# Is Your Company Policy on Equipment Wear Putting You at Risk?

*By Oscar Duckworth*

**Warning!** Use of this component will cause explosion, possible bodily injury, or property damage.

Would anyone use a component displaying this warning? Probably not. Any part of a wet-mix placement system that is in contact with the shotcrete mixture, however, is subject to wear and will eventually fail, creating a serious safety hazard.

Wet-mix placement system components are similar to our truck tires: when new, tires can be considered safe to carry their rated capacity. Over time, wear or abuse will reduce overall safety to the point that failure is imminent. Wet-mix placement system components, like truck tires, must be regularly inspected for wear and cannot be used to their failure point without creating a safety hazard.

The use of high-pressure shotcrete equipment can create an enormous risk should a placement system component failure occur. All wet-mix placement system components must be capable of safely carrying the maximum available outlet pressure for the pump.

## Can Wear and Failure Be Predicted?

A wet-mix placement system component has reached the end of its service life when there is no longer sufficient material to safely carry the component's original working pressure rating. Internal thinning due to wear is the most common cause of wet-mix placement system failures. Concrete is naturally abrasive, and augers and paddles, which rotate within the concrete mixture, quickly wear from contact. Shotcrete placement requires high-output pressures to convey the low slump mixture through the placement system. Increasing placement system length or vertical lift will further elevate line pressures. As internal pressure is raised, abrasive materials are pressed harder against the interior of placement system components. This creates much higher wear rates than would be common for ordinary concrete pumping operations. Increasing line pressure will always increase wear rates. Shotcrete mixture variations may also increase wear rates. All wet-mix placement system components will wear at different rates due to:

- The amount of exposure to abrasion;
- The material the placement system component is made of;
- The amount of pressure to which the component is subjected; and/or
- Mixture proportion variables.

Because expected service life cannot be predicted, how can a wet-mix shotcrete crew determine when a placement system component has reached the end of its safe service life? A worn placement system component can easily be identified as an oversized interior diameter (ID) by inspection with a measuring device. Validation by measurement assures that a component can be removed from service when it is no longer safe.

Your company policy should clearly define the maximum usable interior diameter for all placement system components and discourage the use of any component that is no longer safe.

Elbows, reducers, and sweeps near the pump possess the greatest burst hazard due to high line pressures, but any placement system failure is a potential risk. If a wet-mix placement system becomes plugged near the nozzle, the entire system will quickly reach the maximum available pump pressure and create a serious safety hazard should a failure occur.

Figure 1 shows two identical 2 in. (50 mm) raised-end reducers: Reducer A is in new condition

*Fig. 1: Reducer A (left) is in new condition. Interior diameter is 2 in. (50 mm). Reducer B (right) displays obvious wear. Interior diameter is 2-1/4 in. (56 mm)*

*Fig. 2: Reducer A (left) displays acceptable wall diameter. Reducer B (right), with a wall thickness of 0.06 in. (1.5 mm), illustrates a burst hazard*

*Fig. 3: Elbow A (left) displays a 4 in. (101 mm) interior diameter. Elbow B (right) measures 4-5/16 in. (109 mm)*

and Reducer B is in daily service. The inside diameter of Reducer A is 2 in. (50 mm). Reducer B has thinned to an internal diameter of nearly 2-1/4 in. (57 mm) or about 10% oversize. Reducer B was then cut open and the material thickness was measured at the component's thinnest area (Fig. 2). Wear had reduced the wall thickness to only 0.06 in. (1.5 mm)—dangerously thin.

Two 4 in. (102 mm) elbows were measured for wear (Fig. 3). Elbow A was in new condition and the interior diameter measured 4 in. (102 mm).

Elbow B was well worn and the interior diameter measured 4-1/4 in. (108 mm). Elbow B was then cut open, revealing a wall thickness of less than 1/8 in. (3 mm).

The worn components—both the elbow and the reducer—are vivid examples of how minor differences in oversized IDs can create major differences in safe wall thickness.

## Establishing Safe Wear Limits

National pipe-industry standards define minimum wall thickness requirements for various working pressure ratings. Wet-mix shotcrete placement system components must carry a working pressure rating of greater than 1250 psi (8.6 MPa) to minimize burst hazard. To achieve this rating, a minimum wall thickness of 1/8 in. (3 mm) or more is required for pipe sizes common to wet-mix shotcrete placement (Fig. 4). Most raised-end placement system components are available to safely carry these pressures in "as new" condition.

In an attempt to establish safe wear limits for "in use" components, a total of 24 wet-mix placement system components were tested (Fig. 5). Each had been removed from service after measurement revealed that wear may have increased the interior diameters beyond safe limits. Each component's interior diameter was measured and recorded, then cut open at its thinnest area (Fig. 6) to validate the wall thickness.

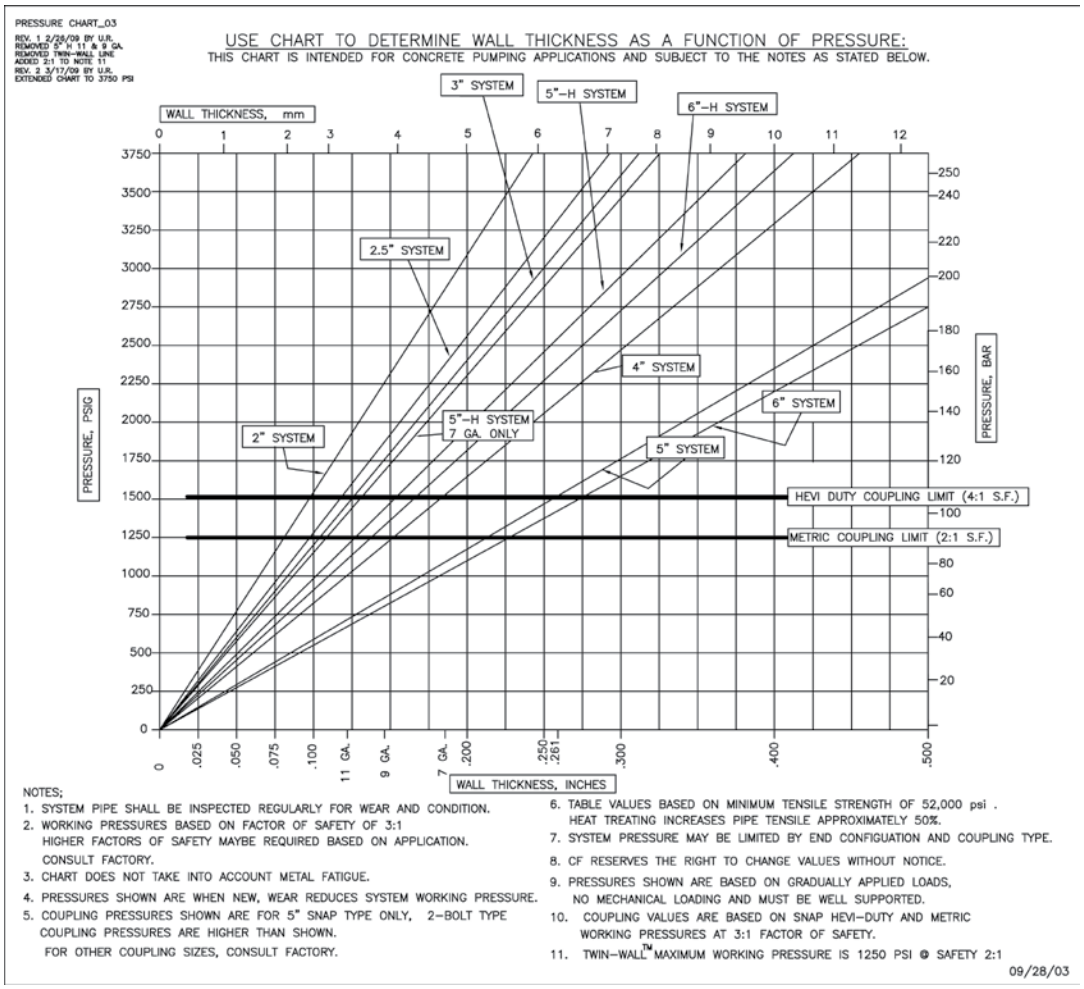


*Fig. 4: Wall thickness chart, courtesy of John Schantz, Chief Engineer, Construction Forms, Inc.*

## Test Results

- The wall thickness fell below 1/8 in. (3 mm) on all 2 in. (50 mm) hose couplers and sweeps with only 1/8 to 5/32 in. (3 to 5 mm) oversized ID.
- The 2 in. (50 mm) reducers (small end) showed a 3/16 in. (5 mm) oversized ID reduced wall thickness below 1/8 in. (3 mm) on average.
- The 3 in. (76 mm) reducers (small end) maintained a 1/8 in. (3 mm) wall thickness only below 3/16 to 1/4 in. (4.8 to 6.3 mm) oversized ID on average.
- The 4 in. (101 mm) reducers (small end) wall thickness fell below 1/8 in. (3 mm) on average at a 1/4 to 5/16 in. (6.3 to 8 mm) oversized ID.

## Discussion

- Due to unique component shapes, conventional machinist style calipers were ineffective to measure the actual wall thickness (prior to saw cutting).
- On average, as the interior diameter is increased 5 to 10%, the wall thickness may decrease by 50 to 90%.
- Saw cuts revealed insufficient wall thickness on every component tested.
- No component tested could be considered safe to carry the stated working pressure rating.

## Summary

A responsible company would not send a loaded truck out of the yard on bald tires, which presents an obvious, visible safety hazard. Wet-mix placement component safety risks are not obvious. Inspection by measurement is the only method available to assure safe, "in use" components. A company policy that establishes wear limits for all pressurized components should be an important part of everyone's safety program. Rigorous inspection by measurement is mandatory. Discard components before wear creates a safety risk. These are essential steps for safe wet-mix shotcrete placement.

## Conclusion

- Never put anyone at risk from wear;
- Never allow a wet-mix placement system component to be used to its failure point;
- Establish wear limits for all placement-system components;
- Inspect and verify placement components with a measuring device before use; and
- Discard any component that may not safely carry its original maximum working pressure rating.

*Fig. 5: Placement system components prior to saw cutting*

*Fig. 6: 2 in. (50 mm) hose couplings create a unique safety risk. Thinnest area of coupler is hidden within collar (pointer), making external wall thickness validation impossible. Saw cutting revealed insufficient wall thickness for any 2 in. (50 mm) coupler, which measured 1/8 to 5/32 in. (3 to 4 mm) oversized ID. Note: Raised-end component shapes created challenges using conventional machinist calipers to determine wall thickness*

*ACI Certified Nozzleman **Oscar Duckworth** is an ASA and ACI member with over 15,000 hours of nozzle time. He has worked as a Nozzleman on over 2000 projects. Duckworth is currently an ACI Examiner for the wet-mix process and is an approved ASA wet-mix and dry-mix Educator. He continues to work as a Shotcrete Consultant and a Certified Nozzleman.*