Pump Stages

By Tom Murray

As is often the case, we in the fire service tend to make things more difficult than they need to be. I believe this is the situation when discussing the pros and cons of single, two-stage and three-stage pumps for fire apparatus.

As stated by Robert J. Barraclough in a *Firehouse Magazine* article written November 1978, "Do we buy the equipment that our department really needs? Or do we buy on tradition, past experience, or misunderstanding?"

When reviewing the pump operations handbooks from the various major fire department pump manufacturers, we may be surprised to see the variety and disparity of opinions of what is best for the fire service.

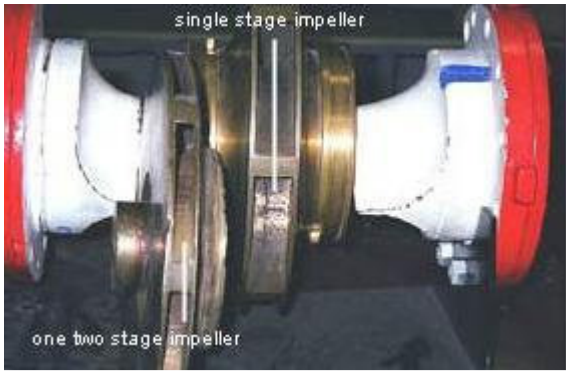
Without discussing the merits of these opinions, I'm going to present mine and allow you to draw your own conclusions.

SINGLE-STAGE PUMPS:

New single-stage pumps are far superior to single-stage pumps of the past. The basic reason for this is the major redesign of the impeller serving the single stage pump. The impellers of older single-stage pumps were basically the same design of those impellers used for two-stage pumps.

The older single-stage impellers were narrow and took supply from only one side of the impeller. Today's newer single-stage impellers are designed with a wider water way and can take supply from both sides of the impeller.

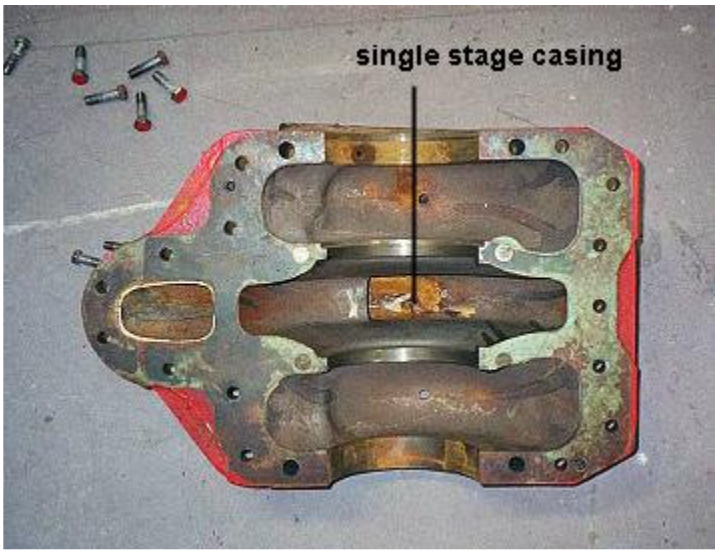
Below is an example of a single-stage impeller next to a two-stage impeller:



View of a single-stage impeller next to a two-stage impeller

With the larger waterway, and ability to take supply from both sides, the single-stage pump is able to meet NFPA and Undwriters Libratory requirements.

Below is a view of the volutes of a single-stage impeller pump casing and that of a two-stage impeller-pump casing.

Single-stage impeller pump casing	
	*Two-stage impeller pump casing*

You can see that the volutes of each are about the same size. However the width of the impellers are substantially different.

With this newer design, single-stage pumps are easily capable of providing the NFPA 1901 and UL pressure and volume ratings required for fire pumps.

The other benefits of a single-stage pump is that they cost less, and because they are easier to operate and have fewer moving parts they are less likely to need repair than a two-stage pump.

Because single-stage pumps don't have a transfer valve as required in multi-stage pumps, training and fireground operations become much simpler — an important point

should your department primarily rely on volunteers or not have pump operator specialists (engineers).

It is true that single-stage pumps of 1,250-gpm rating and higher are not as efficient when supplying low volumes at high pressures. When would this happen? It would happen in situations involving high-rise buildings over 40 stories; when pumping up high, steep hills; or when supplying high-pressure, low-volume wildland-type nozzles. In these situations, single-stage pumps rated at 1,250 gpm and higher, pumping for extended periods of time, would not be your pump of choice.

The reasons are that single-stage pumps become less effective at pressures above 350 psi. 350 psi is a lot of pressure. The fact of the matter is that most departments don't operate with hose with burst pressures above 300 psi, with the exception of Booster Line hose and Forestry line hose. Hose manufactures will suggest that safe operating pressures be kept 50 psi below burst pressure. For most 2½-inch hose, this would mean a maximum of 250 psi pump discharge pressure.

The point is that even if you wanted to pump high pressures, your hose-burst pressure rating would prevent you from doing so safely.

For those departments that frequently respond to wildland firefighting, you would want a pump-and-roll capability. A separate power-takeoff-driven pump designed for pressures above 350 psi would provide you with the capability for high pressures and save the single-stage midship pump for your other pumping requirements.

An example of this pumping configuration is that of the Type-1 Engine operated by the Weed Fire Department, Siskiyou County, in Northern California. This is a small department with a full-time chief of department supported by volunteers and fire technology student sleepers.

Weed (California) Fire Protection District 1,250-GPM, single-stage pump

The water flow capabilities of this single-stage, 1,250-gpm pump is excellent for this community and the firefighters who will be operating this pump.

Ease of operation, means less required pump training, simpler hydraulics, and a lower exposure to downtime due to required pump maintenance.

This single-stage Weststates 1,250-gpm pumper is an excellent choice for this department. A community of primarily one-story, 2-3-bedroom, single-family residences, supported by a small town commercial community of one- and two-story stores and businesses.

The City of Weed does have a large active 24-hour mill operation that does present a significant fire hazard. However, considering this department's resources and normal fire exposure this single-stage pumper is still a very good choice.

TWO-STAGE PUMPS:

High-rise pump operations (over 40 stories) or relay pumping in steep, hilly communities such as San Francisco need a two-stage pump for the wide variety of pump pressures required.

San Francisco has over 800 high-rise buildings. Its tallest building is the 55-story Bank of America World Headquarters at Pine and Kearny Street.

Should the San Francisco Fire Department need to pump to the top floor of this 55-story building, the pumper would have to be able to generate a pump pressure of 500 psi.

Fireground hydraulics are 5 psi head pressure times 55 floors = 275 psi, plus 25 psi friction loss at the FDC, 10 psi minimum friction loss between pumper and FDC (estimate), and a desired fire flow of 150 psi on the fire floor for multiple fire attack lines. (460-psi minimum required).

San Francisco Fire Department 1,500-GPM, two-stage pump

San Francisco must be prepared to pump at high pressures. Its apparatus is very well suited for such pump demands.

San Francisco is the last remaining municipal fire service agency in California that still runs with three-inch hose with three-inch couplings. All newer apparatus have three-inch piping from the pump housing to the discharge outlet.

There are two three-inch piped auxiliary gated inlets piped directly into the fire pump. The two main suction inlets have a three-inch screw-type gated valve inlet that immediately widens out to a six-inch manifold directly to the fire pump.

Two three-inch large-line hose beds have a combined hose load of 1,000 feet of Angus premium fire hose. Two small-line pre-connect hose beds run from the rear tailboard to the front of the hose bed holding 150 feet and 200 feet of 1¾-inch Angus High Combat II hose. The 200-foot pre-connect has a ¾-inch solid stream nozzle. The 150-footer has a Task Force 200-gpm Thunder Fog nozzle.

Subject to the engine captain's choice, the engine will carry either two 100-foot, 1¾-inch hose bundles or 100-foot high-rise packs, or one of each, as the captain believes is needed in the engines response area.

THREE-STAGE PUMPS:

Fire Department New York serves a city with buildings as tall as 110 stories. For this reason FDNY has three-stage pumps.

The FDNY incorporates a recommended-pump-pressure chart in their high-rise procedures. (Keep in mind that the FDNY considers the procedure of high-pressure pumping when pumping to floors over 50 stories and when pumping pressures higher than 250 psi as a last resort, or so I am advised.)

Safety procedures are a must. Those interested in high-pressure pump procedures over 250 psi can contact me via Fire Nuggets for a presentation I gave at FDIC West 1999.

FIRE FLOORS	CONTROLLING NOZZLE	FOG NOZZLE
1-10	150	200
11-20	200	250
21-30	250	300
31-40	300	350
41-50	350	400
51-60	400	450
61-70	450	500
71-80	500	550
81-90	550	600
91-100	600	650
101-110	650	700

With such high pressures required, a three-stage pump becomes a necessity. Hose used for such pumping is Angus 2,000-psi burst pressure.