Managing the Development of Specialty Fertilizers From Inception to Commercialization

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Specialty fertilizers are becoming increasingly important in today's market. Requests for unique release properties, special formulations involving secondary and micro-nutrients and herbicides, special sizes and bulk weights and the use of waste and special raw materials have created a need for new research and development of innovative fertilizer products.

New fertilizer projects encompass almost every facet of a company's organization and can extend over a period of years. Some projects are highly successful. Some projects are not immediately successful, but turn out to be very successful in the long run. And some projects are abandoned or unsuccessful for many different reasons. Sometimes the passage of time kills a golden opportunity or allows another firing to be successful with a similar technology. This paper is based on the experiences of Applied Chemical Technology in the development of specialty fertilizers and the management methods we have used to bring these projects to successful, profitable conclusions. We hope you can benefit from the methods and experience we have to offer. Because of the confidentiality of all our work, we will not give specific examples, but rather include only of ACT in-house activities.

Usually management of a specialty fertilizer project is shared by many people in an organization. The experience at ACT has been that those projects are most successful where one person has overall responsibility for the project's ultimate success, or determines at what point the project should be abandoned. It is essential; however, that the individual not become preoccupied with immediate problems to the exclusion of the project's total progress and original or revised goals.

All new specialty fertilizers go through five primary development phases before they are fully commercialized.

- Conception
- Product Development
- Process Development
- Plant Construction or Alteration
- Production

These can be broken down into the sub phases which we will briefly address in this paper.

The conception phase starts with Project Inception. Fertilizer projects start with the recognition of possible economic opportunity, such as an expanding market which needs to be addressed, a niche market recognition, the realization of a company problem, or the business moves of a competitor. The inception takes place when the above is recognized and the look for a product or process begins. Ideas must be formulated to take advantage of the opportunity. This can be done in-house or with the assistance of a company like Applied Chemical Technology, Inc.

For the best results the developer must constantly be open to consideration of all ideas. This allows combining ideas to form the best solution.

From inception, the project moves to Incubation. Unless the project is the idea of the CEO or equal, all project ideas go through an incubation phase where at best the idea's merits are discussed and left to simmer and often forgotten unless the project has a champion, one who is dedicated to the project concept. A lot of time is lost in this phase and many good projects vanish completely.

Once a project is perceived to be valid, Project Goals must be developed. If properly handled, this phase can provide an excellent foundation on which to build the fertilizer project.

The goals of the project must be clearly defined and should encompass as much information about the project concept as possible, including the following:

- Estimated market potential
- Desired characteristics
- Estimated production needs
- Range of acceptable production costs
- Timing requirements
- Budget limitations
- Project priority
- Special considerations

Many projects have been severely hindered or even abandoned because the above areas were not properly addressed when project goals were laid out.

We now move into the active product development phase. A specialty fertilizer product must be developed to fulfill the goals.

Within the project guidelines, when possible, a list of possible fertilizers and variations of them should be made. Ideas beget ideas, and at this stage it is important to have more than one idea with which to experiment.

With some ideas in hand, the project can proceed to Exploratory Laboratory Work. It is important to take the more promising of the above ideas and work with them to assess their potential.

Lab work should be rough at first – looking at possibilities while relying on experience and literature to aid the work. A lot of money and especially time can be lost here by developing too much detail and/or investigating things which are too tangent from the main thrust to be important.

Early on, losing sight of the true goals can be a real problem because of the high influx of ideas. Daily review of work with others is important to keep the proper goals in focus.

Close contact with an engineer who knows large processing equipment and unit operations is important even in this early state to advise the primary developer on what is practical.

Where possible, the potential fertilizer products should be tested. At this point samples of the laboratory produced product should be greenhouse tested in a quick manner to see which of the products seem to have merit. Results should be fed back to the developers immediately. The developers should continue with variations of the product even while tests are being done, and laboratory testing on these products should be done.

We are now entering the Process Development Phase. As an acceptable fertilizer begins to become apparent, more detailed lab work should be done to develop it into the desired end product. Process feasibility and production cost even though vague, must continually be considered. Once the original criteria has been met and a product has been made in the laboratory, the project should also proceed to the conceptual design phase in a concurrent manner, as this will help guide this phase of the lab work.

The conceptual process should be made based on laboratory work, and a conceptual full-scale plant should be roughly designed to see if the process is feasible. The design should include the plant equipment and a rough plant layout. The developers must consider laboratory methods by which the product has been produced and mesh them with methods viable in a full-scale plant. Again, it is important not to become bogged down in details.

The project manager must be sure that the developers have the experience level with processing plants and the strong positive attitude necessary for developing a good processing technology.

The project should not proceed beyond this phase until a feasible and scalable process has been conceptualized. One of the surest ways to kill a project is to build a pilot plant using processing techniques which obviously cannot be scaled up to a full-scale facility. It is also very important to have greenhouse data which indicates a desirable product has been made.

If the full-scale plant capital and production cost estimates look reasonable, the project should continue through conceptual design of the pilot plants and estimation of their costs. These plants should be designed by scaling down the full-scale conceptual plant as well as scaling-up the laboratory work. Cost estimates should include the cost of pilot plant operation.

A full review of the project should occur at this point to determine if the original project goals are still valid and if they are being met by development efforts. Further, it is important to determine the chance of success for the project and decide whether to continue.

Following conceptual design completion, it will probably become obvious that at least some minor concepts need alterations to improve the fertilizer and the projected product costs, or to avoid processing problems, thus the laboratory efforts moves in the product and process refinement phase. This can be done concurrently with management evaluation of the project and should continue throughout the pilot plant work as needed. Proper use of the laboratory will reduce pilot plant work, minimizing time and money required to complete the project.

Specific Concept Investigation is important even before trying to run an entire pilot plant. It is usually cost effective to test one or two areas of processing uncertainty to become familiar with their problems and determine solutions before attempting to do all functions at once in a continuous pilot plant even if it is small.

Small Pilot Plant

The primary purposes of a small pilot plant are to determine whether the process is in fact feasible and to provide fertilizer for extensive testing. Even the best engineers and chemists do not anticipate all of the processing problems and their solutions, and it is important to build these pilot plants so that they are easy to change and so that the developers will not be reluctant to do so. Wood, plastic, thin gauge carbon steel and even cardboard should be used if suitable. A low cost plant enhances the willingness to make quick changes, even during a test run. Obviously, some reactions, chemicals, etc. take high alloy and/or pressure rated equipment and the high cost cannot be avoided. Nor, in any case, should safety ever be compromised in the quest for lower cost.

A small pilot plant should not be used to optimize conditions; however, it should solve major processing problems and provide adequate data to design the large pilot plant.

As soon as a fertilizer is available from the small pilot plant, full-scale evaluation of its properties should begin.

The process and full-scale plant design should be reviewed and revised based on the small pilot plant operation. New scale-up problems may become apparent and the plant design may have to be revised.

Both the full-scale plant and its production cost, and the large pilot plant must be re-estimated in light of the findings of the small pilot plant.

The project must again undergo detail management review to see if it should be continued. Before progressing to the large pilot plant, a high likelihood of project success should be evident.

Large Scale Pilot Plant

The large scale pilot plant is truly a small plant, but once again built for change and to test how various process functions scale-up. A large pilot plant should mirror every function of a full-scale plant. The rule of thumb for most processes is that the full-scale plant should not be scaled-up more than 10 times larger than the large pilot plant. This determines the size of the pilot plant.

Large scale pilot plants can be expensive to build and run, or they can be built very reasonably and run judiciously. The plant costs depend on several factors:

- What is the size?
- What is the life expectancy of the plant?
- Will it be used for production while the full-scale plant is being built?
- Where will it be located?
- Can existing equipment or facilities be used?
- How experienced are the builders at low cost pilot plant construction techniques?

Initially, the large pilot plant will likely be used to prove the process and find operational and quality control problems.

The plant should be run for short durations until the obvious problems are corrected. The pilot plant should then be used to optimize the process and reduce the full-scale plant capital and production costs. Data gathering to provide scale-up information for the full-scale plant is very important in this stage. When all obvious problems have been corrected, the pilot plant must be run continuously for an extended period, usually between 24 to 72 hours, to find any major long-term problems such as concentration of impurities or solids build-ups.

Large pilot plant test runs allow production of sizeable amounts of fertilizer for product testing and test marketing.

Proper management of a large pilot plant is essential as cost can quickly get out of hand.

Following the successful operation of a large pilot plant the plant design should be revised again, major components sized, and a plant layout determined. The production cost sheet should also be revised. At this point an excellent forecast of the process and plant feasibility and costs should be in hand.

The project should again receive a detail management review. The production feasibility should be assured at this point. Economics of the venture, the sales prospects for the fertilizer, availability of new venture capital and project timing should be the main concern of the reviewers if the development work has been done correctly.

It is sometimes advisable to use the large pilot plant to generate fertilizer for market development before or during full-scale plant construction.

The project now enters the plant construction phase. The revised conceptual design is the basis from which the production plant will be designed. Design engineers should be kept abreast of the project as it moves through the development phase so they will be fully familiar with the problems and their solutions. This will reduce timing and design cost.

The plant fabrication and erection cost are also reduced by encouraging the participation of design engineers throughout the development phase. Often, they can suggest and assist in the design of custom equipment capable of performing more than one function at a time. Such equipment can significantly reduce plant building cost as well as the cost of ductwork, piping, chutes, etc. Constant participation by the design team allows their ideas and equipment to be tested early on in the pilot plant phases.

Production is on-going throughout the life of a product, but plant start-up is part of the development project, in fact the plant start-up is the final exam for the project. The most important points in a good start-up are knowledge of the plant and process and attention to details.

The best start-ups are usually those where this knowledge resides on-site with the person in charge of the start-up as well as supporting engineers and chemists. With good continuity in project leadership and a good development effort, the start-up will be successful, providing a fertilizer which is both effective and profitable.