United States Environmental Protection Agency
Environmental Monitoring Systems Laboratory
Research Triangle Park NC 27711
Research and Development
EPA-600/S4-83-051 Nov. 1983

EPA

Project Summary

Technical Assistance Document: Quality Assurance Guideline for Process Feed Rate Monitors in the Portland Cement and Lime Industries

Robin R. Segall and John R. Richards

This study, sponsored by the Quality Assurance Division of the U.S. Environmental Protection Agency's Environmental Monitoring Systems Laboratory, evaluated the performance of process feed rate monitors used in the Portland cement and lime industries. Particulate emission regulations applicable to both industries are specified as kilograms of particulate per megagram of feed to the process. Regulatory agencies have assumed that feed rate monitors are highly accurate due to process control considerations; this study evaluated the validity of this assumption.

This study has found that six major types of feed rate monitors are currently used in the Portland cement and lime industries. Each of these monitor types is reliable and accurate; seldom do the errors exceed ±3 percent, and in most cases the monitor performance allows control of the process flows to within ±1 percent. This performance level is necessary (1) to ensure that the resulting products meet specifications, and (2) to minimize kiln and calciner operating problems. Operating personnel routinely check the operation of the feed rate monitors and calibration is carried out frequently.

In the majority of cases, regulatory agencies could assume that the process feed rate monitors are sufficiently accurate. However, if some question should arise concerning the monitors, the evaluation procedures listed in this report may be used to verify accuracy. The following material also includes a summary of typical problems and calibration techniques associated with the monitors.

This Project Summary was developed by EPA's Environmental Monitoring Systems Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

The New Source Performance Standards (NSPS) and many State Implementation Plan (SIP) regulations contain several emission rate limits specified per process operating rate, as shown below:

$$\frac{\text{Pollutant emission rate}}{\text{Process operating rate}}$$

In the NSPS, this type of emission standard is found in Subparts F and HH, which contain the Standards of Performance for Portland cement plants and lime manufacturing plants, respectively.[1,2] In these two subparts, the allowable emission limits for particulate matter are expressed per unit of process weight, as indicated by the following:

Portland Cement Plants (Subpart F)
- 0.15 Kg per metric ton of feed (dry basis) to the kiln

Lime Manufacturing (Subpart HH)
- 0.15 Kg per megagram of limestone feed [to the rotary kiln]
- 0.075 Kg per megagram of lime feed [to the lime hydrator]

In the past, a substantial effort has been directed towards the quality assurance (QA) of the numerator in these expressions, while the accuracy of the denominator remained unquestioned. For process control reasons, agencies have routinely assumed the denominator is accurate.

This report examines the information available on the accuracy and reliability of data from these monitors. In addition to the current literature, equipment vendors and plant operators were consulted to obtain information concerning types and applications of these monitors, reported accuracy, sources of error, operation and maintenance procedures, calibration procedures, and general evaluation procedures. This report includes an introductory section that discusses the types and typical locations of process feed rate monitors for the Portland cement and lime industries. The operation and routine calibration of each of the major types of monitors typical of these industries are described in section 2.0. This section also addresses the quality assurance aspects of each type of monitor including accuracies, typical errors and problems, preventive maintenance, and visual evaluation techniques.

Operation, Calibration and Evaluation of Process Feed Rate Monitors

This examination into the use of process feed rate monitors in the Portland cement and lime industries revealed that six main types of monitors are commonly used. These are: (1) the gravimetric weigh belt scale, (2) the gravimetric weigh belt feeder, (3) the nuclear weigh belt scale, (4) the impact flowmeter, (5) the pneumatic weigh feeding system, (6) the plunger-type feeder, and (7) the magnetic flowmeter. This section will examine each of these major monitor types.

Gravimetric Weigh Belt Scales

Gravimetric weigh belt scales are the most basic form of gravimetric continuous-weighing devices. The normal weigh belt scale is part of a material-handling conveyor belt system and supports a portion of the moving conveyor belt. It uses a mechanical lever or load cells to instantaneously weigh the amount of material carried on that portion of the belt. Weigh belt scales are used in both the lime industry and the Portland cement industry. When used for kiln monitoring, weigh belt scales usually act as a materials balance check, in conjunction with another weigh feeding device which actually provides the consistent kiln feed rate.

Accuracy

For factory approved installations, manufacturers guarantee load cell-type weigh belt scales to weigh and totalize with an error not to exceed 0.5 percent of full scale,[3,4] while mechanical type scales may have claimed accuracies of ±0.25 percent or better.[5]

Calibration

There are three common methods for calibration of gravimetric weigh belt scales. These are: using a material test, using test chains, or using test weights. A fourth method, electronic calibration, is not as commonly seen.[6,7]

A typical calibration scheme involves use of a material test for initial belt scale calibration upon installation[8,9] and then use of a test weight or test chain calibration monthly thereafter.[9] Evidence that an instrument is performing incorrectly, of course, indicates that a calibration should be performed immediately.

Evaluation Checklist

In summary, the following checklist may be useful as a guide for routine visual examinations of gravimetric weigh belt scales.

- Belt scale is being operated at between 50 and 90 percent of its rated capacity.
- Belt loading is uniform in flow and symmetry.
- No material lumps are larger than 15 percent of belt width.
- There is no material or water movement in the belt scale area.
- There is a gravity or tension take-up on a belt longer than 40 ft, and it is located near the head pulley.
- Unloaded belt runs completely in the idler trough (at correct belt tension).
- Belt scale is located near the bottom or tail end of the conveyor.
- Belt scale is acceptable distance from convex or concave curves, load-in and load-out points, skirtboards, and trippers.
- Belt conveyor does not have "V"-type idlers, five roll deep trough idlers, rope or cable support rolls type idlers, offset carry rolls, or center rolls.
- Scale mounted idlers and three stationary idlers to either side are dimensionally aligned (within 1/32 in.).
- Belt tracks centrally at all load conditions.
- There are no training idlers within six idlers of the scale.
- Troughing angle of idlers is ≤ 35°.
- A windbreak is provided if the scale area is subjected to >5 mph winds.
- The ambient temperature in the scale area is within the specified operating range for that model.
- There is no dust build-up on the weighbridge, belt, or speed sensor.

Gravimetric Weigh Belt Feeders

Gravimetric weigh belt feeders are somewhat similar to gravimetric weigh belt scales in that they weigh flowing material with a scale applied to a conveyor belt. However, the scales weigh material (usually on its way from one place to another) without concern for the amount delivered per unit of time; the weigh belt feeder, on the other hand, weighs material (on a short belt) in order to deliver a specified amount in a specified time and usually at a constant rate. A weigh belt feeder usually includes feedback controls to achieve this goal.

Accuracy

Because of their shorter belt lengths, weigh feeders tend to be more accurate than comparatively sophisticated weigh belt scales. The literature and vendors cite accuracies of up to ±0.25 percent[10,11] of set rate, and at least ±0.5 percent[11] or ±0.5 percent to ±1 percent of set rate.[5]

Calibration

Gravimetric weigh belt feeders are calibrated in the same manner as gravimetric weigh belt scales; that is, by using material tests, test chains, and test weights (see previous section).

Evaluation Checklist

The following items may be used tc perform a visual evaluation of a weigh feeder.

- Load is at least 50 percent ot capacity.
- Belt is loose enough to permi' deflection at weigh area.
- Belt has tension roll or some othe assurance that it does not slip or drive and measurement pulleys.
- Weigh idler(s) or weighdeck i: aligned.*
- There is little or no dust build-up o weigh deck, platform, etc.
- There is no dust build-up on pulleys
- Belt is tracking correctly.

*To check alignment place a string between the fixe or stationary idlers; it should barely touch the weig idlers.

Nuclear Weigh Belt Scales

Like the gravimetric weigh belt scale systems, nuclear weigh belt scale systems are not generally used as direct kiln feed rate monitors. Instead, they are usually part of a larger materials balance check system. However, the nuclear monitor *can* be used to measure mass flow in material transfer systems other than a conveyor belt.[12] It has been applied directly to proportioning screw feeders, and to the combination system used for kiln feed rate monitoring and control.[13]

Accuracy

Stated accuracy varies between ±0.75 percent and ±1 percent depending upon application and manufacturer.[13,14,15] Discussions with plant operators who use these instruments have indicated typical accuracies of 1 percent with source drift occasionally causing errors as great as 3 percent.[9,16]

Calibration

The two principal methods of nuclear weigh belt scale calibration are the dynamic material test procedure and the static calibration plate (or material) procedure. Most nuclear scale manufacturers recommend conducting a material test for the initial calibration. Recalibration is then performed on a monthly basis using the calibration plate that is usually supplied with the weigh scale.[17]

Evaluation Checklist

The previous discussion suggests the following checklist for nuclear weigh belt scale evaluation.

- Belt loading is between 70 and 100 percent of rated capacity (or at least greater than 2.7 lb/ft^2).
- Belt loading does not vary by more than 30 percent on a regular basis.
- Product profile does not appear to change significantly.
- Product does not include lumps larger than 15 percent of belt width.
- Scale is not used to weigh more than one material or material bulk density without recalibration.
- There is no material slippage in the vicinity of the scale.
- There is no material build-up on the detector.
- There is no material build-up on the belt.
- There is no water running on the belt in the weighing area.

Impact Flowmeters

This type of process monitor is designed for use as an in-line flowmeter for measuring solids, liquids, and slurries. In the Portland cement and lime industries, it finds typical application in the weight measurement of solids less than 3 in. in diameter. Impact flowmeters make material flow measurements by sensing the force produced by the material as it free falls (by gravity) onto a sensing device. Two types of sensing devices are currently used in impact flowmeters: the impaction plate and the impaction cone. The former device is used in the majority of installations in the lime and cement industries, therefore the following discussion will focus almost exclusively on the impaction plate type of flowmeter.

Accuracy

Impact flowmeters are quite accurate; manufacturers generally claim 0.5 percent of full scale, and comments from plant instrument operators confirm this.[9,18,19]

Calibration

As with the weigh belt scales and the nuclear scales discussed previously, initial calibration of an impaction plate flowmeter is usually accomplished by using a material test and subsequent recalibration uses a static test "weight." The initial material test calibration is recommended upon installation, with recalibrations performed at monthly intervals (more often if required by special circumstances or if warranted by inconsistent readings).[9]

Some of the newer flowmeter system installations may have a third calibration check that utilizes a bin-load cell weighing system.[8]

Evaluation Checklist

The previous section suggests the following visual inspection points to be used in routine impact flowmeter evaluation.

- The material flow impacts on the center of the sensing plate or cone.
- Flowmeter is used for only one material (unless material change calibration compensation is built into the electronics).
- There is no appreciable buildup of dust in the impingement area of the impaction plate (or cone).
- There is no airflow against the plate (or cone). Note: Most of these devices are enclosed so this may not be a problem.
- Material measured by the flowmeter does not change in particle shape or hardness.
- Plant maintenance procedures for flowmeter include ensuring that it is kept properly leveled.
- The flowguide assembly is the proper one for current material and flowrate.

Pneumatic Weigh Feeding Systems

Polysius Corporation, a major design/construction firm for cement plants, recently installed pneumatic weigh feeding systems in five U.S plants. The system is marketed under the name POLDOS®.[20,21,22,23]

Raw meal is fed from the homogenizing silos through a set of control valves to a bucket elevator. The meal is dumped into a calibration tank mounted on load cells, then metered out of this tank by a control valve. The meal passes down an airslide to the pneumatic conveyor, which transports the material to the top of the preheater. The mass flow from the pneumatic conveyor is linearly related to the floor pressure below the pneumatic conveyor (AEROPOL®) aeration surface. The pressure is converted by a transducer into an electrical control signal for the main solids flow valve located under the calibration bin. By using the pressure level as an indicator of flow, it is possible to eliminate the weigh belt feeder which used to be installed below the calibration bin.

Accuracy

Polysius claims an accuracy of better than 1 percent which is equivalent to the accuracy claimed for conventional weigh feeding systems.[21]

Calibration

The POLDOS® system is calibrated by interrupting the material flow to the calibration bin and allowing the raw meal to empty out for a period of time.[22,23] The difference in the calibration bin weight before and after the test is compared with the pressure value. A number of tests at different feeding rates are used to generate the complete calibration curve. Examples of these calibration curves are available in references 22 and 23. As part of the overall calibration procedure, the load cells on the calibration bin are checked by hanging various weights on the side of the bin.[21]

Evaluation

Polysius reports no serious problems with the operation of the POLDOS® system,[21] which is entirely enclosed and has no external mechanical parts which could be checked. Because of this, agency observers must rely strictly on plant calibration data.

Plunger Type Feeders

Lime plants with rotary kilns and preheater towers generally use a plunger type feeding mechanism to deliver the hot limestone feed to the kiln.[24,25,26,27,28] By controlling the length of the stroke and the frequency of operation, it is possible to achieve the desired volumetric feed rate.[24,28] Depending on the design of the preheater, the system may be equipped with 4 to 18 of these feeders.[24,25,27,28]

Calibration

Calibration of the feeders can be accomplished in a manner analogous to that used to calibrate the impaction flow monitors and the POLDOS® system. The stone feed bin can be mounted on load cells and emptied over a period of time in order to relate the plunger operation to the mass of material fed. High- and low-level indicators in the stone bin could be used in lieu of the load cells. They can also be calibrated using material balance checks.

Evaluation

Since the feeding mechanisms are mounted internally on most types of preheaters, it is impossible for any agency observer to evaluate their performance. The kiln rotational rate may provide one index of the feed rate since the feeding system is synchronized with the kiln speed.

Magnetic Flowmeters

Because of their ability to measure volumetric flows of abrasive slurries, magnetic flowmeters find prevalent use for kiln feed rate monitoring in the wet process cement industry. These flowmeters measure, over a period of time, the flowrate and total flow of the blended raw material slurry sent into the kiln. This flowrate can be converted to dry raw material mass flowrate by taking into account slurry density (which remains reasonably constant). One plant uses a magnetic flowmeter in conjunction with a density meter.[29,30] The density meter is generally a nuclear density gauge that measures slurry weight per gallon.

Accuracy

Magnetic flowmeter accuracy differs slightly from manufacturer to manufacturer but many claim ±1 percent of full scale or better.[31] Some manufacturers claim accuracies of ±1 percent of actual flow,[32] and others go as low as ±0.5 percent of full scale.[33]

Calibration

Magnetic flowmeter calibration is almost always performed using an electrical simulator;[32] however, in cases where maximum accuracy is required, a comprehensive water calibration that uses a calibration rig is essential.[34] The simulator is connected to the electrode wires in the transmitter, and simulates normal conductor fluid voltages through the flowtube for different flow velocities.[32] The transmitter is checked to ensure that these readings agree with the simulator readings. Because this type of calibration requires that the process be shut down, and because magnetic flowmeters seldom, if ever, drift from calibration, these flowmeters are usually calibrated only once, at the time of installation.[32]

Evaluation Checklist

A magnetic flow monitor is usually not subject to serious operational problems. However, if data confirmation is desirable, the following checklist may be of assistance. Since the instrument is totally enclosed, the extent to which proper operation can be checked is quite limited.

- Check the monitor installation to confirm that the site is free of serious flow disturbances.
- Confirm that instrument is properly grounded, and grounding is free of corrosion, by visually checking ground strap or area.
- Compare instrument reading to kiln rotational speed.

References

1. U.S. Environmental Protection Agency, Standards, of Performance for Portland Cement Plants, CFR Part 60, page 248767, December 23, 1971.
2. U.S. Environmental Protection Agency, Standards of Performance for Lime Plants, CFR Part 60, page 9472, March 7, 1978.
3. Hyer Industries, Inc. Thayer R.F. — A Belt Scale of Proven Stability in Severe Environments, Bulletin 5D66 Rev-1, 1977.
4. Ramsey Engineering Co., Ramsey Precision Belt Scale System Model 10-14, Bulletin TDS 10-14/40-17REV, 1979.
5. Kurylchek, A.L. "Belt Conveyor Scales and Weigh Feeders," Process Instruments and Controls Handbook, Douglas M. Considine (Editor), McGraw Hill Book Company, Second Edition, pages 732-738, 1974
6. National Bureau of Standards. Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring Devices, NBS Handbook 44, September 1980.
7. Pike, C.E. Requirements for the Approval of Belt Conveyor Scales, Southern Weighing and Inspection Bureau, Circular 9585-5, June 1971.
8. Ted Houseconnect, Fuller Inc., personal communication with J. Richards, Engineering-Science, December 14, 1982.
9. Karl Middour, Gifford-Hill, personal communication with R. Segall, Engineering-Science, December 6, 1982.
10. Wallace & Tiernan Division, Pennwalt Corporation, Digital Weighbelt Feeder Series 31-160, Catalog File 310.160, No Date.
11. Hyer Industries, Inc. Thayer — A Weigh Feeder Designed for Computerized Plants, Bulletin 5D65-10/76-5M-SP, 1976.
12. Kay-Ray Inc., Digital Weigh Scale Model 6000X, Bulletin 110-880, No Date.
13. Kay-Ray Inc., Weigh Scale Systems, Bulletin KR123-281, 1981.
14. Ohmart, Weighart Series 4000, Bulletin SDBW-8177, No Date.
15. Kay-Ray Inc., On-Line Weigh Scale Model 6000, Bulletin KR266-1081, No Date.
16. Ken Levin and Morris Yarrow, Ontario Cement, personal communication with J. Richards, Engineering-Science, December 13, 1982.
17. Charles, J., System Service Corporation, personal communication to R. Segall, Engineering-Science, December 8, 1982.
18. Milltronics Inc., Sankyo Flowmeter System Specification Sheet 1051, No Date.
19. Yarway, Solids Flow Transmitter, Bulletin 5M875C, No Date.
20. Wittmann, J.P. Raw Meal Kiln Weigh Feeding Systems, Polysius Corporation, October 1978.
21. Mueller, K., Polysius Corporation, personal communication with J. Richards, Engineering-Science, December 21, 1982.
22. Polysius Corporation, Dosier-System POLDOS, Bulletin 1240 DIE (6000 BU), July 1979.
23. Polysius Corporation, Fordertechnik, Dosier-System POLDOS, Bulletin 1247 (3,5679FM), No Date.
24. Levine, S. High-Value End Uses Underlie Plant Design, Pit & Quarry, pages 53-56 and 123, May 1980.
25. Trauffer, Walter E. Recent Plant Improvement Program Gives Austin White Lime Well Balanced Operation

Pit & Quarry, pages 106-110, May 1965.
26. Gori, T., and Schwarzkopf, F. Metallurgical and Chemical Lime Production via a Coal-Fired Preheater System, Pit & Quarry, pages 100-104, June 1979.
27. Sklavwer, M.M., and Yearham, B. Preheater Cuts Heat Input Demand, Pit & Quarry, pages 52-55, May 1979.
28. No Author. Parallel Flow Lime Kiln Lower As Heat Consumption, Pit & Quarry, pages 85-87, May 1981.
29. Trauffer, Walter E., Peerless' New Detroit Plant, Pit & Quarry, Volume 84, pages 84-93, July 1972.
30. Liptak, B. G. (Editor). Magnetic Flowmeters, Instrument Engineers' Handbook, Volume I — Process Measurement, pages 478-487, Chilton Book Company, 1969.
31. Webb, A. S. Electromagnetic Flowmetering ... Basics, Products, and Applications; Instrumentation Technology, Volume 21, Number 3, pages 29-36, March 1974.
32. Grzenda, J.H., Foxboro Corporation, personal communication with R. Segall, Engineering-Science, December 9, 1982.
33. Liptak, B.G. (Editor). Instrumentation in the Processing Industries, Chilton Book Company, 1973.
34. Harrison, R. Flow Measurement — A State of the Art Review, Chemical Engineering, Volume 87, Number 1, pages 97-104, January 14, 1980.

R. R. Segall and J. R. Richards are with Engineering-Science, Durham, NC 27701.
***Thomas J. Logan** is the EPA Project Officer (see below).*
The complete report, entitled "Technical Assistance Document: Quality Assurance Guideline for Process Feed Rate Monitors in the Portland Cement and Lime Industries," (Order No. PB 84-101 468; Cost: $10.00, subject to change) will be available only from:
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650
The EPA Project Officer can be contacted at:
Environmental Monitoring Systems Laboratory
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

☆U. S. GOVERNMENT PRINTING OFFICE: 1983/759-102/0800

United States
Environmental Protection
Agency

Center for Environmental Research
Information
Cincinnati OH 45268