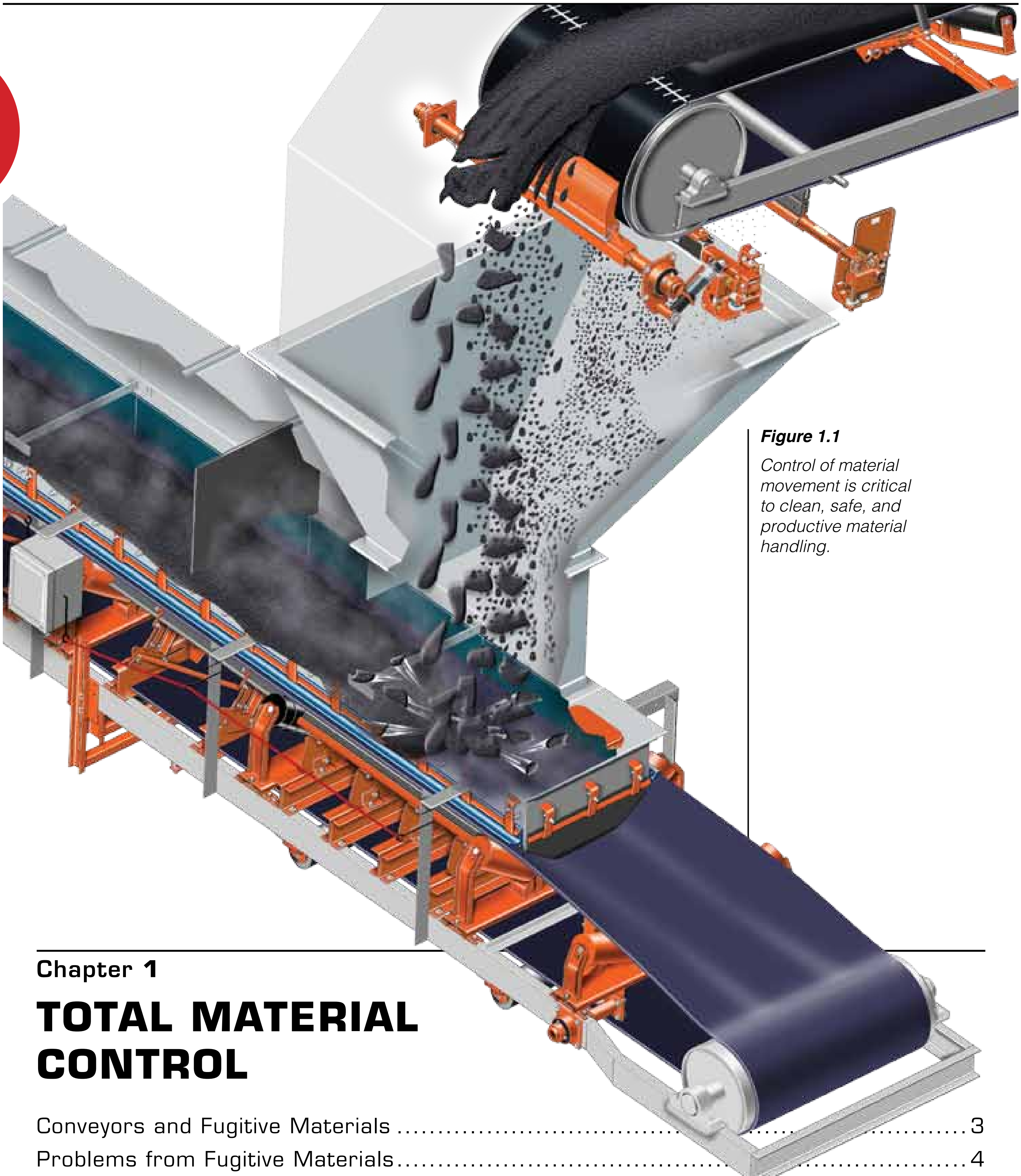

Figure 1.1

Control of material movement is critical to clean, safe, and productive material handling.

Chapter 1

TOTAL MATERIAL CONTROL

Conveyors and Fugitive Materials 3
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In this Chapter...

In this chapter, we describe some of the problems that occur as a result of fugitive materials: reduced operating efficiency, plant safety, product quality, and employee morale along with increased maintenance cost and scrutiny from outside agencies. We also identify the costs from this loss. As a way to address these problems, we discuss the need for total material control, which forms the basis for this book (**Figure 1.1**).

A bulk-materials handling operation is designed to accept the input of a certain amount of raw material and to reliably deliver that same amount of material at a predetermined rate to one or more points at the other end of the process.

Unfortunately, this seldom happens. Material losses, spillage, emissions, flow restrictions, and blockages can all occur in the handling process, resulting in the loss of production and creating other, associated, problems. These problems will cost billions of dollars annually across industries handling bulk materials worldwide.

This book seeks to identify many of the causes of material-handling problems and suggest practical strategies, actions, and equipment that can be applied to help increase efficiency in materials handling. This is a concept called Total Material Control®.

Total Material Control and TMC are registered trademarks of Engineering Services & Supplies PTY Limited (ESS), a Martin Engineering licensee, located in Currumbin, Australia *(Reference 1.1)*.

CONVEYORS AND FUGITIVE MATERIALS

Escape of materials from conveyors is an everyday occurrence in many plants. It occurs in the forms of spillage and leakage from transfer points or carryback that adheres to the belt past the discharge point and drops off along the conveyor return. It also occurs in the form of airborne dust that is carried off the cargo by air currents and the forces of loading and then settles on structure, equipment and the ground. Sometimes the nature of the problems of a given conveyor can be determined from the location of the pile of lost material (**Figure 1.2**). Carryback falls under the conveyor, spillage falls to the sides, and dust falls on everything, including systems and structures above the conveyor. However, many conveyors show all of these symptoms, making it more difficult to place the blame on one type of problem (**Figure 1.3**).

Another problem besetting materials-handling operations is flow restrictions. A materials-handling plant is designed to operate at a certain rate of throughput. While much attention has been paid to the cost of spillage, the cost of restricted throughput and delayed production cannot be ignored.

Chute or bin blockages can bring a production process to a standstill, causing delays that cost thousands of dollars per hour in downtime and in lost opportunities. Chute blockages often cause material boilover, with materials overflowing the

Figure 1.2

The source of the fugitive material can sometimes be determined from the location of the pile of lost material.

Figure 1.3

Many bulk-materials handling belt conveyors show all symptoms of spillage, carryback, and airborne dust, making it more difficult to identify any one source or apply any one remedy.

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chute. Chute or bin hang-ups often cause sudden material surges, in which amounts of material suddenly drop through the vessel and onto the receiving belt. Both boilovers and surges are major contributors to spillage. Material lying under the head end of a conveyor is often mistakenly identified as carryback, when it can actually result from surges and boilovers. Carryback will generally be fine material, so the presence of lumps greater than 10 millimeters (0.39 in.) will often pinpoint the cause of the fugitive material as a surge or boilover.

PROBLEMS FROM FUGITIVE MATERIALS

Results of Fugitive Materials

Fugitive materials have been around plants since conveyors were first put into operation; therefore, their presence is often accepted as a part of the industry. In fact, maintenance and production employees who are regularly assigned to cleaning duties may see this work as a form of "job security."

As a result, the problem of materials escaping from bulk-materials handling systems is often regarded with resignation. While it is recognized as a mess and a hazard, it is believed that no effective, practical, real-life systems have been developed to control it. Therefore, spillage and dust from leaky transfer points and other sources within plants are accepted as routine, unalterable courses of events. Fugitive materials become a sign that the plant is operating: "We're making money, so there's fugitive material."

At one time, pollution—whether from smokestacks or from conveyor transfer points—was seen as a sign of industrial strength. Now these problems are recognized as an indication of possible mismanagement and waste. This pollution and waste offer an opportunity for improvements in both efficiency and bottom line results.

Left unchecked, fugitive materials represent an ever increasing drain on a conveyor's, hence a plant's, efficiency, productivity, and profitability. Materials lost from the conveyor system cost the plant in a number of ways. The following are just a few:

A. Reduced operating efficiency

B. Increased conveyor maintenance costs

C. Reduced plant safety

D. Lowered employee morale

E. Diminished product quality

F. Heightened scrutiny from outside agencies and other groups

These costs will be more thoroughly covered in the sections that follow.

Reduced Operating Efficiency

It can be said the most expensive material in any operation is the material spilled from the belt. At a clean plant, "all" the material is loaded onto a conveyor belt at one end and then it is "all" unloaded at the other end. The material is handled only once: when it is placed on the belt. This, of course, equates to high efficiency: The plant has handled the material as little as possible. Material that has spilled or otherwise become fugitive, on the other hand, is material that has been received, processed (to some extent), and then lost. It has been paid for, but there will be no financial return.

In fact, fugitive material may prove to be a continuing drain: It degrades equipment, such as conveyor idlers, over time, and it might require additional labor to reprocess it before it can be returned to the system—if it can be returned to the process. However, once fugitive, it may be contaminated and unsuitable for return to the system. If fugitive material cannot be reclaimed, efficiency decreases more dramatically. In many places, even basic materials such as limestone or sand that fall from the belt are classified as hazardous waste and must be disposed of at a significant cost.

Fugitive materials also prove to be a drain in efficiency by requiring additional labor to clean up. Production materials can be handled by large machinery in significant quantities in large batches, in massive bucketfuls, and by the railcar load, often automatically or under remote controls. Fugitive materials, in contrast, are usually picked up by a skid steer, an end loader, or a vacuum truck—or the old-fashioned way, by a laborer, one shovel at a time.

Increased Conveyor Maintenance Costs

The escape of materials from conveyors leads to any number of problems on the conveyor system itself. These problems increase maintenance expenses.

The first and most visible added expense is the cost of cleanup. This includes the cost for personnel shoveling or vacuuming up material and returning it to the belt (**Figure 1.4**). In some plants, cleanup means a man with a shovel; in others, the cost is escalated, because it includes equipment hours on wheeled loaders, "sucker" trucks, or other heavy equipment used to move large material piles. A factor that is harder to track, but that should be included, is the value of other work not being performed because personnel have their attention diverted to cleanup activities. This delay in maintenance activities may result in catastrophic failures and even additional expense.

As materials escape, they accumulate on various conveyor components and other nearby equipment. Idlers fail when clogged or buried under materials (**Figure 1.5**). No matter how well an idler is constructed, fines eventually migrate through the seal to the bearing. Once the bearings seize, the constant movement of the belt across the idler can wear through the idler shell with surprising rapidity, leaving a razor-sharp edge on the seized roll, posing a threat to the life of the belt (**Figure 1.6**). "Frozen" idlers and pulleys increase the friction against the belt, consuming additional power from the conveyor drive motor.

Seized idlers create other even greater risks, including the possibility of fires in the system. A coal export facility in Australia suffered damage from a fire on a main in-loading conveyor. The fire was caused by a seized roller and fueled by accumulated spillage. The fire destroyed much of the head end of the conveyor, causing the failure of the 1600-millimeter (60-in.) belt and burning out the electrical cables and controls. Repairs were completed in four days to restore operation, but the total cost of the fire was estimated at $12 million USD.

Another risk is that material buildup on the face of pulleys and idlers can cause the belt to run off center (**Figure 1.7**). An accumulation of materials on rolling components can lead to significant belt-tracking problems, resulting in damage to the belt and other equipment, as well as the risk of injury to personnel.

Figure 1.4

For some plants, the cost of cleanup includes the cost of operating vacuum ("sucker") trucks and other heavy equipment.

Figure 1.5

Fugitive material can bury the load zone, resulting in idler failures, belt fires, and belt mistracking.

Figure 1.6

Idlers fail when clogged or buried under material. The motion of the belt across "frozen" idlers will wear rollers to knife-like edges.

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A mistracking belt can move over into the conveyor structure and begin abrading the belt and the structure. If this condition is not noticed right away, great lengths of valuable belting can be destroyed, and the structural steel itself can be destroyed. Belt wander creates interruptions in production, as the belt must be stopped, repaired, and retrained prior to resuming operations.

A particularly ugly circumstance is that fugitive materials can create a problem and then hide the evidence. For example, accumulations of damp materials around steel conveyor structures can accelerate corrosion, while at the same time making it difficult for plant personnel to observe the problem (**Figure 1.8**). In a worst-case scenario, this can lead to catastrophic damage.

What is particularly troubling about these problems is that they become self-perpetuating: Spillage leads to buildups on idlers, which leads to belt wander, which leads, in turn, to more spillage. Fugitive materials truly create a vicious circle of activities—all of which increase maintenance costs.

Reduced Plant Safety

Industrial accidents are costly, in terms of both the health of personnel and the volume and efficiency of production. In 2005, the National Safety Council in the United States listed $1,190,000 USD as the cost of a work-related death; the cost of a disabling injury assessed at $38,000 USD includes wage and productivity losses, medical expenses, and administrative expenses. These figures do not include any estimate of property damage, and should not be used to estimate the total economic loss to a community.

Statistics from the Mine Safety and Health Administration (MSHA) in the United States indicate that roughly one-half of accidents that occur around belt conveyors in mines are attributable to cleanup and repairs required by spillage and buildup. If fugitive materials could be eliminated, the frequency at which personnel are exposed to these hazards would be significantly reduced. Excessive spillage can also create other, less obvious, safety hazards.

In Australia, a Department of Primary Industries safety seminar advised that in the six-year period from 1999 to 2005, a total of 85 fires were reported on conveyor belts in underground coal mines in the state of New South Wales. Of these, 22 were identified as attributable to coal spillage, and 38 to conveyor tracking. Included among the twelve recommendations of the report were: “Improve belt tracking” and “Stop running the conveyors in spillage.”

In 2006 in the United States, a conveyor belt fire in an underground coal mine caused two deaths. The cause of this fire was attributed to frictional heat from a mistracking belt that ignited accumulations of coal dust, fines, and spillage, along with grease and oil.

Many countries now enforce regulatory safety procedures on companies. Included is the requirement to conduct hazard analyses on all tasks. Codes of practice in design and in plant operation require that once a hazard has been identified, it must be acted upon. The hierarchy of controls

Figure 1.7

Material buildup on the face of pulleys and idlers can cause the belt to mistrack, resulting in damage to the belt and other equipment.

Figure 1.8

Accumulations of damp material around steel conveyor structures can accelerate corrosion, while at the same time making it difficult for plant personnel to observe the problem.

for hazards will usually advise that the most appropriate action will be to "design out the hazard." The control will depend on the severity of the hazard and the layout of the existing equipment.

Lowered Employee Morale

While the specific details of an individual's job have much to do with the amount of gratification received at work, the physical environment is also a significant influence on a worker's feelings toward his or her workplace.

A clean plant provides a safer place to work and fosters a sense of pride in one's workplace. As a result, employees have better morale. Workers with higher morale are more likely to be at work on time and to perform better in their assignments. People tend to feel proud if their place of work is a showplace, and they will work to keep it in that condition. It is hard to feel proud about working at a plant that is perceived as dirty and inefficient by neighbors, friends, and, especially, the workers themselves.

It is recognized that jobs involving repetitive and unrewarding tasks, such as the cleanup of conveyor spillage, have the highest levels of employee absenteeism and workplace injuries. It is a mind-numbing exercise to shovel away a pile of spillage today, knowing that the pile will be back again tomorrow.

Diminished Product Quality

Fugitive materials can contaminate the plant, the process, and the finished product. Materials can be deposited on sensitive equipment and adversely influence sensor readings or corrupt tightly controlled formulas.

Fugitive materials impart a negative image for a plant's product quality and set a bad example for overall employee efforts. The most universal and basic tenet of many of the corporate "Total Quality" or other quality improvement programs popular in recent years is that each portion of every job must be performed to meet the quality standard. Each employee's effort must contribute to, and reflect, the entire quality effort. If employees see that a portion of the operation, such as a belt conveyor, is operating inefficiently—making a mess and contaminating the remainder of the plant with fugitive material—they will become used to accepting less than perfect performance. A negative attitude and lax or sloppy performance may result. Fugitive materials provide a visible example of sloppy practices that corporate quality programs work to eliminate.

Heightened Scrutiny from Outside Agencies and Other Groups

Fugitive materials act as a lightning rod: They present an easy target. A billowing cloud of dust draws the eye and the attention of concerned outsiders, including regulatory agencies and community groups. Accumulations of materials under conveyors or on nearby roads, buildings, and equipment sends a message to governmental agencies and insurance companies alike: The message is that this plant is slack in its operations and merits additional inspections or attention.

If a plant is cited as dirty or unsafe, some regulatory agencies can mandate the operation be shut down until the problems are solved. Community groups can generate unpleasant exposure in the media and create confrontations at various permit hearings and other public gatherings.

A clean operation receives less unwanted attention from regulatory agencies; it is also less of a target for environmental action groups. Cost savings can result from fewer agency fines, lower insurance, reduced attorney's fees, and less need for community relations programs.

The Added Problem of Airborne Dust

Serious concerns arise when dust becomes airborne and escapes from conveyor systems. Dust is a greater problem than spillage: Whereas spillage is contained on the plant's ground, airborne dust particles are easily carried off-premises (**Figure 1.9**).

In its series, *Best Practice Environmental Management in Mining*, Environment Australia (the Australian government's equivalent to the US Department of the Environment) issued a report on dust control in 1998 *(Reference 1.2)*. The report analyzed the sources of airborne dust in various mineral processing plants. The report indicated that the primary sources of dust were as follows:

Crushing................................ 1-15 percent

Screening................................ 5-10 percent

Stockpiling............................ 10-30 percent

Reclaiming .... 1-10 percent

Belt Conveyor Systems.......... 30-60 percent

In the Clean Air Act, the United States Environmental Protection Agency (EPA) is required by law to reduce the level of ambient particulates. Most bulk-materials handling facilities are required to maintain respirable dust levels in enclosed areas below two milligrams per cubic meter (2.0 mg/m^3) for an eight-hour period. Underground mining operations may soon be required to meet levels of 1.0 mg/m^3. Failure to comply with air-quality standards can result in stiff penalties from federal, state, and local regulatory agencies.

The Occupational Safety & Health Administration (OSHA) in the United States has determined that airborne dust in and around equipment can result in hazardous working conditions. When OSHA or MSHA inspectors receive a complaint or an air sample that shows a health violation, litigation may follow.

Figure 1.9

Airborne dust is a serious concern as it escapes from conveyors and transfers.

Respirable dust, particles smaller than 10 microns in diameter, are not filtered out by the natural defenses of the human respiratory system and so penetrate deeply into the lungs—where they can get trapped and lead to serious health problems. These health issues could be seen in the workforce and might even occur in neighborhood residents.

A frightening possibility that can arise from airborne dust is the risk of dust explosions. Dust can concentrate to explosive levels within a confined space. One incident of this nature—while tremendous in repair, replacement, regulatory fines, and lost productivity costs—can result in the greatest cost of all: the cost of someone's life.

ISO 14000 and the Environment

The continuing globalization of commerce promises more unified standards. Just as ISO 9000 developed by the International Organization for Standardization (ISO) has become a worldwide standard for codifying quality procedures, the development of ISO 14000 will set an international agenda for an operation's impact on the environment. ISO 14000 prescribes voluntary guidelines and specifications for environmental management. The program requires:

A. Identification of a company's activities that have a significant impact on the environment

B. Training of all personnel whose work may significantly impact the environment

C. The development of an audit system to ensure the program is properly implemented and maintained

Regulatory Limits

While no regulatory agency has established specific limits on the amount of fugitive materials allowed—the height of a pile beside the conveyor or the amount of carryback under an idler—there have been limits specified for quantities of airborne dust. OSHA has determined Permissible

Exposure Limits (PELs) and Threshold Limit Values (TLVs) for about 600 regulated substances.

These regulations specify the amount of dust allowed, as expressed in parts per million parts of air (ppm) for gases and in milligrams per cubic meter (mg/m^3) for particulates such as dust, smoke, and mist. It is the company's responsibility to comply with these standards or face penalties such as regulatory citations, legal action, increased insurance rates, and even jail time.

These OSHA procedures note that inspectors should be aware of accumulations of dust on ceilings, walls, floors, and other surfaces. The presence of fugitive materials serves as an alarm to inspectors and drives the need for air sampling to address the possibility of elevated quantities of airborne dust.

While ISO and other agencies/groups continue to push for regulatory limits, these limits will continue to differ from country to country. It seems safe to say that environmental regulations, including dust control, will continue to grow more restrictive around the world. These guidelines will almost certainly be extended to include fugitive materials released from conveyors.

ECONOMICS OF MATERIAL CONTROL

How a Little Material Turns into Big Problems

Fugitive materials escaping from conveyors present a serious threat to the financial well-being of an operation. The obvious question is: "How can it cost so much?" A transfer point spills only a very small fraction of the material that moves through it. In the case of a transfer point on a conveyor that runs continuously, a little bit of material can quickly add up to a sizable amount. Relatively small amounts of fugitive materials can accumulate to large quantities over time (**Table 1.1**).

In real life, fugitive materials escape from transfer points in quantities much greater than four grams per minute. Studies performed in Sweden and the United Kingdom examined the real losses of fugitive materials and the costs of those losses.

Research on the Cost of Fugitive Materials

In a report titled *The Cost to UK Industry of Dust, Mess and Spillage in Bulk Materials Handling Plants*, eight plants in the United Kingdom handling materials such as alumina, coke, limestone, cement, and

Table 1.1

Accumulation of Fugitive Material Over Time

Fugitive Material Released	Accumulation				
	Hour (60 minutes)	Day (24 hours)	Week (7 days)	Month (30 days)	Year (360 days)
"packet of sugar" (4 g) per hour	4 g (0.1 oz)	96 g (3.4 oz)	672 g (1.5 lb$_m$)	2,9 kg (6.3 lb$_m$)	34,6 kg (75.6 lb$_m$)
"packet of sugar" (4 g) per minute	240 g (8.5 oz)	6,2 kg (13.8 lb$_m$)	43,7 kg (96.3 lb$_m$)	187,2 kg (412.7 lb$_m$)	2,2 t (2.5 st)
"shovel full" 9 kg (20 lb$_m$) per hour	9 kg (20 lb$_m$)	216 kg (480 lb$_m$)	1,5 t (1.7 st)	6,5 t (7.2 st)	77,8 t (86.4 st)
"bucket full" 20 kg (44 lb$_m$) per hour	20 kg (44 lb$_m$)	480 kg (1056 lb$_m$)	3,4 t (3.7 st)	134,4 t (15.8 st)	172,8 t (190 st)
"shovel full" 9 kg (20 lb$_m$) per minute	540 kg (1200 lb$_m$)	13 t (14.4 st)	90,7 t (100.8 st)	388,8 t (432 st)	4665,6 t (5184 st)

china clay were examined. The costs have been adjusted to reflect an annual increase for inflation. This study, compiled for the Institution of Mechanical Engineers, established that industrial fugitive materials add costs amounting to a one percent loss of materials and 40 pence ($0.70 USD) per ton of throughput. In short, for every ton carried on the conveyor, there is a loss of 10 kilograms (or 20 lbs lost for every short ton of material), as well as substantial additional overhead costs.

This overall cost was determined by adding four components together. Those components included:

A. The value of lost material (calculated at one percent of material)

B. The cost of labor devoted to cleaning up spillage, which averaged 12.8 pence ($0.22 USD) per ton of output

C. The cost of parts and labor for additional maintenance arising from spillage, which averaged 8.6 pence ($0.15 USD) per ton of output

D. Special costs peculiar to particular industries, such as the costs of reprocessing spillage and the cost of required medical checkups for personnel due to dusty environments, representing 19.7 pence ($0.33 USD) per ton of output

Note: This loss includes fugitive materials arising from problems such as spillage and conveyor belt carryback along with fugitive materials windblown from stockpiles.

A similar study of 40 plants, performed by the Royal Institute of Technology in Sweden, estimated that material losses would represent two-tenths of 1 percent of the material handled, and the overall added costs would reach nearly 13 Swedish Krona ($2.02 USD) per ton.

It is interesting that in both of these surveys, it was actual material loss, not the parts and labor for cleanup and maintenance, which added the largest cost per transported ton. However, the indirect costs of using labor for time-consuming cleanup duties rather than for production are not included in the survey. Those figures would be difficult to calculate.

It is easier to calculate the actual costs for the disruption of a conveying system that, for example, lowers the amount of material processed in one day. If a belt runs 24 hours a day, each hour's production loss due to a belt outage can be calculated as the amount and the market value of material not delivered from the system's total capacity. This affects the plant's revenues and profits.

The Economics of Material Control

The cost of systems to control fugitive materials is usually considered three times during a conveyor's life. The first is during system design; the second, at system startup; and the third, during ongoing operations, when it is discovered the initial systems did not prevent fugitive materials.

It is often very difficult, with new installations, to predict the precise requirements for material control. In most cases, only a guess can be made, based on experience with similar materials on similar conveyors, indexed with "seat of the pants" engineering judgments. An axiom worth remembering is this: "A decision that costs $1 to make at the planning stage typically costs $10 to change at the design stage or $100 to correct on the site." The lesson: It is better to plan for worst-case conditions than to try to shoehorn in additional equipment after the initial system has been found to be underdesigned.

The details of conveyor transfer points, such as the final design and placement of chute deflectors, are sometimes left to the start-up engineer. It may be advantageous to allow the suppliers of specialized systems to be responsible for the final (on-site) engineering, installation, and start up of their own equipment. This may add additional start-up costs, but it is usually the most effective way to get correct installation and single-source responsibility for equipment performance.

Plants are often constructed on a rate of cost per ton of fabricated steel. Even if the best materials-handling controls are not put into place at the time of design, it costs little extra to ensure structures and chutes are installed that will allow for the installation of superior systems at some future date. The consequences of penny-wise, pound-foolish choices made in the initial design are the problems created: fugitive materials and chute plugging, compounded by the additional expense of doing it over again.

RECORD-KEEPING FOR TOTAL MATERIAL CONTROL

A great deal of attention is paid to the engineering of key components of belt conveyors. Too often, other factors affecting the reliability and efficiency of these expensive systems are ignored. The cost of fugitive materials is one such factor.

Record-keeping on the subject of fugitive materials is not part of standard reporting done by operations or maintenance personnel. The amount of spillage, the frequency of occurrence, maintenance materials consumed, and labor costs are rarely totaled to arrive at a true cost of fugitive materials. Factors—such as cleanup labor hours and frequency; the wear on conveyor skirting and conveyor belting; the cost of idler replacement including purchase price, labor, and downtime; even the extra power consumed to overcome stubborn bearings seizing from accumulations of materials—should all be calculated to determine a true cost of fugitive materials. Components whose service-life may be shortened by fugitive materials, such as idlers, pulley lagging, and the belt itself, should be examined to determine service-life and replacement cycle.

Computerized maintenance programs could easily include a field for cause of failure of any replaced parts. Pull-down prompts in these programs should include causes such as spillage, dust ingress, water ingress, and wear from material abrasion (for rollers). This would allow computer-generated reporting of cost versus cause of component failures. This program should include data on belt-cleaning and belt-sealing devices, so accurate costs can be determined for the system installed.

Some contract maintenance services maintain conveyor databases on customers' conveyors, recording system specifications, details of equipment status, and service procedures performed. This information is helpful in scheduling preventative maintenance activities and in determining when outside resources should be utilized. This information can be used to better manage an operation's equipment and budget.

The measurement of fugitive materials at transfer points is difficult. In an enclosed area, it is possible to use opacity measuring devices to judge the relative density of dust in the air. For transfer points in the open, dust measurement is more challenging, although not impossible.

A basic technique is to clean a defined area and weigh or estimate the weight or volume of material cleaned and the time consumed in cleaning. Follow up is then conducted with repeat cleanings after regular intervals of time. Whether this interval should be weekly, daily, or hourly will depend on plant conditions.

What will be more difficult to determine is the point of origin of the lost materials. Fugitive materials can originate from conveyor carryback, spillage due to belt wander, skirt-seal leakage, spillage from loading surges or off-center loading, leakage through holes in chutework caused by corrosion or missing bolts, or even from floors above.

The individual making a fugitive material study has to bear in mind the number of variables that may influence the results. This requires the survey to be conducted over a reasonable time frame and include most of the common operating conditions, including: environmental conditions, operating schedule, material moisture content,

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and other factors that create or complicate problems with fugitive materials.

Record-keeping of the amount of spillage—and of the costs of labor, parts, and downtime associated with it—should be a key part of the management information system for the operation of belt conveyors. Only when armed with such records covering a period of operation will an engineering study of fugitive materials and recommendations for total material control seem reasonable.

For many conveyor systems, the costs associated with lost materials will easily justify corrective measures. In most cases where adequate records have been kept, it has been shown that a modest improvement in material control will rapidly repay the costs of installing improved systems. Savings in labor expense alone often offsets the cost in less than one year of any retrofit equipment installed.

ADVANCED TOPICS

The Management of Risk and the Risk for Management

Many countries are starting to hold management personally accountable for failing to mitigate conditions such as spillage and dust resulting from poorly designed, operated, or maintained conveyors. In Australia, for example, the maximum penalty for failing to take corrective action to a known problem that causes death or grievous bodily harm is a $60,000 (AUD) fine and two years in prison for the manager, as well as a $300,000 (AUD) fine levied against the company. There is no doubt that a substantial number of accidents around conveyors are directly related to cleaning spillage and carryback, and it is also known that there are methods and products to control these problems. Consequently, any manager who chooses to ignore these problems and, as a result, risks the health of workers runs the risk of these penalties.

Using a standard industrial "Hazard Analysis" format—to determine the probability and consequence level of "hazards" experienced in cleaning spillage and carryback from under and around conveyors—provides a determination of the risk for employees and managers (**Table 1.2**).

Most conservative operators and maintenance people would evaluate the "Probability" of a safety incident taking place when cleaning spillage and carryback from under and around belt conveyors as "B: Has happened or near miss has happened" or "C: Could occur or I have heard of it happening," with the "People Consequence" rated as "2: Serious Injury." By moving these "Probability" and "People Consequence" values to the "Level of Risk Reckoner," a rating of Level 5 or Level 8 places the cleanup activities in the category of "Extreme Risk" of a serious injury (**Table 1.2**).

These ratings demonstrate a situation in which the risk management for the operations manager means proper diligence must be exercised by putting systems in place to eliminate or minimize these hazards.

Consequently, managers must do all within their power to eliminate the occasions (such as conveyor cleanup) that put employees in harm's way, both for the well-being of their employees and for the reduction of their own personal risks.

THE OPPORTUNITY FOR TOTAL MATERIAL CONTROL

In Closing...

When the costs created by fugitive materials are understood, it becomes obvious that controlling materials at conveyors and transfer points can provide major benefits for belt conveyors and to the operations that rely on these conveyors. This control has proven difficult to achieve—and more difficult to retain.

A planned and maintained approach is needed to aid in total material control. This is an opportunity to reduce costs and to increase efficiency and profitability for many operations.

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Total material control means that materials are kept on the belt and within the system. Materials are moved—where they are needed, in the condition they are needed, at the flow rate they are needed—without loss or excess energy consumption, and without premature equipment failures or excessive maintenance costs. Total material control improves plant efficiency and reduces the cost of ownership.

This book presents many concepts that can be used in a program to achieve total material control for belt conveyors.

Looking Ahead...

This chapter about Total Material Control, the first chapter in the section Foundations of Safe Bulk-Materials Handling, introduced the need for and benefits of reducing spillage and dust. The following chapter, Safety, continues this section and explains the importance of safe practices around bulk-materials handling equipment as well as ways in which total material control will increase safety in the plant.

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1.2 Environment Australia. (1998). *Best Practice Environmental Management in Mining: Dust Control*, (ISBN 0 642 54570 7).

Table 1.2

Risk Matrix System

Step 1: Determine Probability		Step 2: Determine Consequence (Higher of the Two)		
Probability		**People Consequence**		**Plant, Property, Productivity, & Environmental Consequence**
A	Daily: Common or frequent occurance	1	Fatality, permanent disability	Extreme danger, extreme business reorganization. Major environmental damage.
B	Weekly: Has happened or near miss has happened	2	Serious injury or illness (lost time)	High-level damage, significant business reorganization. Serious environmental damage.
C	Monthly: Could occur or I have heard of its happening	3	Disability or short-term injury (lost time)	Medium-level damage, serious production disruption. Reversible environmental damage.
D	Annually: Not likely to occur	4	Medical treatment injury	Low-level damage, slight production disruption. Minor environmental damage.
E	Once in 5 Years: Practically impossible	5	First aid or no injury	Negligible damage, minimal production disruption. No environmental damage.

Step 3: Level of Risk "Reckoner"—Calculate Risk

	A	B	C	D	E
1	1 EXTREME	2 EXTREME	4 EXTREME	7 EXTREME	11 SIGNIFICANT
2	3 EXTREME	5 EXTREME	8 EXTREME	12 SIGNIFICANT	16 MODERATE
3	6 EXTREME	9 SIGNIFICANT	13 SIGNIFICANT	17 MODERATE	20 MODERATE
4	10 SIGNIFICANT	14 SIGNIFICANT	18 MODERATE	21 LOWER	23 LOWER
5	15 SIGNIFICANT	19 MODERATE	22 LOWER	24 LOWER	25 LOWER

Typical example of a risk matrix system as used in Australia, origin unknown.