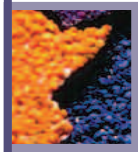
Flow of Solids

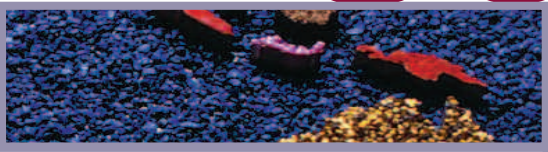
JENIKE & JOHANSON INCORPORATED

Bulk Solids: Science / Engineering / Design

The Newsletter of Jenike & Johanson, Inc.

Fall 2003





New European standard on silo loads nearing completion

A new standard on silo loads is in the process of being adopted. Designated EN 1991-4, it is titled "Eurocode 1 – Action on structures, Part 4: Actions on silos and tanks". This new standard, which encapsulates extensive European research on silo loads over the past 20 years, is widely recognized as the most advanced standard of its kind in the world.

This standard has been under development for over ten years. The committee responsible, headed by Prof. Michael Rotter of the University of Edinburgh, sought and received significant input from civil, mechanical, and chemical engineers from around the world, including engineers from Jenike & Johanson.

Three Reliability Classes are identified, enabling the designer to choose loading conditions appropriate to the size and complexity of the silo structure. The simplest is Class 1, which involves silos with capacities below 100 tonnes. The most complex is Class 3, covering silos with capacities in excess of 10,000 tonnes, or in excess of 1,000 tonnes if the eccentricity of the inlet or discharge exceeds more than half the cylinder radius. Class 2 silos fall between these two extremes.

Silo loads vary widely depending on silo geometry, stored bulk solid, and conditions of filling and discharge. This is the first standard to identify many different conditions and regulate how each should be treated. Requirements according to safety implications are carefully identified.

Not only are the loads associated with classic mass flow and funnel flow conditions described, but the latter is further divided between "pipe flow" (internal flow channel that does not intersect the silo walls) and "mixed flow." Geometries varying from retaining silos (flat bottom with cylinder height no more than 40% of the silo diameter) to very slender silos (cylinder heights in excess of four times their diameter) are covered.

Eccentric filling and discharge cause more silo failures than any other condition. This is the first comprehensive standard to give a rational treatment of each of them. The complexity depends on the Reliability Class. Patch loads are used to deal with smaller eccentricities.

This is also the first standard to fully treat the problem of variability in the properties of the stored bulk solid. Since the characteristic actions

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The Inside View

The world lost a great man on August 8, 2003. Dr. Andrew Jenike, a founder of Jenike & Johanson and the originator of modern day bulk solids theory, was an inspiration to all who had the good fortune of working with him. His keen technical mind, excellent practical insight, good business sense, and boundless energy advanced the field of bulk solids handling more than any other individual has ever done. I couldn't have asked for a better mentor. He was demanding, but no more so than he expected of himself. He valued each employee, and was always looking for ways to make things better for everyone. He accomplished what few in this world have ever achieved, and for this we can all be eternally grateful.

John W. Carson

John W. Carson, Ph.D.,
President, Jenike & Johanson, Inc.

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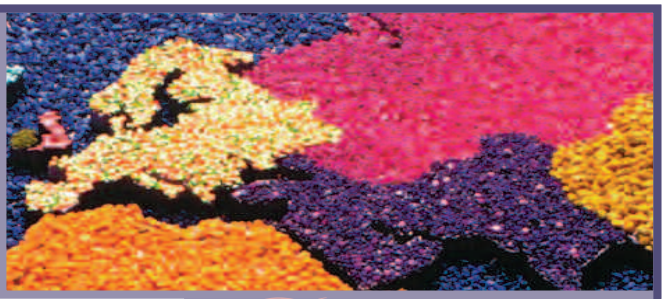
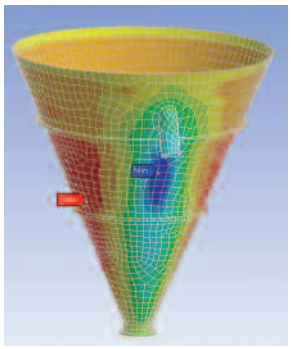
New European standard on silo loads nearing completion



for different parts of a silo are controlled by different ends of the statistical distribution, significant reductions in empirical overpressure factors are possible by taking explicit account of material property variability.



The standard includes a description of test methods to generate parameters needed to calculate silo loads, along with tables of values of these parameters for 24 common bulk solids. Since only a few bulk solids are described in the code, and since the tabulated ranges of design parameters for even these materials are, in many cases, too narrow to cover all design conditions, there is a strong advantage to measuring these parameters on the actual materials to be stored. In this way each silo can be designed safely and, at the same time, economically.

While this standard represents a significant advance, it does not cover many common silo designs and loading conditions. For example, the loads associated with inserts and other internals are not specified. Only conical and wedge-shaped hoppers are included; common geometries such as transition and chisel hoppers are not. The effects of increased loads due to silo vibrations are not considered.

Engineers at Jenike & Johanson are well aware of how to apply this new code as well as its limitations. We have developed proprietary methods to calculate loads for most of the conditions not covered by it. We of course have the capability to measure the various parameters of stored bulk solids that are used in this standard. We also have structural engineers on our staff who are specialists in silo design. Using Finite Element and other design tools, they know how to properly analyze existing and proposed silo structures.

Contact your nearest office of Jenike & Johanson to discuss how we can be of service.

Behind the Scenes: Meet Mike Rulff

Title: Senior Project Engineer
Joined J&J: January, 1990
Job Description: Mike works out of our Toronto, Canada office. He is responsible for working with clients to solve their bulk solids flow problems. He consults on projects ranging from maintaining batch integrity in small dosing systems, to detailed design of belt and apron feeders, capable of delivering up to 7000 tph! Projects can involve all aspects of bulk solids handling: transportation, transfer, storage, and feeding. Specific problems include freezing, dust generation, segregation, lack of live storage capacity, and flow stoppages.

Of note: Mike received his Bachelor of Applied Science in Mechanical Engineering from the University of Waterloo. He is a registered professional engineer in Ontario. Prior to joining J&J, Mike worked as a plant engineer at Pratt & Whitney, American Can, and Inglis. This background, coupled with J&J's scientific knowledge of bulk solids flow, allows him to provide practical solutions that match each client's needs.

"I thoroughly enjoy the variety of industries that I have the opportunity to work with, from small specialized chemical plants to large mining companies. I believe that our mandate at J&J is to ensure that our clients have reliable bulk handling so that they can concentrate on producing superior products without aggravation from the handling system."

New ASTM Standards

The following ASTM standards have recently been adopted for test equipment and procedures developed by Jenike & Johanson. The testers measure the segregation potential of bulk powders, due to either a sifting or fluidization mechanism.

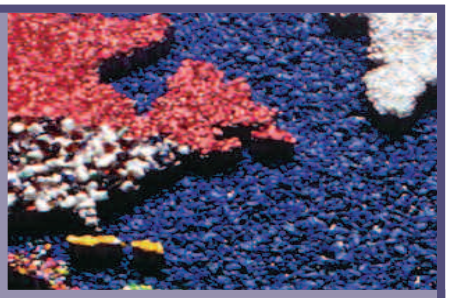
D6940-03 Standard Practice for Measuring Sifting Segregation Tendencies of Bulk Solids

D6941-03 Standard Practice for Measuring Fluidization Segregation Tendencies of Powders

For more information on these testers, please visit our web site:
www.jenike.com/pages/services/test_equip/test_equipment.html

J&J adds representative in Brazil

We are pleased to announce that Gregory Hoyl has recently been appointed as our representative in Brazil. For many years, Jenike and Johanson engineers have been involved in numerous projects in Brazil, concentrating on companies in the mining sector, producing materials such as nickel, iron, copper, and cement. With this new initiative, we can better serve clients in other important Brazilian industries, such as chemical, pharmaceutical, glass, plastic, wood and paper.



Dr. Andrew W. Jenike, 1914-2003

It is with immense sadness that we report the death of Dr. Andrew Jenike, one of the founders of Jenike & Johanson, Inc. Dr. Jenike was widely recognized for his invaluable contribution to the field of bulk solids handling.

Dr. Jenike graduated from the Warsaw Polytechnic Institute with a B.S. in Mechanical Engineering, in 1939. Upon graduation, he entered the Polish Army where he served with distinction as an officer during World War II. In 1949 he obtained his Ph.D. in Structural Engineering from the University of London. Shortly thereafter, Dr. Jenike immigrated to Canada, and later to the United States. Approaching the age of 40, he had an urge to find a field in which he could make a unique and significant engineering and scientific contribution. After a year of study and research, he chose bulk solids flow, specifically flow in bins and hoppers. His primary motivation for choosing this field over the 40 or so others that he considered, was the low level of technology that existed at the time. Most hoppers were either 45° or 60°, because most engineers had a 45° and a 30°-60°-90° triangle in their desk. No consideration of flow properties entered into the selection of hopper geometry or material of construction. With financial assistance of the Engineering Foundation, National Science Foundation, and the American Iron and Steel Institute, he set up the Bulk Solids Flow Laboratory at the University of Utah. He entered full time private practice in 1962, and in 1966, he organized Jenike & Johanson, Inc., putting his knowledge and insight to work solving numerous industrial bulk solids handling problems.

Dr. Jenike was known worldwide as the originator of modern day bulk solids flow theory. Through his research, Dr. Jenike was able to identify and define mass flow, identify basic flow properties of bulk solids, design equipment to measure these properties, recognize that feeder design affects flow behavior in bins, develop techniques to predict limiting flow rates from bins, and develop equations to predict loading on bin walls.

In recognition of his pioneering efforts, Dr. Jenike received the Humboldt Scholarship in 1976; in 1989 he was elected Fellow of the ASME; in 1993 he received the Solids Handling Award from the Institute of Mechanical Engineers, the first non-U.K. citizen to do so; and in 1998 he received the Particle Technology Award from AIChE.

In addition to Dr. Jenike's research and development work, he lectured extensively, authored numerous publications, and worked as a consultant for 25 years. Almost every significant technical paper written in the past 40 years, having to do with bulk solids flow, references one or more of Dr. Jenike's publications. It is impossible to estimate the number of bins, hoppers, and feeders that have been built based on the sound principles and design guidelines developed by Dr. Jenike.

"To live in the hearts we leave Is not to die."
-THOMAS CAMPBELL

On behalf of the staff at Jenike & Johanson, we would like to extend our heartfelt condolences to Una, Dr. Jenike's wife of 60 years, as well as to the rest of his family.

Editor's note: In this limited space, it is not possible to properly credit Dr. Jenike with the accomplishments he has achieved, and describe the positive impact he has had on numerous businesses as well as many individuals. And maybe such a task is not truly necessary. His work, and the memories that others share will live on, for a long time.

Did you know?

This issue, and recent past issues of our newsletter are available for downloading from our web site in PDF format. Some of our most requested papers are also available. For more details, please visit the following web page:
www.jenike.com/pages/education/education.html

Q&A with J&J

Q How often should I inspect my silo, and what should I look for?

A It is important to clean and inspect the inside of every silo on a regular basis. There is no all-encompassing rule that dictates how often this should be done; frequency is determined by many factors, including how much use the silo sees, whether it is indoors or outside and exposed to the weather, and the variety of stored materials and their respective flow and chemical properties. Regular cursory inspections while the silo is operating should be scheduled about once every two or three months, and cleanout and inspection of the inside of the silo at least once every year. The latter should be done more frequently if shutdown times permit or if there are signs of silo distress (holes, wrinkles, etc).

Jenike & Johanson engineers are experts at silo inspection. We can set up an inspection program for you to conduct yourself, or do the inspection for you.

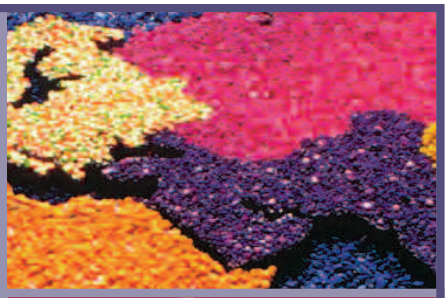
If you have any bulk solids handling questions, or if you have suggestions for future articles, please contact:

Flow of Solids® Newsletter
Jenike & Johanson, Inc.
One Technology Park Drive
Westford, MA 01886-3189

E-mail: newsletter@jenike.com

Flow-of-Solids Industry Calendar

"You get the benefit of years of experience."
"Instructors were very knowledgeable, well prepared, and professional"
- From course attendee evaluations of recent Jenike & Johanson presentations



Oct. 26-30 2003, Salt Lake City, UT
AAPS Annual Meeting and Exposition. The largest gathering of pharmaceutical scientists in the world. Talk to a Jenike & Johanson engineer at booth #720.

Oct. 29-31 2003, Houston, TX
AIChE courses, *Flow of Solids in Bins, Hoppers, Chutes, and Feeders*, and *Pneumatic Conveying of Bulk Solids*†.

Oct. 30-31 2003, Brazil
David Goodwill, president of Jenike & Johanson Ltd., will present the two-day course, *Flow of Solids in Bins, Hoppers, and Feeders*.

Nov. 3-4 2003, Miami, FL
3rd North & South American Cement Conference and exhibition for markets, production and processing technology of cement in North, Central, and South America. Jenike & Johanson project engineer, Eric Maynard, will present a paper on bulk solids handling in the cement industry.

Nov. 5-6 2003, Ypsilanti, MI
P/M Parts Compacting/Tooling Seminar. Jenike & Johanson senior consultant, Brian Pittenger, will discuss the "Impact on Product Quality by Hopper Design and Conveying System."

Nov. 18-19 2003, San Juan, Puerto Rico
Troubleshooting Technology '03 Conference. Jenike & Johanson project engineer, Roger Barnum, will present, *A Solid Dosage and Blend Content Uniformity Troubleshooting Diagram*.

Nov. 18-20 2003, New York, NY
50th Chemical Processing Industry Exposition (Chem. Show). Jenike & Johanson engineers will present the following seminars and tutorials:

- How to select or troubleshoot volumetric and gravimetric feeders to ensure reliable flow
- Blending and segregation and their effects on product quality
- How to ensure reliable solids flow in bins and hoppers
- Fine powders: reliably handling bulk solids that can behave like fluids

Dec. 4-5 2003, Bethesda, MD
Product Quality Research Institute (PQRI) Blend and Dosage Unit Uniformity Workshop. Jenike & Johanson senior consultant, Jim Prescott, will discuss segregation, and troubleshooting blending and content uniformity issues.

Dec. 8-10 2003, New York, NY
AIChE courses, *Flow of Solids in Bins, Hoppers, Chutes, and Feeders*, and *Pneumatic Conveying of Bulk Solids*†.

Dec. 9-11 2003, Las Vegas, NV
POWER-GEN International. The largest power event in the world. Jenike & Johanson senior project engineer, Rod Hossfeld, will present a paper titled, *New Technology Restores Waste Coal Feed to Boiler.*

Mar. 29- Apr. 1 2004, Baltimore, MD
6th Annual Electric Power Conference and Exhibition. Jenike & Johanson senior project engineer, Rod Hossfeld, will present a course on *How to Assess Your Bunker for Coal Flow Reliability.*

†To register, contact AIChE, (800) 242-4363, or visit www.aiche.org.

More complete course information is available at www.jenike.com/pages/education/dates.html

Hot Off the Press

Silo Maintenance – It's Up To You
by J. W. Carson and T. Holmes

The Dangers of Relying on Wall Friction Values in Codes
by J. W. Carson, H. Purutyan, and J. M. Rotter

The Use of Stratified Sampling of Blend and Dosage Units to Demonstrate Adequacy of Mix for Powder Blends
by J. K, Prescott, et al

What You Need to Know to Reliably Handle Waste Coal
by R. J. Hossfeld, D. A. Craig, and R. A. Barnum

Storage and Feeding of Dry Copper Concentrates Into Bath Smelting Vessels
by P. Chacana, R. Valenzuela, D. Goodwill, A. del Campo, and F. Cabrejos

How to Avoid Common Shear Testing Mistakes
by D. A. Ploof and J. W. Carson

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West Coast, USA
Jenike & Johanson, Inc.
3485 Empresa Drive
San Luis Obispo, CA
93401-7328 USA
Voice: (805) 541-0901
Fax: (805) 541-4680

Canada
Jenike & Johanson, Ltd.
400 Carlingview Drive
Toronto, Ontario
M9W 5X9 Canada
Voice: (416) 674-8595
Fax: (416) 674-8520

South America
Jenike & Johanson, Chile S.A.
Av. Libertad 798, Of. 701
Viña del Mar, Chile
Voice: (+56) 32 690 596
Fax: (+56) 32 690 596

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