White Paper: Hydraulic Hose Sizing

The Importance of Hydraulic Hose Size: The Adverse Effects of Replacing a Hydraulic Hose with the Incorrect Size

Many customers who make hydraulic hose assemblies will face this common scenario: an end-user brings in a worn-out hydraulic hose to be replaced, but the couplings needed for this particular size hose are out of stock, back-ordered, or the store doesn't stock the couplings needed to replicate the original hose assembly. However, you do stock the correct couplings in a smaller hose size inside diameter (ID). For the sake of the sale and the customer experience, the most logical solution is to rebuild the hose assembly using the smaller size hydraulic hose with a jump-size fitting. Though this may seem like a harmless solution, replacing a hose assembly with a smaller hose size than what was designed for that hydraulic system could cause unintended harm and create inefficiency to your customer's equipment.

What is affected when you replace a hose with the incorrect hose size?

Flow is the movement of fluid and is broken down into two categories: flow rate and flow velocity. Flow rate is the volume of hydraulic fluid produced by the hydraulic pump over a specific amount of time and is commonly measured using gallons per minute or GPM. Flow velocity is the speed at which hydraulic fluid travels in a certain direction over a specific amount of time and is measured using feet per second. Flow velocity is determined by both the hydraulic pump's flow rate and the hydraulic hose size. Changing the flow rate of the hydraulic pump but leaving the hydraulic hose size the same will affect flow velocity. In contrast, keeping the flow rate the same but changing the hose size will affect flow velocity.

Flow velocity is an important consideration when replacing a larger hydraulic hose ID with a smaller hydraulic hose ID. When an existing hydraulic hose is replaced with a new hydraulic hose that has a smaller ID, the same amount of fluid that was flowing through the original, larger hydraulic hose is now forced through the new, smaller hose. This will restrict flow and increase downstream pressure, thus causing flow velocity to increase. In some situations, this might not be a problem, so it is important to properly analyze the situation. An easy option to avoid this problem is to size-up to the next larger hose size. However, larger hoses usually come with a higher price, which your customer might not appreciate, plus larger hoses take up space and could even decrease the customer's equipment performance.

Why can high flow velocity be undesirable for a hydraulic system?

Flow velocity determines if the flow pattern will be in a laminar or turbulent state. Ideally, we would like for flow to be a steady, smooth, and uniform pattern from the pump all the way to the actuator. This pattern is referred to as laminar flow. Laminar flow is achieved at lower velocities, and the fluid layers move in a nice, even, parallel flow pattern. This flow pattern is ideal to minimize friction and pressure drops and maximises hydraulic system efficiency. Fluid-on-fluid friction will still be created as the layers of fluid, which are flowing at different velocity rates, slide on each other, but this is expected. A laminar flow pattern also provides better system response, lubrication, and decreases air pockets or bubbles that can cause inefficiencies.

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The higher the flow velocity, the more turbulent flow characteristic are seen. When flow velocity is high, the roughness on the surface of the inner tube will disrupt the flow path and cause it to become chaotic. Turbulent flow patterns cause a decrease in energy in the form of friction (law of conservation of energy), resulting in unwanted pressure drops and hydraulic system inefficiencies. Furthermore, high flow velocity also causes increased fluid temperatures. Fluid temperature has been empirically linked to significant reduction in hose life, so a reduction in hose size may additionally cause unwanted system downtime. Additional details on this temperature impact can be reviewed in the Heat Gain Data section of the Gates Fluid Flow Pressure Calculator, which can be found at https://www.gates.com/us/en/knowledge-center/calculators/fluid-flow-pressure-calculator.html. For suction and return lines, having high flow velocity can lead to pump cavitation over time. In other words, the hose tube ID must be suitable to keep flow velocity at an appropriate rate to avoid energy loss due to friction.

How do you determine fluid velocity and how much velocity is acceptable?

To calculate flow velocity, use a constant, the cross-sectional area of the hose, and the hydraulic pump's flow rate using a flow meter. With this information, apply the formula:

$$Flow\ Velocity = \frac{0.3208 * Flow\ Rate}{\pi r^2}$$

Once flow velocity is determined, use the calculated velocity rate, along with the pump's flow rate, to verify if the replacement hose size is acceptable for the system. An easy way to do this is to use the Gates nomographic chart located in the Gates Hydraulic and Fleet Hose catalog or online at gates.com. The chart has 3 parts: (1) the flow rate axis, (2) the hose ID axis, and (3) the flow velocity axis. You only need to know two of the three axis values to determine the third value – lay a straight edge through the known values and extend the line to determine if the flow rate and flow velocity are at acceptable levels based on your hose size, or help you determine the proper hose size based on flow rate and fluid velocity.

Below are the recommended velocity rates found on a typical hydraulic system:

Hydraulic System	Recommended Flow Velocity
Suction Lines	2 to 4 ft/sec
Return Lines	10 to 15 ft/sec
Medium-Pressure Lines	15 to 20 ft/sec
High-Pressure Lines	20 to 25 ft/sec

Conclusion

Though it may be convenient to substitute a customer's hydraulic hose with a different sized hose than what is intended for the hydraulic system, you can inadvertently cause your customer's hydraulic equipment to become less efficient and potentially damage the hose tube. The best practice is to replace the hose with the same size. If you are unsure, contact the Gates Product Application Engineers on the technical hotline at (03) 9797-9688 or salesAUS@gates.com.

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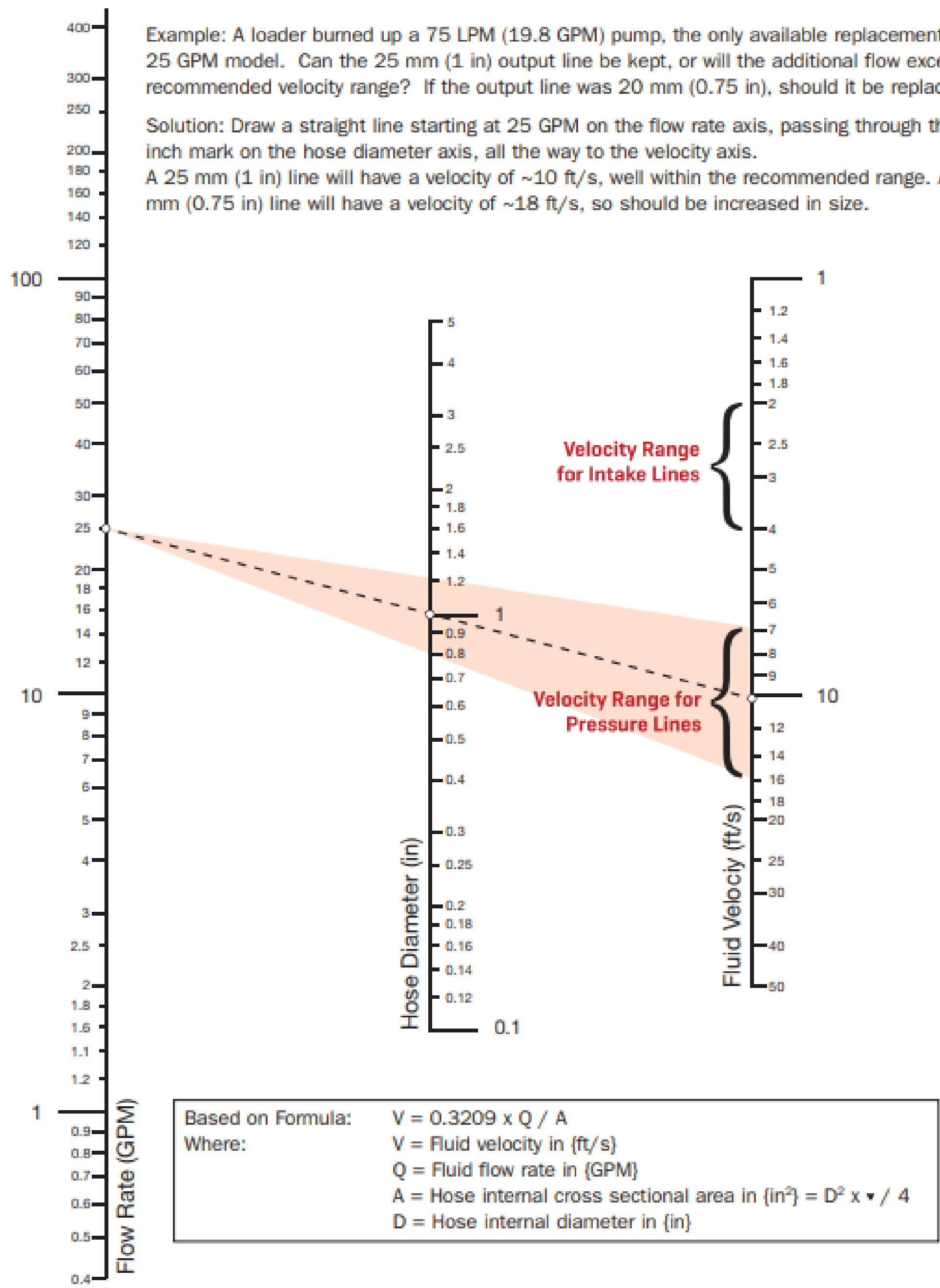
FLOW CAPACITY OF HOSE ASSEMBLIES AT RECOMMENDED FLOW VELOCITIES

Example: A loader burned up a 75 LPM (19.8 GPM) pump, the only available replacement is a 25 GPM model. Can the 25 mm (1 in) output line be kept, or will the additional flow exceed the recommended velocity range? If the output line was 20 mm (0.75 in), should it be replaced?

Solution: Draw a straight line starting at 25 GPM on the flow rate axis, passing through the 1 inch mark on the hose diameter axis, all the way to the velocity axis.
A 25 mm (1 in) line will have a velocity of ~10 ft/s, well within the recommended range. A 20 mm (0.75 in) line will have a velocity of ~18 ft/s, so should be increased in size.



Based on Formula:	$V = 0.3209 \times Q / A$
Where:	V = Fluid velocity in {ft/s}
	Q = Fluid flow rate in {GPM}
	A = Hose internal cross sectional area in {in^2} = $D^2 \times \pi / 4$
	D = Hose internal diameter in {in}