NEW

Is Your Wet-Mix Placement System Safe?

By Oscar Duckworth

"It's lucky no one was killed," said the nozzleman. "I just didn't see it," was the only explanation offered by the pump operator. Moments earlier, a plug had occurred within a placement hose a few sections downline of the shotcrete pump. As the line pressure climbed quickly toward the maximum, a placement hose ripped open, unleashing a destructive force none of us would ever forget.

Every day we routinely connect a high-pressure shotcrete pump to a wet-mix placement system, but how much do we really know about the potential hazards created by its use? A modern wet-mix shotcrete pump is capable of producing extremely high operating pressures, often 1250 psi (8.6 MPa) or higher. The operating pressure created within a modern wet-mix shotcrete pump can be extremely dangerous if precautions are not taken to assure that placement system components are able to withstand maximum pump pressures.

Today the crew was lucky—no injuries—just an immense cleanup. But next time, who knows? Anytime we use a wet-mix placement system, there is a potential for injury. How do we ensure that our wet-mix placement system is as safe as possible?

Fig 1: Top hose has a working pressure of 800 psi (5.5 MPa), which is underrated for shotcrete placement. The 1250 psi (8.6 MPa) pressure of the lower hose may be acceptable

Wet-Mix Placement System Components

Wet-mix shotcrete placement system components consist of all reducers, couplings, pipes, elbows, and hoses that convey the shotcrete mixture from the pump outlet to the nozzle. All air supply lines and couplers, from the compressor outlet to the nozzle and blow pipe, are also part of the placement system.

Each component must display a working pressure rating that is equal to or greater than the maximum available outlet pressure of the pump to which it is connected (refer to Fig. 1). A working pressure rating is typically 1/3 to 1/2 of a component's burst or failure pressure. Many currently available placement system components will create a hazardous condition if used in conjunction with a modern shotcrete pump. Don Mace, Safety Director, Schwing of America, states, "the Schwing shotcrete pumps can produce in excess of 1250 psi (8.6 MPa) outlet pressure." Mace cites the American Concrete Pumping Association (ACPA) safety guidelines as the only safe use of the Schwing wet-mix equipment. This excerpt is reprinted with permission from the *ACPA Safety Manual* (refer to Fig. 2).

> "Heavy-duty or raised-end couplings are designed to handle pressure up to 2250 psi (15.5 MPa) @ 2:1. They have a tapered face that draws the sections together during assembly.
>
> Grooved-end couplings of a lip height of 0.15 in. (3.8 mm) or less are designed for pressures below 750 psi (5.2 MPa) @ 2:1. The recessed groove is hard to clean when changing sections on the job. This end will fail before the pipe will fail because the groove is cut into the pipe thickness, making it the weakest spot.
>
> Grooved ends are not recommended for wet-mix shotcrete placement."

How About Nozzle Couplings?

Many wet-mix nozzlemen have resisted the use of raised-end clamps at the nozzle, citing their

inherent bulkiness and significant additional weight, which hinders maneuverability and increases fatigue. In the past, the lightweight grooved end clamp was commonly used in this location; however, many nozzle manufacturers no longer produce grooved-end nozzle fittings citing ACPA Safety Guidelines that prohibit their use. Some nozzlemen still prefer the use of a threaded (no clamp) nozzle connector due to its exceptional maneuverability and light weight (refer to Fig. 3). The pipe threads, however, can foul with concrete, making removal and safe installation difficult.

Are Other Couplers Available?

A new flared-end clamping format has recently been introduced by Construction Forms Inc. (Conforms), which uses the lightweight, compact characteristics of a grooved-end coupler with the same working pressure rating of the much larger raised-end coupler (refer to Fig. 4 and 5).

John Schantz, Product Development Engineer, Con Forms, states, "the flared coupling system seems ideal for hand-nozzle shotcrete applications where the placement system must be lifted or carried during placement. Less weight means less effort for the nozzleman and crew with no compromise to safety."

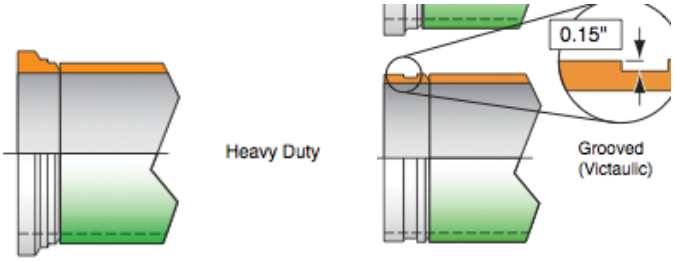
Reduce Pressure When Possible

Wet-mix placement systems, which convey the shotcrete mixture long distances or to higher elevations, can work under enormous pressures. Steps may be taken to reduce pressure and increase safety, such as the use of steel pipe (slick line) instead of rubber hose when possible. Concrete requires less line pressure conveyed through the steel line than through rubber hoses and is more resistant to puncture and abrasion (refer to Fig. 6). If possible, situate the pumping equipment as close to the work area as possible to minimize placement system length. Reduced placement system length means lower operating pressure.

When routing your placement system, avoid or provide protection from chafing and possible puncture from hard or sharp objects.

Never use placement system hoses that display visible abrasion damage. A damaged hose is a potential burst hazard and should be discarded. When possible, route the system away from public areas due to the potential hazards.

The use of the provided pin on a raised-end coupler will prevent an unintentional opening during use and should always be in place.



GENERAL RULES

SAFETY MANUAL

5.9 **WARNING** Do not use a piece of pipeline, end hose, coupling, or any other material delivery component that is not in good condition. **Replace, do not repair damaged pipes and hoses.** Concrete pipeline system is subject to wear, and the rate of wear is affected by pumping pressure, concrete composition, pipeline material, and other factors. Read and understand the minimum wall thickness chart in the *Appendix* of this manual. **Bursting pipes and concrete escaping under pressure is a serious safety hazard!** (See Figure 7)

Figure 7
Delivery system components must be able to withstand maximum pump pressure

5.10 When laying out a pipeline, it is preferable to use an elbow instead of a hose to make direction changes. Elbows have less resistance to flow than hoses, and will therefore reduce the overall pressure required to push the concrete.

5.11 Always use the largest diameter pipeline that is practical, and use steel pipe instead of rubber hose. This will keep the pressure required to push the concrete to a minimum.

5.12 Support the delivery pipeline. Either an "S" transition pipe should be used to bring the pipe to ground level, or **each** section of the pipeline should be supported at the pump outlet level.

5.13 **WARNING** The sections of pipe nearest the pump are subjected to the highest pressure and the greatest wear. Because of this increase of pressure near the pump, you should install only thick walled pipe, in "like new" condition there. Read and understand the minimum wall thickness chart in the *Appendix* of this manual.

5.14 **WARNING** **The maximum concrete pressure of the pump must be the only factor used to determine what thickness of pipe and what type of ends are needed.** In the case of a rock jam or any other type of blockage, **the maximum pressure of the pump will be exerted.**

5.15 Grooved (Victaulic) ends are **not recommended** for concrete pumping. Read and understand the comparison between heavy duty raised, metric, and grooved ends in the *Appendix* of this manual.

5.16 **WARNING** If the pipeline remains on the job (as is the case when pumping a high rise building), **the operator is responsible for checking the pipeline for dents, cracks, wear, and continuity each day before the pour begins.**

Fig 2: Excerpt of American Concrete Pumping Association Safety Manual.

Fig 3: Two inch (50 mm) pipe thread acts as nozzle coupler

Fig 4: Heavy-duty coupler (bottom) weighs nearly 40% more than the flared end fitting (top). Both have a 2 in. (50 mm) interior diameter

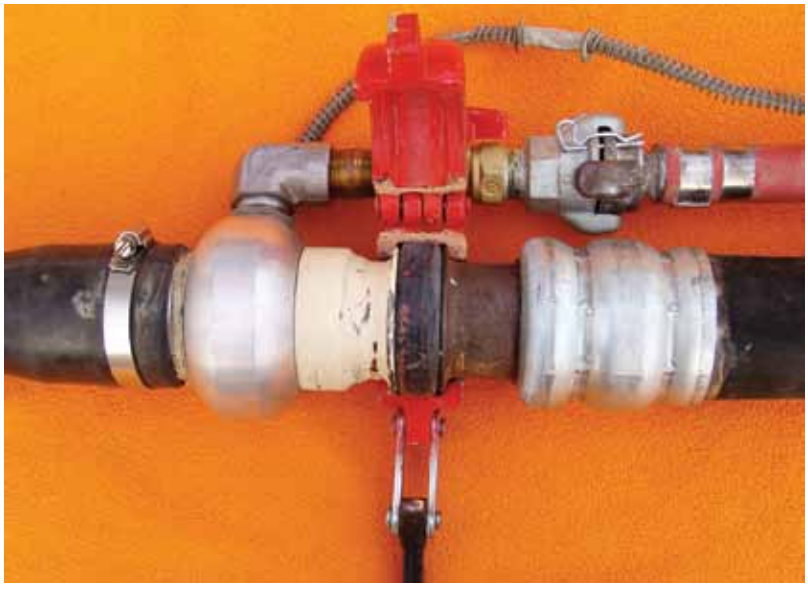


Fig 5: Flared-end coupling and gasket-in-nozzle application

Fig 6: Interference with a foreign object caused this preventable failure

A safe placement system must also include the use of approved components within the air supply lines. If Chicago-style fittings are to be used, safety clips are essential (refer to Fig. 7). Some job-site safety requirements, however, prohibit the use of Chicago-style fittings.

Current safety requirements mandate the use of positive interlocking couplers such as the Thor fittings (refer to Fig. 8) with whip checks installed at all air supply line couplings.

Whenever any material is highly pressurized and conveyed through a pipe or hose, there is the potential for an accident. The proper selection and rigorous inspection of all placement system components for wear, chafing, or cracking are essential elements to the use of a safe wet-mix placement system and should be part of a wet-mix shotcrete crews' daily routine.

Wet-Mix Placement System Safety Checklist

- Know the maximum outlet pressure of your wet-mix shotcrete pump. If the maximum outlet pressure is not known, ask.
- All placement system components must display a working pressure rating at or above the maximum outlet pressure of the pump.
- Safely route the placement system away from sharp objects that may damage or rupture a system during use. Discard components that show visible damage or wear.
- Use only approved coupling devices. Avoid Victaulic-type grooved-end couplings.
- Always use whip checks on air supply line couplings. Use positive interlocking couplers such as Thor fittings.
- If Chicago-type fittings are used, always use safety clips.
- Pressures are greatest near the pump. Only use new or like-new condition parts for the first several sections.
- Keep the placement system as short as is practical—less system requires lower line pressure.

Remember: the failure of any wet-mix shotcrete component while under pressure can cause serious injury or property damage.

Be vigilant about inspecting placement systems. Components are subject to extreme pressures that can quickly cause wear, cracking, or other potentially dangerous damage. Placement systems cannot be inspected too often. Visual inspection by the nozzleman and crew is a key element in the use and maintenance of a safe wet-mix placement system.

Fig 7: A Chicago-style fitting with whip check and safety clip in place

*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.*

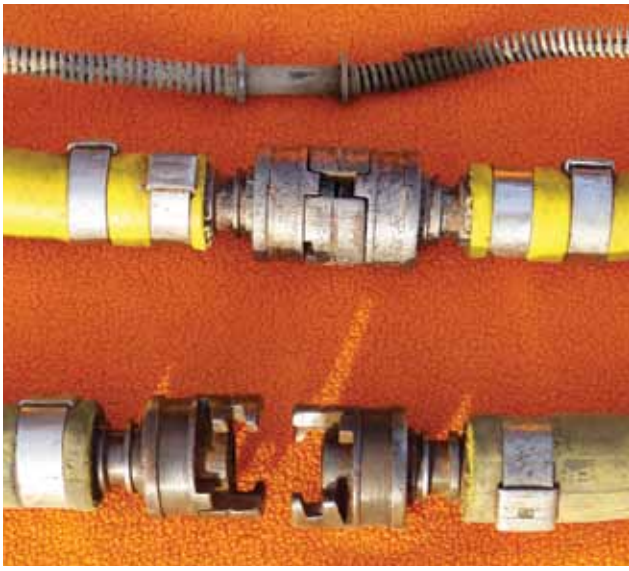


Fig 8: Thor positive-interlocking coupler. Note locking teeth on the open coupler