Measurement and Control of Spillage and Leakage at Conveyor Transfer Points

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The measurement of spillage is a straight forward engineering survey task that can be accomplished with relative ease. However, the results of such surveys are often not believed because they often accurately determine that huge amounts of material is lost from conveyor systems. More credibility can be lent to these surveys if accurate and coordinated record keeping is made a part of the management information system. Very modest amounts of spillage can easily justify expenditures to control fugitive materials.

1.0 Summary

Record-keeping of spillage and the associated labor costs should be a key part of the management information system for the operation of conveyor systems. Only with such records covering a reasonable time of operation will an engineering study of spillage and the recommendations for control seem reasonable. In many conveyor systems the costs associated with spillage and leakage will easily justify corrective measures. The savings in labor often offset the cost of equipment in less than a year.

2.0 Introduction

Much attention has been paid to the details of engineering conveyor belt systems key components and estimating the reliability and efficiency of these systems. Spillage and leakage from conveyor belt systems have only recently received detailed scientific study.

The purpose of this paper is to point out the key areas of spillage and leakage on conveyor belts, suggest techniques for measuring or estimating the amount of spillage and examine the economic consequences of controlling the spillage. It can be shown that good control of conveyor belt leakage and spillage is cost effective and results in improved safety and improved productivity.

2.1 Discussion

At first it would seem to be a simple matter to determine the amount of spillage or leakage from a conveyor transfer point. However, many practical problems exist which make it difficult to accurately determine the amount of fugitive materials, their source and the economic impact.

For example, record-keeping on this subject is often not part of the standard reporting done by operations or maintenance personnel. When it is done it is often not coordinated. Clean-up labor, the amount of spillage, frequency of occurrence, maintenance materials and labor are very rarely totalled to arrive at the true cost of spillage and leakage.

Another complicating factor is the distinction between a process upset condition and normal operating conditions. In many cases simple changes in operating procedures and a minimal investment in equipment can greatly reduce spillage and leakage. Changes in the material being handled can greatly affect the amount of fugitive material released by a conveyor system. Weather and related changes in the moisture content of the material handled is usually the single largest contributor to changes in the rate of spillage or leakage.

In order for a survey or study to be representative of long-term operations, the person making the study has to keep in mind a variety of factors which may influence the results. This requires that the survey be conducted over a reasonable time frame and include the most common operating conditions that cause spillage or leakage.

2.2 Measuring spillage and leakage

Why bother? Conveyors are going to leak and there's nothing that can be done about it. There are a variety of reasons for studying the problem. Dirty belts create dirty work environments and reduce the level of morale. In many cases there are regulations that define the standard of cleanliness, such as in coal mining or grain handling. If for no other reason, it makes economic sense to keep the material on the belt and deliver it to the place you wanted to the first time rather than pay to do it twice.

The first place to start in measuring the problem is to establish a system for keeping track of the amount of labor spent controlling spillage and leakage in both maintenance and production departments. This does not need to be a permanent system, but it is difficult to accurately estimate the amount of labor dedicated to cleaning up around conveyors, and several months worth of records are usually needed for an accurate picture. Records should be kept on items or components that have relatively short lifetimes. The components on a clean conveyor will often last several times as long as the identical components on a dirty conveyor. Idlers are an example of where life extensions of up to four times are not unusual.

Spillage can be easily measured if the area around a conveyor is cleaned up and a set amount of time lapses before the next clean-up when the spillage is weighed or its volume and weight estimated. It is more difficult to determine from where the spillage originates.

At a conveyor transfer point there are several possible sources of spillage or leakage. In my experience the order of magnitude of spillage generated and the type of spillage can be listed as:

2.2.1 Carryback

Carryback on the conveyor belt - Usually in the form of very fine particles, flakes produced from these fine particles, or a slurry or paste consisting of these very fine particles. It is easily identified as piles of material under bend pulleys and return idlers. This material can become airborne, but in general remains as piles under the conveyor.

2.2.2 Skirt leakage

Leakage at the skirt seal - When handling granular material the leakage from the skirt section tends to be particulate matter of one to five millimeters in diameter, which is sized by the characteristic gap between the rubber seal and the sag in the belt between idlers. This material will typically accumulate in the immediate area around the skirted portion of the conveyor. If the material being conveyed has a large percentage of fines this material can also leak from the skirted area. This material usually is airborne and deposits itself as a layer of dust over a large area. In extreme cases it may accumulate in piles at the transfer point.

2.2.3 Spillage at loading

Spillage at the exit of the skirted area - Spillage in this area can be caused by a too short transfer point or by dust curtains that knock material from the belt or by material that rolls back down inclined conveyors. It is typically large lumps of material and is found scatterd in an area around the exit of the transfer point chute work. It also is commonly found on the inside return strand of the conveyor and may accumulate at the tail pulley in the form of build-up on the pulley. In extreme cases this build-up can stick to the belt and be carried to the head pulley.

2.2.4 Spillage at discharge

Spillage at the head section can be caused by an overloaded conveyor. As the belt flattens out to go over the head pulley the load spills to the side; or it can be the placement of the dust curtain or the restricted entrance caused by the design of the chute work. The material spilled at this location is similar to that spilled at the exit of the transfer point. It too can be distributed over a long section of the conveyor.

2.2.5 Belt mistracking

Spillage from mistracking can be the most catastrophic of all types of spillage. In a matter of seconds tons of material can be dumped, belts rolled over and transfer points destroyed. The causes of mistracking are numerous. A well-tracked or trained belt is the first prerequisite to a clean operation. Misalignment switches are a must and can be justified by the elimination of just one major mistracking incident.

2.2.6 Process spillage

Spillage from above - Often our surveys will determine that the spillage is due to holes in the chute work, missing bolts on chute work and equipment or from float dust from the floors above. Control of spillage is a job that requires attention to detail.

2.3 Measurement of Carryback

One of the key relationships to be determined is how much material is carried back with the return run of the conveyor vs. how much falls off during the return run and becomes spillage. Measurement of the carryback has been done in laboratory conditions by stopping the belt and scraping a known area in key locations, such as before belt cleaners, after the belt cleaners and after return idlers. From these readings an indication of the amount of material that is likely to end up as spillage and the efficiency of the cleaning system can be measured. Carryback typically accounts for between 50% and 99% of the spillage on a conveyor system. There have been several studies done in private industry, by government agencies and universities on this subject.

Carryback can be measured in an operating system by use of an instrument known as the Stahura Carryback Gauge. (drawing) This device can take samples while the belt is in operation whether it is manual or in an automated system. The samples are then weighed and, knowing the belt speed and the time it took to collect a sample, the amount of carryback can be accurately estimated. The method currently recommended is to take three samples immediately after the conveyor belt cleaners and three samples after the last return idler in the system. These samples are taken at a distance from the edge of the belt equal to 1/6 belt width, 1/4 belt width and 1/2 belt width, and the sample is one inch or 25 millimeters in width. The sample should be of 15 seconds duration. The carrying surface of the belt is usually 2/3 belt width. So in combination with the speed and amount of carryback collected at each station, the amount of material spilled is easily calculated.

Studies have shown that the return idlers cause a great amount of the carryback to fall from the belt. One study showed that a relationship between the amount of spillage and the number of return idlers was, in general, possible to define mathematically. Field studies have shown that approximately 5% of the carryback on the belt at each return idler is removed at each idler. Using this model, approximately 50% of the material that will become fugitive will happen in the first 15 return rollers. (Ref. #3)

In extreme cases 100% of the material conveyed will be carried back. Obviously this situation won't go on long. There are cases where the carryback is 50% to 75% of the load, and the drop-off was accepted as a fact of life rather than corrective action taken.

2.4 Measurement of dust

Measurement of dust at transfer points is more difficult if not impossible on open conveyors. In enclosed areas it is possible to use opacity measuring devices to judge the relative dustiness of the air. Some key raw materials have permissible concentration levels set based on health or flammability standards. In those cases where there is no standard or requirement, a more effective measurement is the amount of dust build-up on floors and building components. The housekeeping standards need to be set by the management of the plant, but our recommendation is that no more than 1/16 inch or two millimeters of dust be allowed to accumulate before clean-up or wash-down is required. A reasonable cleaning frequency would be once per week.

Dust can be controlled by negative pressure dust collection by reducing the generation of dust through transfer point design or by dust suppressant systems ranging from water sprays to chemical treatment. Dust is often the most difficult problem to control. Often individual transfer point systems are the best way to control dust, as each transfer point has its own set of dust problems. Dust in the air often becomes attracted to the conveyor belt and becomes deposited under return idlers. (sketch)

2.5 Economics of Spillage Control

Economics of spillage control are usually considered at three times during a conveyor system's life. The first consideration is given in the design phase, the second is during start-up and the third is ongoing operations.

During the design stage the primary economic consideration is to keep the capital cost to a minimum as well, as engineering costs. Detailing and engineering of a transfer point are time consuming and usually left until after the contract is won. Designs tend to be done to minimum standards unless the owner insists on particular specifications. Most standards for transfer points, such as the length of skirting, are adequate for average conditions. By definition this is adequate for oniy 50% of the time and you could expect 25% of the operating time to be above average conditions for spillage and leakage. How many people would purchase a conveyor system with a guarantee that it will leak 25% of the time?

Specifications for the transfer point should be specific and based upon the experience of the operator or tests performed by an experienced material handling engineer. The specification should include performance guarantees. Among the items that should have performance requirements are:

- Allowable rate of leakage from conveyor skirts per 24 hrs.
- Allowable rate of carryback from belt cleaners per 24 hrs.
- Allowable leakage of dust at transfer points per 24 hrs.

Design specifications are also important. A checklist of items to consider in specifications is given in Reference #1.
The question of reasonable cost and reasonable spillage rates will be a difficult one to answer. There will be a tendency to pad the estimates to extremes to cover unknowns if the specifications are too tight. In most cases suppliers of specialized equipment or engineering are much better able to provide performance guarantees based on conditions, such as regularly scheduled maintenance and proper installation according to the suppliers instructions.

During the construction and startup phase, costs become a matter of budget vs actual. Details around transfer points are often left to the start-up engineer. Suppliers of specialized equipment should be responsible for the installation and start-up of their own equipment. This may add additional cost, but usually is the most cost efficient way to get correct installation of equipment and provide single source responsibility for meeting specifications.

2.6 Justification

In order to justify equipment or services certain costs must be determined or assumed. These include:

1. Increase or decrease in power consumption
2. Labor costs
3. Equipment costs
4. Installation costs
5. Maintenance costs
6. Value of material conveyed

The change in power requirements should be looked into, as cleaners and skirting systems do require a certain amount of power. Usually the values given in the different conveyor belt design manuals (Ref. #4) are generous enough to cover most situations.

Belt cleaner tension - 3 lbs. per inch of blade contact

Skirtboard tension - 3 lbs. per lineal foot of skirt

Labor costs can be determined from records or estimated from the results of various surveys, such as a person can clean up one ton per day using a shovel and broom and ten tons per day with a small endloader. (Ref. #3)

Equipment and installation costs can be easily determined from quotations from suppliers. Generally equipment costs will range from $500 to $5,000. A complete belt washing station can cost up to $40,000, and a complete rework of the transfer point can range from $10,000 to $50,000. A skirting installation can range from $500 to $10,000 on a typical 48 wide belt. The calculation on the cost vs benefit can be as simple as you like or very complex. In any case the savings and the costs should be real costs or savings. The final determination is: Did it reduce expenses for labor and material or did it increase productivity?

It is often very difficult to predict on new installations the need for controlling spillage beyond the accepted norm. In most cases only a guess can be made at the amount of spillage. In these cases a cleaning system choice is not as important as designing in the room for adequate adjustments after start-up. A rule of thumb stated by one study: A decision that cost $1 to make at planning stage cost $10 to change at the design stage and $100 on site. (Ref. #2) It is often cheaper to plan to subcontract this type of work to specialists during construction and startup.

In the design stage the most cost effective steps that can be taken involve allowing enough room to adequately clean and seal a belt. The cost is minimal.

A Swedish report, surveying over 40 companies using over 1,000 belts, resulted in the following time required for cleaning up spillage and repairing damage directly related to spillage. (Ref. #2)

Mines/Concentrators/Sinter plants	.0025
Smelters	.013
Coal	.026
Coke	.03
Pulp	.024
Cement	.006
Chemical/Fertilizer	.011

To use this information, multiply the tons conveyed times the factor to determine the man hours of labor. These values were developed over a time frame of a years operation. For example, you could expect a cement plant conveyor that handles 100,000 tons per year would likely have a labor content due to spillage of 100,000 x .006 or 600 hours. The amount of material spilled varied from a minimum of .1 kg to 2 kgs spilled per ton handled. The life of the conveyor equipment was reduced 30% to 50% on those belts that had spillage problems.

2.7 Conclusion

Each operation has its own method of justifying expenditures so no financial method is presented here. The control of spillage and leakage is work that requires attention to detail. Detail work in planning, designing, installation, operation and maintenance.

In most cases where adequate records are kept and an engineering survey done, a very modest improvement in the control of spillage and leakage will pay for extensive rework of a transfer point or installation of a transfer point dust collector. With the costs of material handling to put your materials into a conveyor system, the most expensive raw material you have is the material that spilled or leaked from the belt. Why pay to put it on the belt more than once?

REFERENCES

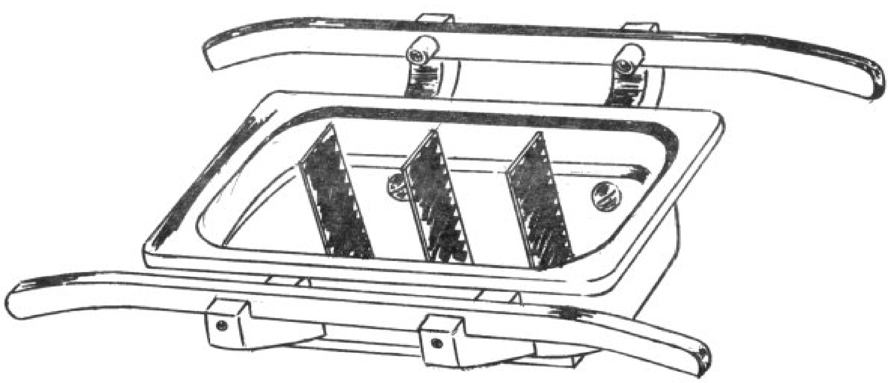
Bureau of Mines, United States Department of the Interior. Safety Evaluation Of Conveyor Belt Cleaning Systems. A mining research contract report. Washington, D. C., January 1983.

Conveyor Equipment Manufacturers Association. Engineering Conference. Belt Conveyors for Bulk Materials. 2nd ed., Boston, MA: CBI Publishing Company, Inc., 1979.

Oberg, Ola. Material Spillage At Belt Conveyors. Sweden, 1986-01-10.

Sabina, William E., Stahura, Richard P., and Swinderman, R. Todd. Conveyor Transfer Stations Problems And Solutions. Neponset, IL: Martin Engineering Company, 1984.

Stahura, Richard P. Conveyor Belt Washing - Is This The Ultimate Solution? Neponset, IL: Martin Engineering Company.



STAHURA CARRYBACK GAUGE
Reference # 1

CONVEYOR TRANSFER STATIONS PROBLEMS AND SOLUTIONS

WILLIAM E. SABINA
William E. Sabina, Inc.

RICHARD P. STAHURA
Martin Engineering Company

R. TODD SWINDERMAN
Martin Engineering Company

Reference # 2

Kungliga Tekniska Högskolan
Institutionen för
Produktionsteknik,
särskilt gruv- och stålindustri
Stockholm

Materialspill vid bandtransportörer


"Man ser inte problemen förrän man skottat fram dem"

Författare: Ola Öberg

Reference # 3

A mining research contract report
JANUARY 1983

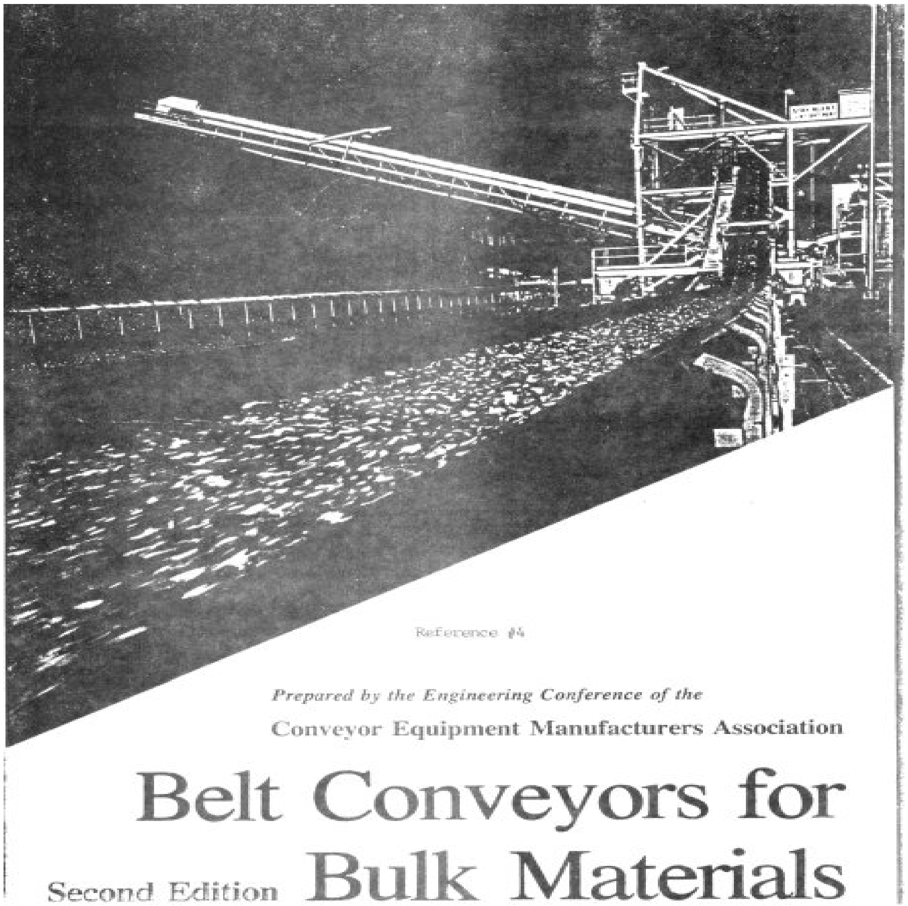
SAFETY EVALUATION OF CONVEYOR BELT CLEANING SYSTEMS

Contract J0215015

Wyle Laboratories

BUREAU OF MINES
UNITED STATES DEPARTMENT OF THE INTERIOR

Reference # 4


Reference #4
Prepared by the Engineering Conference of the
Conveyor Equipment Manufacturers Association
Belt Conveyors for
Second Edition Bulk Materials

Reference # 5

WASH BOX/DRY DUST COLLECTOR COMBINATION

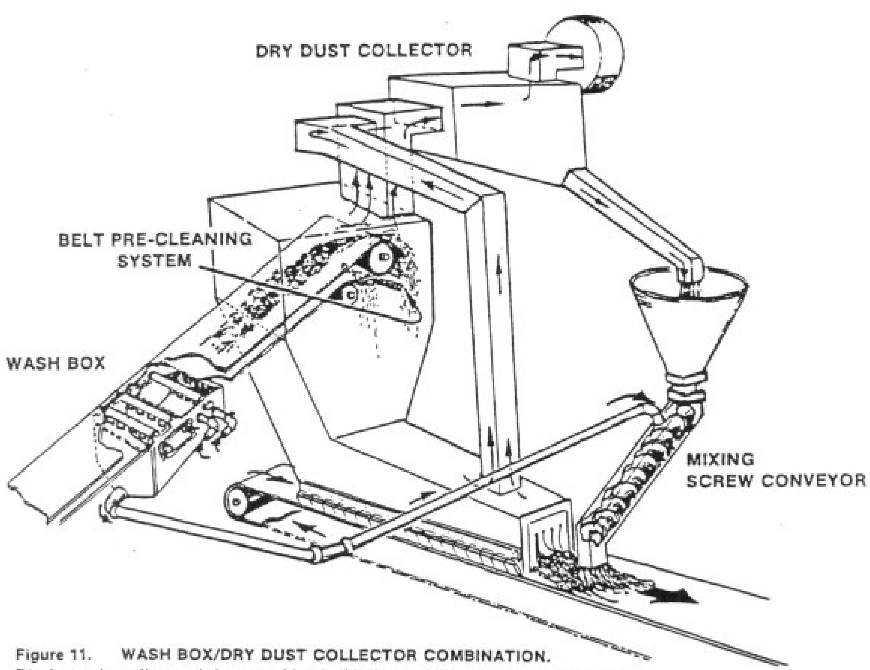


Figure 11. WASH BOX/DRY DUST COLLECTOR COMBINATION.
Discharge from the wash box combined with the dust from the dust collector to agglomerate the dry dust and cycle it back into the system.