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Test Devices Inc.

Anatomy of an Accident *(Sidebar to:Ensuring Spin Test Safety)*

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IN LATE 1984, Test Devices Inc. in Hudson, Mass., was contracted to build a 36-inch spin test facility for a manufacturer of large centrifugal compressors for air conditioning systems. These compressors use large impellers that are typically 30 inches in diameter and weigh up to 600 pounds. The customer had a spin pit of its own until an impeller burst in the pit and the system was destroyed as a result of inadequate design of the burst containment structure. The burst destroyed the chamber and put holes in the wall and roof of the building. Several people witnessing the test in the same room narrowly missed serious injury.

As part of the acceptance test for the system, Test Devices agreed to burst a similar rotor in the new pit to demonstrate that it would satisfactorily contain such an event. On January 9, 1985, a 600-pound stainless steel rotor was installed in the completed spin pit. The burst test was run at ambient temperature and in a vacuum. At approximately 13,000 rpm the rotor grew plastically and became grossly unbalanced. This occurred a total of three times and each time it was necessary to stop the test, rebalance the part, and begin again.

At approximately 1 A.M. on January 10 the rotor reached 14,000 rpm and burst. Three people conducting the test were located in a room adjacent to the test room and one floor above. They were above the burst plane and away from the top of the chamber, both of which are classic hazard zones. The burst made a single thud-like noise (typical of bursting rotors), and the testers approached the room to inspect the part. The corridor and stairwell were full of plaster and concrete dust and the sprinkler alarm was sounding loudly. Lead bricks from inside the spin pit were found in the hall, and soon sirens were heard outside.

The scene in the test room was one of complete devastation. The cover of the spin pit, weighing 11/2 tons, had been blown up through the ceiling and fallen back down. The rollup door of the test room had been blown out into the parking lot. The side of the building had extensive damage from lead bricks and pieces of the impeller penetrating the wall. One lead brick flew out the side wall, penetrated the side of a neighbor's house, and came to rest in the kitchen. Miraculously, no one was injured.

There were holes in the walls of the building on a line approximately 45 degrees up from the centerline of the pit covering an area of about 320 degrees. This ejection cone directly intersected the control room where the test engineers were located, but the area of destruction had a gap almost exactly the size of the control room (fragments had penetrated the walls within two feet of the control room).

Considerable time was spent analyzing the incident and examining the forensic evidence. The spin chamber had contained the radial burst forces, and only 5 percent of the kinetic energy escaped from the pit. This energy, however, was enough to cause structural damage to the steel beams that held up the building, blowout walls, and drive the spin chamber into the concrete floor of the room. The floor was pushed down about 1 inch and the three leveling pads (2 inches tall) were embedded in the concrete.

It was concluded that the cause of the accident was the impact of impeller fragments on the lead wall inside the chamber, extruding the lead bricks vertically and exerting a force on the cover of the spin pit of approximately 2.1 million pounds. The cover bolting arrangement used 24 each of 1 inch bolts and nuts with a combined strength of 1.9 million pounds. Some of the high-strength bolts were broken in the tensile mode but most of them remained intact. However, the threads were stripped out of the nuts and some damage to the bolt threads occurred. After an analysis, it was determined that the bolts were able to develop approximately 80 percent of their rated holding power. There was no evidence of chemical explosion, no fire, and no excess heat.

A one-fifth scale model of the spin pit and rotor was built, put inside another spin pit, and burst to verify the failure theory. A ledge was then designed and welded onto the pit liner. This ledge was designed to turn the lead bricks back inside the pit and contain the extrusion. This procedure confirmed that the ledge in the liner would contain the extrusion forces.

A new full-size spin test system was built, with the new ledges installed, and tested at the customer's site with the same type of rotor and in the same conditions under which the accident had occurred. The spin pit was placed inside a reinforced concrete test room for safety. The test was successful, and the burst was contained exactly as predicted by the model pit experiment.

Customers with spin test systems designed by Test Devices were notified immediately after the accident to cease usage until an analysis of the accident was completed and a solution could be found. Retrofit packages were designed for all in-field spin pits and lead retention ledges were in. stalled in the existing Test Devices spin systems.

The most remarkable fact regarding this accident, like other spin test accidents, was that the people involved in the testing survived unscathed. It is for this reason, and a healthy respect for the unknown and unplanned, that Test Devices strongly urges installation of spin test systems inside concrete test cells.

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