addition to ammonia the air contains some Prussic acid, phenols and methane. There is not nearly enough agricultural land available on which to spread the huge amounts of manure, which in any case would result in intensive ammonia emissions, and transportation of the manure to remote agricultural areas is expensive (90% consists of water). In many cases an excess amount of manure is spread on land resulting, in addition to the ammonia emission, in nitrate concentrations in both ground and surface waters which are considerably higher than health standards permit. In addition, much of the excess manure runs off into surface water such as canals and rivers, causing extensive pollution and destroying many forms of aquatic life.

This situation poses an increasing ecological, economical and social problem in these areas and thoses downstream from them. A growing concern was the incentive for the deverlopment of this complete manure treatment system at the farm. It has no ecological drawbacks at all and operates at acceptable cost leverls. It converts the manure from a "waste material" into a valuable, fertilizing and emission free product, which is an economical stimulus for the farmers to operate the equipment properly. The features of the system and a description of it are presented in the following chapters.

3-Description of the system

The system as illustrated by the attached figure, is composed of a number of connected parts.

The floor of the production building consists of grids through which the produced manure falls into the cellar underneath. This manure cellar is (re)constructed in such a way that all parts can be flushed effectively.

The manure is periodically flushed from the manure cellar to a manure separation system and separated into a solid an a liquid fraction. The latter is then aerated in a buffer tank. The aeration causes a nitrification/denitrification process, by which a considerable part of the nitrogen in the ammonia and other compounds is removed as non-hazardous nitrogen gas, while the remaining nitrogen is present as nitrate or in an organically bound form. After the aeration the liquid is pumped back to manure cellar as a flushing liquid.

As a result of this flushing system, the concentration of ammonia and the other hazardous compounds in the production building is reduced by more than 90%. The excess liquid from the buffer tank is pumped to an evaporator. This is a scrubber type reactor which makes use of the ventilation air from the production buildings, and effectuates an intensive, counter current contact between the liquid and the ventilation air stream. As a result, the liquid is evaporated to a small volume, while at the same time the ammonia, offensive odor and dust particles which are still present in the ventilation air are absorbed by the liquid. As a result, the treated air from the production buildings, which is blown into the open air, contains only a small percentage of the usual concentration of ammonia and other hazardous compounds. Also bacteria and viruses, such as the swine plague virus, are removed because they adhere to dust particles, which are completely removed. The remaining small volume of liquid is pumped to the composting reactor and further dried.

The composting reactor treats the solid fraction of the manure. The composting process is carried out at about 60 °C over a period of three weeks. The final product has a dry matter content of 60-80% and it contains no ammonia. During the process the remaining small amount of liquid fraction is added and further dried. The final product contains all the phosphorus and potassium of the manure and a reduced amount of nitrogen. In addition, it contains stable organic matter, which is important for the soil fertility. This "fertilizing" compost is an excellent fertilizer with market value, and it causes no ammonia emission when spread on land.

4-Features of the system

- The system comprises a complete, ecological manure treatment at the farm.
- 1 m^3 of porker manure is converted into approximately 100 kg of compost with the same fertilizing value, that is to say, with the same amounts of phosphorus and potassium, but only 30-35% of the nitrogen, which is actually an advantage for agricultural use. The dry matter content can be controlled between 50% and 80%.
- In addition to the minerals the compost contains stable organic matter, which is important for maintaining an effective soil fertility.
- The compost has no odor. When used on land no emission of ammonia will occur, not even during rain, which will happen when spreading dried manure.
- The compost is free of pathogens and germinating seeds.
- Transportation and spreading on land are less expensive and much easier for compost than for untreated maure, because the compost is much lighter.

- The conversion of the manure into compost causes no emission.
- The production building becomes almost free of emission of ammonia and offensive odor, less than 5% of the usual values, probably less than 2%.
- No contamination of the open air occurs, including contamination with viruses, such as the swine plague virus.
- The production building air contains less than 10% of the usual concentration of hazardous gases, including ammonia, Prussic acid, phenols, methane, etc. This is a considerable improvement in the well-being of both people and animals inside the production building. This results in fewer illnesses and losses of animal life, and a better conversion of the feed (10%), thus constituting a substantial saving.
- The treatment converts the manure into just the compost, there is no remnant liquid.
- The compost lends itself well to being exported.
- The total cost of the treatment is similar to or lower than the costs that have to be made without this treatment.
- The value of the compost provides a stimulus to the farmer for operating the system a c curately.

Porker manure						
	kg	dry matter	N-tot	P2O5	К ₂ О	Organics
raw manure	1000	90	7.2	4.2	7.2	60
brine	70	20	1.5	1.1	5.1	8
compost from solid fraction	80	40	2.1	3.1	2.1	25
compost from solid fraction plus brine	100	55	3.6	4.2	7.2	30
Sow manure						
	kg	dry matter	N-tot	P ₂ O ₅	К ₂ О	Organics
raw manure	1000	55	4.2	3.0	4.2	35
brine	80	15	0.9	0.9	2.9	7
compost from solid fraction	60	25	1.3	2.1	1.3	15
compost from solid fraction plus brine	75	35	2.2	3.0	4.2	20

Composition of different manure fractions, expressed in kg



The Manuraway Flow Sheet

Magplane or "Beam Me Up, Scotty" Vaughn Astley

IMC Agrico







Linear Synchronous Motor Transportation

NCRICO

- Usual Proposals for High Speed Passengers
- Fast Travel
- No waiting
- Comfortable Ride
- Poor use of Track
- High Energy use for High Speed
- What if we move rock?

Fertilizer Round Table



















Eco	onomic	s	3,013,00 1910
 Distance (Miles) Tonnage (MM/Yr) Op Cost \$/T-M Capital \$MM Cap. Rec. \$/T-M Total Cost/T-Mile 	30) 10 0.02 60 0.04 0.065	10 3 0.05 16 0.11 0.16	3 2 0.17 6 0.22 0.39
Fer	tilizer Round Table		

Thursday, October 28, 1999

Session IV Moderator:

William L. Hall

Tour-IMC Agrico Facilities

New Wales, Milberry Florida

At 12:00 noon, on the invitation of IMC Agrico, the group left the hotel and traveled by bus to the location of the material transportation project (Magplane) site. After a demonstration of the equipment there, the tour proceeded to an IMC Agrico dragline site and then to the IMC Agrico plant at New Wales.

The Fertilizer Industry Round Table is most appreciative of the hospitality and effort of IMC Agrico (including their furnishing the buses and box lunches) and in particular of the attention given by Dr. Vaugh Astley and Bill Hall.

Friday, October 29, 1999

Session V Moderator:

Luc M. Maene

Slow Release Methodology

William L. Hall, Jr. IMC Global, Inc.



Fertilizer Industry Round Table October 29, 1999 William L. Hall Jr. IMC Global

Overview of Recent Developments

The Need

- New Products
 Regulatory Needs (Labeling and Enforcement)
- Environmental Concerns
- The Plan
- AAPFCO Slow Release Taskforce
 Methodology
- · Expression of the Data
- The Result
- Proposed Method
- Collaborative Study
 The Data
- The Data

The Need

- New Products PCU's
 - PCU's
 New UF's
 - New UP
 - MU's
 Bio-Solids
- Bio-Solid
- Inhibitors
 WSSA
- Environmental Concerns
- Fertilizer Efficiency
- Nutrient Management
- · Regulation of Non Point Source Additions

The Result

- Proposed Method
 - Developing a List of Goals
 - Many Years of Laboratory Evaluation
 Bags, Filters, Coffee Makers, Jacketed
 - Chromatography Columns • Effects of : Sample Size. Time, Temperature,
 - Solvent, Air, Agitation, Detection Methods • Evaluation, Duplication and Communication
 - Numerous Drafts. Comments and Revisions
 - Current Version- Draft #9 September, 1999

The Plan

- AAPFCO Slow Release Taskforce
- Formation Over Six Years Ago
 Methodology, Labeling . Enforcement. New Products
- Methodology
- Present Methodology Not Sufficient
- New AOAC Method, Approved and Collaborated
- Goals of the Method
- Soil Correlation Companion Method
- Expression of the Data

Consumer Friendly Yet Informative Allows for Regulatory Control



5. Fotal cumulative extraction time - 162 Hr.

The Result

- Collaborative Study
 - Protocol
 - Sample Selection
 - Enlisting and Evaluating Collaborating Labs
 - Statistical and Safety Reviews
 - Practice Samples
 - Unknown Sample Distribution
 - Data Collection
 - Statistical Evaluation
 - Protocol Presentation AOAC 9/99

The Result

- Collaborators BASF (Germany), Canada, N. Carolina, Kentucky, Illinois, Louisiana, Indiana, Pursell Ind., Scotts, IMC Global
- Practice Sample Overview Data on Eight Samples From 9 Labs
- What Was Learned From Running the Method • Procedural Information
 - Review of Comments
 - Equipment Setup and Description Enhancements
 - List Helpful Hints and Minor Modifications
 - AOAC Protocol Comments and Responses

The Result

- The Practice Data
 - Highlights the Need for a Data Expression Method
 - Proposed Expression Strategy
 - Labeling Issues
 - . Keeping the Goals in Mind
 - Consumer Understanding
 - Consistent Throughout All Labels
 - Ability to Regulate Claims Using a Standardized Format
 - Ability to Maintain Today's Claims
 - Able to Address Multiple Materials Within a Blend
 - . Review of the Data

Practice Sample Review

Targets and Expectations

- #1 PC Urea (Target 95% SR) 100 Day Material
- #2 UF+SCMAP+PCKNO3 (Target 80 to 95% SR-N-P-K) > Four Month Release
- #3 Biosolids (Target 90% SR) No Specified Release
- #4 SCU, Urea, DAP, SOP (Target 50 % SRN) Up To Three Month Release

LA	SC	PU	CFW	NC	KY	R	B
0	0	0	0	0	0	0	0
7.56	5.25	5.18	4.62	7.8	3.45	8.55	5.55
19.08	12.61	11.24	10.78	18.3	15.75	16.45	14.3
57.06	45.05	45.56	53.63	55.5	38.85	58.8	37.8
104.54	89.45	92.2	94.63	109.8	70.85	98.5	96.5


	LA	SC	PU	CFIA	KY	NC	FL	BASF
(0	0	0	18. jan 0	0	0	
14.47	10.96	12.11	13.94	17.75	13.15	15.1	10.34	14.5
25.32	18.55	21.5	27.13	25.85	24.75	29.8	20.44	22.50
41.47	29.2	35.99	43.9	42.8	40	49.65	38.92	35.8
53.24	38.38	52.62	60.71	58.7	55.3	66.8	52.22	44.2
UF	+SCN	1AP+1	PCKN	03 B	lend.			



0	0		A STREET WORKS AND THE	Call States	and the difference
	0	0	0	0	0
8.4	4.54	4.48	8.3	10.76	4.8
23.57	22.39	19.965	23.3	21.42	30.05
62.05	65.79	63.505	61.1	62.04	67.15
75.84	82.04	80.695	80.4	78.36	81.45
UF+SCI	MAP+PC	CKNO3 B	lend,		



L	LA	SC	PU	KY
0	0	0	0	0
9.84	0.89	0.45	0.6	0.45
14.03	5.17	2.74	6.6	4.1
23.96	20.22	13.92	17.7	16.8
40.77	40.62	32.51	40.3	39
UF SR Du	+SCMAP Target 80 ration Mat	+PCKNO3 -95%, > 4 terials	3 Blend, I Month	



BASF	LA	NC	PU	FL	L	CFIA	
支援	0	0	0	0	0	0	
	11.625	9.39	15.6	18.06	10.94	7.01	11.5
	17.035	22.08	22.45	29.66	34.38	21.64	18.4
	22.32	23		42.65	39.07	38.2	20.7
	25.45	25.28		49.88	46.88	54.32	28



LA	Tel S	SC F	V	R	CFIA	NC	KY	BASF
0	0	0	0	0	0	0	0	
52.87	54	53.72	53.32	54.69	50.85	45.6	53	51.3
68.67	68.75	75.39	67.79	68.98	62.5	64.95	68.95	66.0
89.08	78.04	84.1	82.87	81.63	74.8	77.25	84.95	78.6
96.07	81.23	84.95	87.16	93.87	80.3	82.6	88.35	82.6
96.07	81.23	84.95	87.16 S. I. I.r.	93.87	80.3 H D A	82.6 P	88.35	



LA	BAS	if pu	FL	KY	
0	0	0	0	0	0
78.95	80.35	83	78.8	80	80.25
92.13	90.34	93.4	93.1	87.6	90.4
97.18	95.07	99.79	95.5	95.3	97.05
97.18	95.31	99.79	98.8	96	97.4



Samj	ple #4 \$	SCU +	Solubl	e NPK	K
L	LA	SC	PU	BASF	KY
0	0	0	0	0	0
84.6	90.85	92.93	96.6	90.28	86.95
94	95.96	97.06	99.1	91.24	92.25
101.99	96.68	97.7	99.9	92.09	93.15
106.76	96.68	97.98	100.3	92.09	93.2
	No Sl	ow Re	lease K	-	



What Was Learned From The Data

- Detection Issues
- Data Groupings
- Good Inter Laboratory Agreement
- Can Distinguish Between Material Types
- Need For Efficient Means of Data Expression
- Need to Account for Three Factors
 - % Slow Release
 - Rate of Release
 - Overall Period of Release

Agronomic Comparison Method

Background

- Purpose to Correlate Lab Method Data to a Set of Controlled Biological System Variables
- Goals Develop a Method Containing Soil and Microbial Factors Not Possible With a Lab Method
- Obstacles NH₃ Volatilization, Death of Nitrifying Bacteria (high pH), Leaching of Nutrient from Soil

Proposed Rating/Labeling Plan

Three Numbers Relating To Three Attributes

- Percent of Product Classified as Enhanced Efficiency • % Slow Release In The Product
- Way To Rate The Release Rate or Efficiency • % Slow Release/Hours To Reach 100% Release
- Way to Rate The Longevity of the E. E.
 Hours/Days to Release 100% of Material
- How to Express These Attributes Effectively???

Summary

- We've Come a Long Way
- Labeling Issues to be Resolved
- Minds on Approach to Data Expression
- Correlation to Soil Methodology
- Acknowledgements
 - . Weldon Wallick & Dr. Gary L. Smith
 - The Collaborators

Evaluation of N Release From Slow-Release Materials

Jerry B. Sartain University of Florida

Introduction

Slow or controlled-release N sources have been marketed in the US since the 1950's. Laboratory methodologies to determine the total N content of these controlled-release N sources have long existed, but methods to evaluate the timed release of these materials have not.

Currently, the controlled-release portion of a material is evaluated by either a leaching or dissolution test. However, these tests do not determine the rate of release of N or the quantity that will be released in a specified period of time. In order to label a controlled-release material properly one needs to be able to specify the quantity of nutrient that will be released in a given period of time. In response to a request from the American Association of Plant Control Officials, we began a study in 1996 to develop methodology which could be used in conjunction with laboratory analysis procedures to evaluate and label controlled-release N sources. A recounting of the successes and failures in the development of a N release rate incubation procedure for controlled-release N sources follows.

Initial Design

In late 1996, Bill Hall, Don Waddington, Wilbur Frye and myself designed an incubation procedure to evaluate controlled-release N sources. Not knowing which variables would most impact the incubation process we included a number of variables, such as controlled-release N source, N application rate, soil inoculant source, mixing methodology, and sampling time. It turned out that this was an overly ambitious project. There were simply too many variables to evaluate and a number of unanticipated problems with the methodology were discovered. The initial study involved the evaluation of urea, ammonium nitrate, ammonium sulfate, sulfur-coated urea, nitroform, IBDU, polyon and milorganite mixed with 250 g of incubation media at 125 and 250 mg N. These materials were either mixed or placed on the surface of the incubation media. The incubation media was composed of 245 g of a mixture of 85% sand and 15% organic matter and 5 grams of soil from either California, Kentucky, Pennsylvania or Florida. Incubation media containing the desired N source and N rate was moistened to approximately field capacity and placed in a plastic bag. These were incubated at room temperature for 7, 14, 28, 56 or 112 days. Triplicate samples were used. After the desired incubation period, the soil was removed from the bags, placed in specially designed funnels and leaching with 200 ml of DI water under vacuum. The leachate was analyzed for nitrate and ammonium nitrogen. When the bags were first opened a strong odor of ammonia was observed from some bags. Additionally, leachate color varied according to N source. Recovery of N was very poor even for the soluble N sources.

This was very disappointing since such a large number of experimental units had been prepared.

Based on the poor recovery of N from the first three incubation periods, 7, 14 and 28 days, the study was terminated. A much smaller scale investigative study was designed.

Investigative Study

It was believed that the poor N recovery was due to the volatilization of N as ammonia because of the strong smell of ammonia coming from some of the incubation bags, thus an ammonia trap was placed in the incubation chamber. In this phase of the methodology development, the plastic incubation bags were replaced with incubation jars and a beaker containing 20 ml of 0.2M sulfuric acid was placed in the jar as an ammonia trap. The beakers were replaced every 14 days and titrated with base to determine the quantity of N lost through volatilization. In an attempt to reduce the number of samples during this investigative study, only the Florida soil was used as an inoculant. These soils were leached with three 100ml volumes of DI water to determine if all of the N was being leached. Very little to no N was detected in the third leachate; therefore we were confident that our leaching procedure was adequate. However, after accounting for the evolved N only approximately 60 to 80% of the applied N was recovered from the soluble N sources. Obviously, the methodology was still inadequate for determining the N release from controlled-release N sources. A relatively large portion of the applied N was still going undetected. The only plausible explanation for the poor N recovery from the soluble N sources was that it was being fixed in some manner which inhibited its leaching. Organic matter been shown to fix applied ammonium nitrogen and render it unavailable to plants. Thus, a media containing 245 g of sand and 5 g of Florida soil was employed.

Media Study

This study involved the use of ammonium nitrate, ammonium sulfate, urea, sulfur-coated urea, nitroform, IBDU and milorganite applied at 250 mg N. These materials were mixed with a media containing 245 g sand and 5 g of an Arredondo fine sand, moistened to 12% moisture and incubated at room temperature for 7, 14, 28, 56 and 112 days. A beaker containing 20 ml of 0.2 M sulfuric acid was placed in the incubation jar for ammonia entrapment. The beakers were removed and titrated with 0.2M sodium hydroxide every 14 days. After the desired incubation period the soil was leached under vacuum with 300 ml of DI water. Ammonium and nitrate nitrogen were determined on the leachates using a rapid flow N analyzer. At the 7 day sampling in excess of 90% of the N was recovered from the soluble N sources. Much smaller amounts of N were recovered from the different slow-release N sources at the 7 day sampling, but over time the quantity of N recovered increased in relation to the N release from the materials that is typically seen in field evaluations.

Conclusions

Following a few disappointing experiences it appears that a laboratory incubation method for determining the N release rate from controlled-release N sources is close to development. With a few more refinements in the procedure it should correlate well with in-field responses of the materials. In the next phase, the incubation N release rate of these controlled-release N sources should be correlated with the rapid laboratory analysis procedures being developed. Once this is achieved controlled-release N materials can be labeled based on established timed release criteria.

Who Is Tetra Micronutrients?

Charlie Chandler **Tetra Micronutrients**



TETRA Technologies, Inc.



TETRA is a specialty inorganic chemical company developing innovative products, services and process technologies for Oil & Gas, Agriculture and Environmental industries.













































Fertilizers Are Safe Daniel Woltering The Weinberg Group

Fertilizers Are Safe

The Fertilizer Industry Round Table Lake Buena Vista, Florida October 27-29, 1999

> Dan Woltering, Ph.D. on behalf of The Fertilizer Institute



Presentation Outline

- Accomplished since Annapolis (1998)
- Actions being taken as a result of the risk evaluations
- The Fertilizer Institute's plans going forward

Accomplished Since Annapolis

- TWG / TFI. Dec. 1998. Industry and Literature Survey of Nutritive and Non-nutritive Elements in Inorganic Fertilizer Materials
- Battelle / EPA. Jan. 1999. Background Report on Fertilizer Use, Contaminants and Regulation
- TWG / TFI. Feb. 1999. Health Risk Based Concentrations for Fertilizer Products and Fertilizer Applicators



Since Annapolis (con't)

- TWG / TFI. Feb. 1999. ... Applicator Health Risk Evaluation: RBCs Compared to Measured Levels of Non-nutritive Elements in Products
- EPA. Aug. 1999. Estimating Risk from Contaminants Contained in Agricultural Fertilizers
- TWG / TFI. Sept. 1999. RBCs for 9 non-nutritive elements in fertilizers (farm family receptors)
- Product monitoring data (states)
- CDFA. Mar. 1998. Development of RBCs for Arsenic, Cadmium and Lead in Inorganic Commercial Fertilizers



© ©

5

TFI Risk Assessment Strategy



Industry and Literature Survey - TFI

- TFI member companies provided data for up to 26 elements in 15 fertilizer materials (e.g., ppm Cd in 600 samples of phosphate)
- Literature search for same elements and materials (e.g., Cd in 180 samples of P)
- Provides average and maximum element concentrations for major N, P, K materials; these values used in exposure estimates



Fertilizer Use, Contaminants and Regulation - Battelle

 Provided fertilizer application rates, nonnutrient element concentrations, and other data that EPA used in its 1999 fertilizer risk assessment



Health Risk Based Concentrations for Fertilizer Applicators - TFI

- Safe exposure levels of As, Cd, Hg and Pb were established for applicators including farmers and lawn care professionals
- Evaluated cancer and non-cancer health effects and life-time exposures
- RBCs are screening-level values using conservative (high end) exposure estimates

© ©

10

11

Applicator Health Risk Evaluation - TFI

- Screening RBCs were compared to element concentrations in phosphate and micronutrient fertilizers
- Industry and literature concentrations plus up to 260 phosphate samples and 190 micronutrient samples in States' database
- <u>Conclusion</u> non-nutritive elements are not a health concern for applicators
 - no exceedences for P; only 2 iron micronutrient samples exceeded the As RBC by >2X

Estimating Risk from Contaminants Contained in Agricultural Fertilizers

- EPA evaluated 9 metals in ~190 NPK and P and ~70 micro-nutr. samples in 13 products
- Conservative estimates of cancer and noncancer health risks from:
- fertilizer ingestion / inhalation during application; farm family incidental soil and food ingestion (p/a)
- Screening level ecological assessment based on runoff into streams and comparison to Water Quality Criteria



EPA Risk Assessment (con't)

- <u>Conclusion</u> "hazardous constituents in fertilizers generally do not pose harm to human health or the environment"
- Exceedences for farm family indicated for As in1 liming agent sample, and in each of 1 iron, 1 boron and 1 zinc sample
- No risks from Cd, Cr, Cu, Hg, Ni, Pb, V, Zn and none for applicator exposures



TWG/TFI Health RBCs for Fertilizers

- Established risk-based safe concentrations for 9 metals in phosphate and micros
- Conservative estimates of cancer and noncancer health risks to farm families from:
 - incidental soil ingestion, skin contact with soil, and food ingestion (roots, grains, vegies)
- Comparison of screening RBCs to metal concentrations in ~1000 P and ~200 micro. samples show large margins of safety (a few micronutrient exceedences)



12

CDFA RBCs for Fertilizers

- Established risk-based safe concentrations for As, Cd and Pb in phosphate and micros
- Conservative estimates of cancer and noncancer health risks to farm families
- Pre-screened metals, receptors and exposure pathways to focus on greatest risk
- California conditions and risk methodology
- No comparison to product concentrations
- Rigorous peer review

13

14

Actions Being Taken as a Result of the Risk Evaluations

- Appears EPA will not initiate a broader regulatory program for fertilizers
- EPA will use its rulemaking authority to address hazardous waste derived fertilizers
- CDFA proposes to modify regulation adding risk-based numerical standards for As, Cd, Pb in phosphate and micronutrient products

Overall Conclusion of Risk Analyses

Fertilizers Are Safe

- EPA, Cal., industry come to same conclusion
- Applicators and the public are not at risk
- Macronutrient fertilizers and 99+% of micronutrient products pass the conservatively derived screening-level "safe estimates"
- The few samples that are outliers, e.g., where As was particularly high in an iron product, should be evaluated case by case

Actions Being Taken (con't)

16

- Monitoring of products in some states (e.g., as part of registration in WA)
- AAPFCO has proposed interim standards for 9 metals per Canadian limits (not risk based), and has agreed to consider the CDFA, EPA and TFI risk assessment results

• ||

Overall Conclusions (con't)

Fertilizers Are Safe (con't)

- A need for numerical standards is not justified based on the risk analyses
- For 15 years, risk assessment is the most widely used and accepted practice in the US for setting health and environment protective standards
- Margins of safety are large
- No expectation that levels of metals in source materials will change significantly



TFI'S Plans Going Forward

- Complete the 'farm family' risk assessment and make the report available (publish)
 - add Cr, Cu, Va, Ra
 - address additional non-nutritive elements by relative toxicity and concentration in products
- Discuss results with the coordinating group and with other stakeholders (e.g., AAPFCO)
- Complete monitoring program at NCSU
- Continue with product testing program



Precision Farming John Dantinne Ventures, L.L.C.

I felt before coming, this would be a difficult speech to give. I was asked to discuss production agriculture technologies to engineers, who for all intents are arm's length away from such issues. To complicate matters, I was specifically to focus on so called "Precision Ag" and the associated technologies. As I explained to those left in the seats, I had no intention of talking about Precision Ag, at least if defined as infield management or more commonly known as Variable Rate Technology (VRT).

However, I believe myself to be an optimistic individual, which ultimately is the theme of this talk. And I believe now is the time for this industry to look for opportunities. Even within this economic environment that agriculture finds itself facing, optimistic opportunities exist.

It is no secret that the face of agriculture will change. Even you left in this room will be impacted. Let me give you one small example related directly at you. Recently, I learned that the price of 32% N solution was selling for \$70/ton. If you factor in any CPI you choose, this price is the lowest in 30 years. These are your clients, Nitrogen manufacturers, and their profits directly relate to orders for your job.

But let me give you more broad based reasons to indicate that this economic change is inevitable.

- Economically, macro economics has new meaning. The world is the macroeconomic field today as opposed to a national field of the past. Currency devaluation's, unstable governments, rising land development in developing nations and many other economic factors will have significant impact on world wide agriculture.
- Politically, the Nafta & Gatt trade agreements, Freedom to Farm in the U.S and the long term lessening of price supports(even in the ECC) will have long term and significant impact on the profitability of production agriculture, which we all live off of.

- Weather and climatic instability exists and will continue to influence all section of the globe. I'm not talking of the greenhouse effect, but the continued predictable unpredictability of weather patterns.
- Technological impacts such as the Bio-industry, Internet and other information technologies. Although the Bio-industry is experiencing current difficulty, the potential influence looms and this doubt is in itself challenging the economics of agriculture.

The important fact is this, none of these influences are going away any time soon. In fact, because they are not directly related or a driven by the agriculture economy itself, they will be become even more significant. They may not have equal and/or enduring impact, but all will or are increasing the risk of production agriculture and those associated with this industries profitability.

However, I'm not here to discuss up and down the system implications. But to be specific to production agriculture itself, the grower level. After all, the grower pays all of our paychecks. There is so much change occurring at this level, that just the speed of change adds risks. Last night I heard talk of the North Carolina tobacco grower losing markets to lower tobacco sales and the shear change to the N.C. culture and economy would be staggering; the 50 % decline in Cotton acres grown in the Delta south and what options exist for these growers and the 400 lbs. N applied to a field and is this a risk worth other producers to make. The bottom line, with change occurring so fast, growers world wide can't afford to make mistakes.

So what is there to be optimistic or opportunistic about. Whenever there is threats or challenges there are always opportunities. The opportunity is to lower risk. Lower the crop management risk by informing growers as to there options, probable response and alternatives. The key is to utilize yield monitors and result driven analysis. The opportunities are the ability to measure the yield (yield monitor technology) and information technologies aimed for cause and affect, result driven. What works and what doesn't.

How?

1st, what I call the Nth Response and 2nd to reduce the opportunities lost. This is the difference between Precision Agriculture and Decision Agriculture. Where will it pay to apply 400 lbs of N as opposed to can I measure and deliver specific amounts.

As already stated, speed of decision is crucial. The economic changes at hand will not afford growers the same time as in the past to try and experience. What they need is a method to ascertain quickly if a management practice they implement will work all the time, or the Nth time they utilize or implement that practice. That can only be achieved by large numbers which enhance the statistics. Or stated differently, large data sets add confidence in analysis which lowers the risk.

The second risk to reduce is "lost" opportunities. Something that could have been chosen, but was not is a "lost" opportunity. Growers do not have the ability to try everything. The flow of new options will be staggering, escalating each year. It will be even more important to isolate the better opportunities quickly. The ag-economy of the future will be more competitive and mistakes will be less forgiving. Choosing the best practices will be imperative.

The opportunity for production agriculture is to produce smarter. The more you learn, the more you earn is a true statement. Lower a grower's risk by supplying knowledge. Those that help reduce the growers risk through information management will gain. Therefore, the opportunity at hand is Decision Agriculture, not Precision Agriculture and those that embrace this concept, both grower and supplier, will prosper.

THE FERTILIZER INDUSTRY ROUND TABLE

1914 Baldwin Mill Road Forest Hill, Maryland 21050 U.S.A. E-Mail:silbersack@erols.com TEL: (410) 557-8026

FAX : (410) 557-8026

FINANCIAL STATEMENT OCTOBER 26,1998 TO OCTOBER 27,1999

Cash Balance October 26, 1998		\$65,532.31
Income October 26, 1998 to October 27. 1999		
Registration Fees - 1998 Meeting & Cocktail		
Party & Coffee Break Receipts	\$ 9,834.28	
Sale of Proceedings	1,017.31	
Registration Fees - 1999 Meeting & Cocktail		
Party & Coffee Break Receipts	22,317.07	
Total Receipts October 26, 1998 to October 27, 199	99	<u>33,168.66</u>
Total Funds Available October 26, 1998 to Oct	toher 27 1999	
		\$98,700.97
Disbursements October 26, 1998 to October 27, 1999	9	
1998 Meeting Expenses (Incl. Cocktail Party)	\$ 18,107.36	
Misc. Expenses Incl. Postage, Stationery, Internet, e	etc. 1,434.75	
1998 Proceedings	7,493.49	
1999 Meeting Preliminary Expense	508.74	
2000 Meeting Preliminary Expense	1,000.00	
Directors Meetings	2,623.32	
Secretarial Contract Expense	7,500.00	
Petty Cash	<u>85.98</u>	
Total Disbursements October 26, 1998 to October 2	27, 1999	
		<u>\$38,753.64</u>
Cash Balance October 27, 1999		\$50 047 22
		\$39,947.33
Respe	ctfully submitted,	
Paul J.	. Prosser, Jr.	

Secretary\Treasurer

Meeting Attendance: 127