All Those Small Numbers We Ignore - What Do They Mean?

By Oscar Duckworth

We have all seen those small letters and numbers that mark practically everything we use in construction. To most, these are meaningless markings that are meant for someone else. However, with shotcrete, nothing could be farther from the truth.

Nearly every component we use is designed to meet a certain specification, capacity, or load rating. Chains, cables, tires, hardware, even nuts and bolts carry clear markings that define exactly what range(s) they are rated to perform within.

You may not be aware that the delivery line components such as hoses, pipes, clamps, and elbows we use every day are *not* specifically designed for high pressure shotcrete use. They are designed to safely convey concrete or grout materials during routine concrete pumping operations, and function within a specific pressure range known as the component's working pressure. Common concrete placement system components such as pipes, sweeps, hoses, and couplers are available in every price range. These components can appear similar, and fit a certain size profile, but may not be designed to safely function at the high pressures we need for shotcrete placement.

Fig, 1. Similar appearing tires may have very different load ratings.

As a comparison, the vehicles we use, and their weight carrying capacity can vary considerably. Tires are not designed to be vehicle specific. They are designed to a certain size profile and engineered to function within a specific load range known as the tire's weight rating. A common passenger car tire may fit a heavy truck, but the tire may not be designed to safely carry the fully loaded weight of the truck. This is why load carrying capacities are required by federal law to be clearly identifiable on all tires. Tire manufacturers spend millions designing and testing their products prior to assigning a load rating. To select the correct tire, it is essential that we know the expected total loaded weight of the vehicle, and a tire chosen to function within a range at or above its expected fully loaded weight. Guesswork can lead to selecting a tire that may be under-designed and fail under a fully loaded condition. For this reason, federal regulations require the gross vehicle weight rating (GVWR), or fully loaded weight information to be prominently displayed beside every vehicles identification number in the driver's side door area.

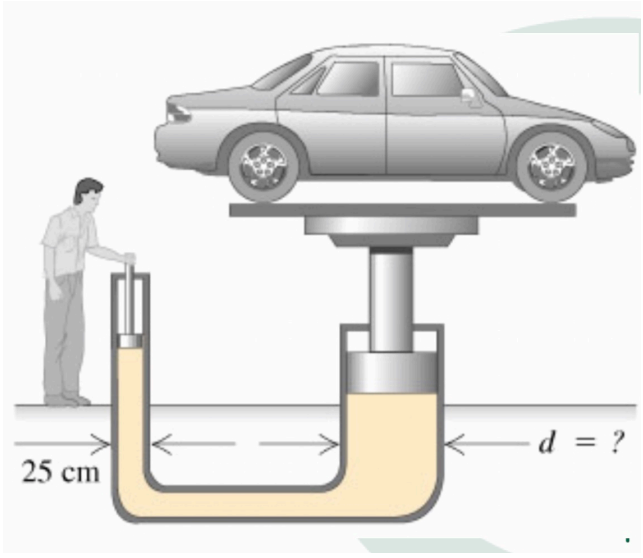
Fig, 2. A high powered Shotcrete pump sheared an un-rated elbow reducer. Luckily, no one was injured.

Like the tire, to properly select delivery line components to be used with shotcrete, it is essential that we know exactly what the expected total "load" or maximum pressure rating of the concrete pump used. Unfortunately, these critically important maximum values are not required to be displayed on the concrete pumping equipment. Additionally, concrete pumps designed primarily for shotcrete placement typically produce far more available pump pressure than a common concrete pump. Worse, few workers can determine a pump's maximum available concrete pressure from information provided by the values displayed on the instrument panel's gauges.

The pressure carrying capacity or "working pressure rating" of each delivery line component is critical because in the event of a blockage, the system will become loaded to the concrete pump's maximum available pressure within moments. Components not designed to function at the pump's maximum concrete pressure become a serious safety hazard.

Fig, 3. Working pressure ratings clearly displayed on common placement components.

So... how can a crew know that placement system components that are designed to convey concrete can be considered safe to be used with the far higher pressures of a shotcrete-specific concrete pump?



Fig, 4. The hydraulic system permits a nearly limitless multiplication of force.

Working Pressure Safety Checklist:

1. Determine the ACTUAL maximum concrete pressure your pump can produce.
2. Become familiar with the location and meaning of the working pressure ratings displayed on reducers, sweeps, hoses, clamps, and other placement system components.
3. Never purchase or use un-rated delivery line components or parts that are designed to a lower working pressure rating than your pump's maximum concrete pressure rating.
4. Educate operators and other workers of working pressure ratings and their relationship to safe operation.
5. Remember that the working pressure rating is for components in as-new condition. It does NOT account for wear.

Delivery line components are designed to safely function within a range not to exceed the posted working pressure. Manufacturers establish safe working pressure limits through over-designing to attain a working pressure of approximately 1/3 to 1/2 of the component's actual burst or failure pressure.

To determine whether a component can be safely used, or is under-designed for shotcrete placement, it is essential to recognize that the maximum available concrete pressure of the pump should not exceed the delivery line component's posted working pressure rating.

SHOTCRETE PUMP EVOLUTION HAS CREATED SAFETY HAZARDS

Early mechanical action concrete pumps multiplied available pushing pressure to the concrete by numerous gears, pulleys, belts, and chains. These machines were not capable of producing concrete pressures above about 300-500 lb/in^2 (2 – 3.5 MPa). Delivery line manufacturers were not required to display working pressure ratings due to the low available pressure of that era.

As placement equipment evolved, hydraulically-driven concrete pumps became available. The hydraulic design allows for a nearly limitless multiplication of force between the available hydraulic pressure and the pushing pressure that can be exerted to the concrete in the delivery line.

The maximum available concrete pressure that can be produced by a modern hydraulic concrete pump MUST be governed by a bypass valve which releases excessive hydraulic pressure at a pre-set limit that is determined by the manufacturer. Without this function, a hydraulic concrete pump is capable of developing concrete pressures far greater than the delivery line hoses, fittings, couplers, and other components can safely withstand. Although elbows, sweeps, and reducers can be efficiency manufactured with thicker materials to facilitate higher working pressures, flexible hoses, particularly their crimped end couplings, cannot. Currently, flexible steel braided or fabric corded delivery line manufacturers offer few, if any placement hoses designed with a working pressure rating above approximately 1250 lb/in^2 (85 Bar). For safety reasons, many, but not all hydraulic concrete pump manufacturers pre-set the factory bypass valve to limit concrete pressures to 1250 lb/in^2 or below. Unfortunately, some pump operators alter the bypass settings to increase pressure above the factory-set levels. As a very general rule, concrete pressure is approximately one-third of the hydraulic pressure displayed on the main hydraulic pressure gauge on the pump's instrument panel. As an example, a hydraulic pressure gauge displaying about 3000 lb/in^2 (200 Bar) would theoretically have a concrete pressure of approximately 1000 lb/in^2 (70 Bar) during placement. Likewise, a gauge reading 3600-3800 lb/in2 (250-260 Bar) would indicate a concrete pressure of roughly 1250 lb/in^2.

THE ANSWERS ARE OUT THERE - READ THE MANUAL!

Concrete and shotcrete pump manufacturers supply detailed operation and safety manuals that clearly define the maximum pumping distance, height, or available concrete pressure that a pump will produce if factory bypass settings are maintained. The only way to correctly determine if a delivery line component can be safely used for shotcrete placement is to know your pump's maximum available concrete pressure rating and validate that the working pressure rating of all delivery line components are equal or greater than that value.

Those small numbers are important! Paying attention to the working pressure capacity of the components used on your delivery lines is just as important as the size of the pump or nozzle! Don't shortchange your safety by ignoring these details!

*ACI Certified Nozzleman **Oscar Duckworth** is an ASA and American Concrete Institute (ACI) member with over 25,000 hours of nozzle time. He has worked as a nozzleman on over 2500 projects. Duckworth is currently an ACI Examiner for the wet- and dry-mix processes. He serves on the ASA Board of Directors and as Chair of ASA's Education Committee. He continues to work as a shotcrete consultant and certified nozzleman.*