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ECONOMIC FEASIBILITY OF PHOSPHINE RECIRCULATION SYSTEMS IN SEALED SILOS AT US GRAIN ELEVATORS

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ABSTRACT

A gas recirculation, or closed loop fumigation (CLF), system for phosphine (PH_3) fumigation using a low volume blower/piping system per tank was patented by James Cook of Houston, TX, in 1980. In 1991, two large grain storage tanks (2,000–10,000 t/tank) were manifolded to one blower in order to make CLF more effective. Research on the manifolded PH_3 recirculation (MPR) system design concept was expanded in 1995, through an EPA grant, to include concrete silos. In an effort to make concrete CLF systems as cost effective as those for 2,000–10,000-t steel tanks, MPR designs for three to seventeen silos manifolded to a single blower (forming a 1,500 to 8,000-t fumigation unit) were developed in 1995.

Economic data in cost/unit volume for sealing, plumbing and blower equipment vs. fumigated storage volume for five concrete silo installations are compared to those for representative steel tank MPR systems. Installation and operating costs for representative steel tank MPR systems are reviewed.

BACKGROUND

"Closed Loop Fumigation" (CLF) was originally known as a recirculation process developed for methyl bromide (MB) fumigation in the US and other major grain producing areas. Reports cite recirculation of MB as early as the 1920's. James S. Cook of Houston, Texas, developed the J-SYSTEM®, a low airflow fumigation recirculation process, for use with phosphine (PH_3). Cook received US Patent No. 4,200,657 on this process on April 29, 1980.

The CLF system was designed to improve fumigant distribution and to reduce both worker exposure and the incidence of fumigation failure. It involves the use of a simple, low pressure, low volume centrifugal blower which draws the fumigant/air mixture from the head space of a sealed structure and pushes the gas into the base of the structure, forcing it to flow upward through the grain and back to the head space in a closed loop cycle.

FUMIGATION SAVINGS

CLF systems minimize worker exposure to fumigants. They also increase fumigation efficacy through better gas distribution. The most measurable economic benefits of MPR systems are that they use lower amounts of fumigant and also reduce labor and grain turning expenses.

The most common method of fumigating grain stored in concrete silos is by distributing PH_3 pellets into the grain with automatic pellet dispensers while the grain is being turned (moved from one silo to another). However, unless there are other sound management reasons for turning the grain, the extra electricity needed to turn grain, the additional shrink (0.25–0.50% per turning cycle) and the labor to monitor turning must all be considered as part of the fumigation costs.

DEMONSTRATION PROJECT

In the fall of 1995, Oklahoma State University initiated a demonstrational project focused on PH_3 recirculation systems. In this project, 17 recirculation systems were installed in participating country elevators for use during the 1996 grain handling season. Five of these demonstrational units involved the installation of MPR systems in units of sealed concrete silos. Oklahoma State University supplied almost all of the MPR piping systems, including blowers, for all cooperating elevators. Each elevator manager was responsible for the construction/wiring costs of installing the system. The size (total amount of manifolded silo space) of the MPR systems ranged from 1,590 to 7,950 t. Based on actual material cost and projected installation cost, the total installation cost, projected to range from US$1,481 to US$1,895, averaged US$1,768.

The MPR system represents the first practical system for fumigating concrete grain silos without turning the grain. Elimination of grain turning can generate substantial savings in fumigation expense. The use of MPR systems also allows managers to reduce the amount of PH_3 used while still obtaining results equal to, or better than, those with conventional methods.

This continuous recirculation, which distributes the gas more uniformly throughout the grain mass, generally allows PH_3 use to be reduced by 25% or more. A summary of the potential cost savings of MPR systems is shown in Table 1.

CONSTRUCTION COSTS

Construction costs of the five representative concrete silo MPR systems are summarized in Table 2. These installations involve manifolding 3–17 concrete silos together to form 1,590- to 7,950-t sealed fumigation units. These systems used 0.5–1.5 HP low-volume centrifugal blowers to recirculate the gas from the headspace of one silo into the base of each silo. All outside vents and silo openings were sealed while the existing inter-silo vents were maintained, except where MPR fumigated silos were intermixed with non-fumigated silos. In that case, both exterior and interior vents on the fumigated silos

TABLE 1
Cost reductions obtained by using Manifolded Phosphine Recirculation (MPR) versus automatic dispenser and turning (conventional)

Component	System	
	Conventional (US$/t)	MPR (US$/t)
Labor (sealing)	0.0755	0.0755
Labor (turning)	0.0377	–
Fumigant[1]	0.1877	0.1405
Supplies and overhead	0.1132	0.1132
Fumigation cost	0.4152	0.3303
Grain turning electricity[2]	0.1510	–
Grain turning shrink	0.2831	–
Total cost, fumigation and turning	0.8492	0.3303
Projected savings		0.5190

[1]Based on a 25% reduction in the amount of phosphine needed for the MPR system.
[2]Electricity for operation of the MPR is ignored since it is projected at less than US¢0.01/t.

TABLE 2
Average installation costs of MPR systems in Oklahoma country elevators[1]

Component	Cost (US$)
Blowers (1 HP each)	594
Ducting materials (PVC pipe)	392
Hardware	184
Installation labor	598
Misc. hardware (rubber boots, bolts, screws, etc.)	428
Total installation costs	1,768
Total installation cost per t	0.396

[1]Does not include a minor amount of elevator personnel labor.

were sealed. The inter-silo vents allowed a group of silos to function as a single large fumigation unit, substantially reducing the CLF system cost per t. As the table indicates, the total installation cost was US$1,768, or approximately US$0.40 per t. The range of construction costs for the three separated MPR silos was projected as US$0.23 to US$0.91 per t.

ECONOMIC ANALYSIS

The most important aspect of any new technology is how the adoption of the technology will affect a grain-handling firm's profitability. Three common measures of the attractiveness of an investment are the payback period (PP), the net present value (NPV) and the internal rate of return (IRR).

The PP measures the time required for the savings in annual fumigation costs to equal the original cost, without regard to either any interest costs or any alternative uses of the investment funds. The PP indicates how long it will take to recover the invested funds, but it does not measure overall profitability.

The NPV reflects net savings over the life of the project. These savings balance the installation cost against savings over the 20-year life of the system and include an inferred interest charge on the original cost. Since NPV measures the total net savings over the life of the system, a positive NPV means the CLF system should be an attractive investment.

The IRR measures the financial return, just as the interest rate measures the return on funds in a bank account. The IRR converts the annual savings in fumigation costs into a rate of return on the original investment. As long as an elevator manager can borrow funds at a lower rate than the IRR on the fumigation system, the MPR is a good investment. Results of the investment analysis for the MPR system are summarized in Table 3. The comparative measures in tonnes for a PH_3 recirculation system in a steel grain bin are provided for comparison.

TABLE 3
Summary of costs and benefits of closed loop fumigation systems

Component	Probe and tarp in corrugated steel bin (5,300 t)	MPR systems (5,700 t)	
		Ignoring grain turning savings	One grain turning eliminated
Total construction cost (US$)	1,358	1,768	1,768
Construction costs per t (US$)	0.2563	0.3099	0.3099
Cost reduction per t (US$)	0.0566	0.0566	0.0566
Payback period (years)	4.5	5.5	0.6
Net present value at 8% interest (US$/t)	0.30	0.2460	4.79
Net present value at 8% interest (US$/t) over 20-year life	1,587	1,404	27,310
Internal Rate of Return (%)	21.65	17.55	167.48

As Table 3 indicates, the MPR system provides an investment return similar to that of conventional recirculation systems installed in steel bins. A grain elevator manager can expect to recover the costs of a MPR system in less than 6 years, even if grain turning cannot be completely eliminated. The present value of the MPR investment to the elevator (net expenses of US$1,403) is equivalent to a 17.6% return on investment. Firms which turn grain from one silo to another for the sole purpose of fumigation can reap an exceptionally high return on their investment in MPR technology. When a grain turning can be eliminated, the MPR system should more than pay for itself in a single fumigation.

CONCLUSIONS

Manifolded Phosphine Recirculation systems represent an improved technology for fumigating grain stored in sealed concrete silos. The initial results from the six demonstration projects in grain elevators located in Oklahoma in the USA indicate that MPR systems will allow managers to reduce the amount of PH_3 used by 25% without any loss in effectiveness. The MPR technology can be installed for a modest investment (approximately US$0.30/t). Analysis indicates that the MPR technology is thus an attractive investment. In situations where MPR systems can completely eliminate grain turning, managers can pay for a MPR system in under 1 year.

REFERENCE

Cook, J.S. (1980) US Patent No. 4,200,657. US Patent Office, Washington, DC, 29 April 1980.