# CHAPTER 5: Pump Staging for Energy Efficiency

## SECTION I: APPLICATION

**Consider alternate staging scenarios:**

- One of the benefits you enjoy with Armstrong is a wide choice of pump selections, system configurations and staging scenarios. Make certain that you have exhausted all possible capacity splits. You may find that the total BHP used on an un-equal (33/67, 20/80, 20/40/40, 10/45/45) split may be less than an equal (50/50, 65/65, 33/33/33, 50/50/50) pump capacity split

**Don't encourage consultants to "over-design" redundancy.**

- Redundancy is certainly reasonable to any design criteria, however there are ways to make the best use of the pumping power and still have redundancy. (Ex: Suggest that instead of using a 65/65% capacity split which adds un-necessary capacity to the system when the lead pump runs, take the design load, add 15% redundancy and suggest a 33/67 split where cost effective.) The redundancy is still built into the system, however the smaller pump will likely run most of the time.

## SECTION II: PUMP SELECTION

**Typical capacity splits and reasons for choice:**

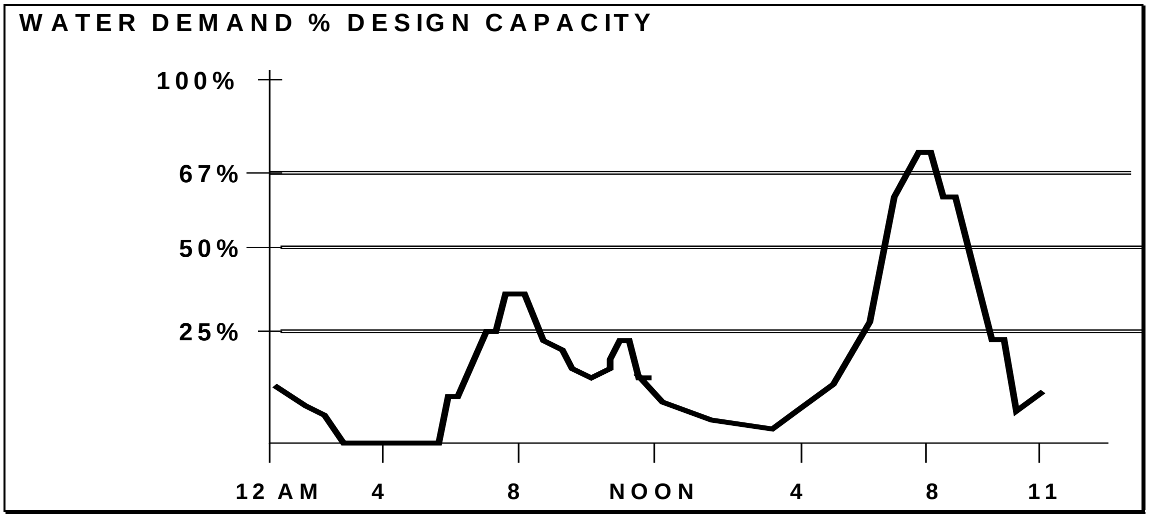
| Duplex | | |
|---|---|---|
| **P-1** | **P-2** | **Possible reason for choice** |
| 33% | 67% | Very economical (especially in system flows over 200 GPM), effective use of pumping power, ability to use 3-Step sequencing control optimizing BHP to Flow need. |
| 50% | 50% | Preferable in system capacities below 200 GPM since motor H.P.'s are typically the same as 33/67 split, allows auto lead alternation (equal wear), parts interchangeable |
| 65% | 65% | Similar to reasons used in 50/50 split, however, allows for additional redundancy since (1) pump operating alone can handle a larger portion of the load. |
| 100% | 100% | Provides full stand-by in the event of a pump failure, recommended for packages which are typically very small in H.P. since this is not effective use of BHP. |

| Triplex | | | |
|---|---|---|---|
| **P-1** | **P-2** | **P-3** | **Possible reason for choice** |
| 20% | 40% | 40% | Most common sequencing option, allows for up to 5-Step sequencing, very good use of pumping power, small lead acts as jockey pump for large periods of low-flow. |
| 30% | 40% | 40% | Similar benefits to sequence above, however allows for up to 70% or 80% peak demand with (2) pumps running but has 10% built in redundancy. |
| 33% | 33% | 33% | Typically used when minimum loads always exceed 20%, primarily used on hospital applications where loads are seldom low, this split only allows for 3-Step sequence. |
| 30% | 70% | 70% | Provides a peak load of 100% when (2) pumps are running as well as an increased capacity and 70% system redundancy, not used very often. |

**Example of System Splits and use of multiple sequences**

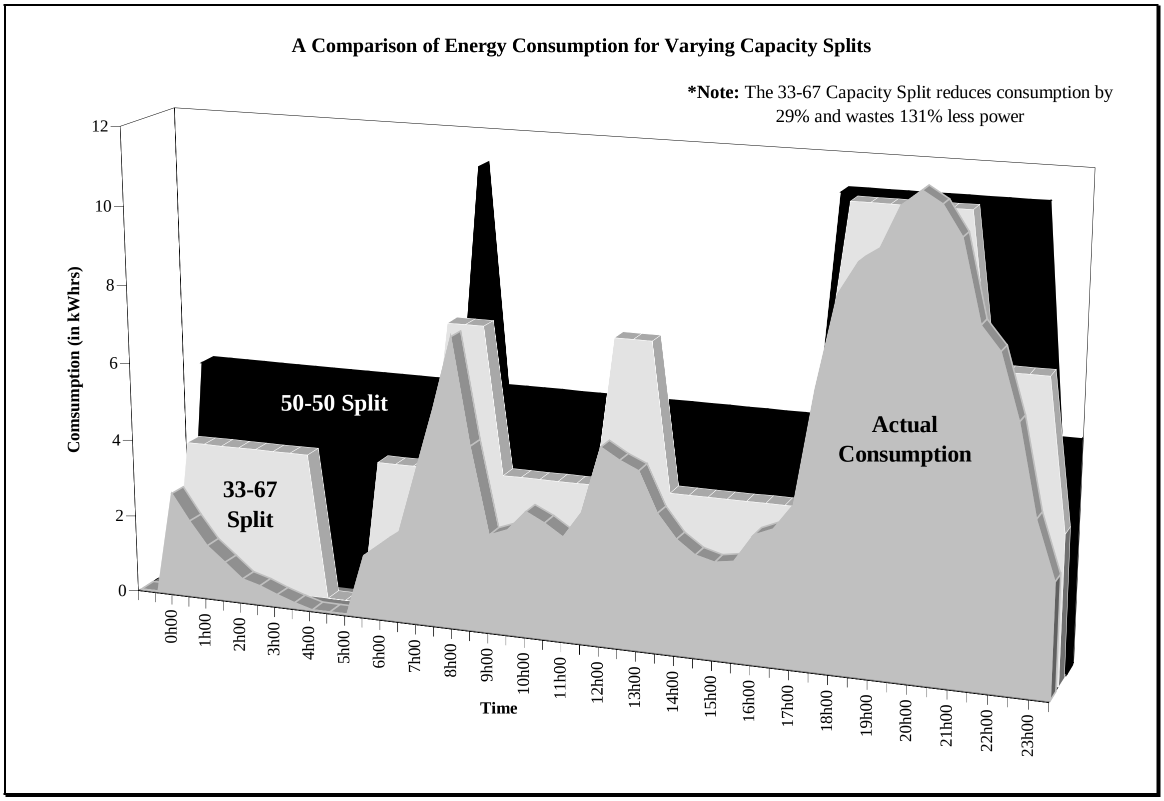
- In the following example of a 33/67% system split, a comparison is made on 50/50, 2 Step sequencing versus 33/67, 3 Step. Notice how dramatic the savings are by simply changing the existing system flow to sequence at un-equal capacities, as well as adding an additional step of control to the pump package.

**SECTION III: THE BUILDING LOAD PROFILE**




***Typical residential building demand curve showing the relationship of system demand versus time of day. Notice how the system demand falls off in the early morning hours.***

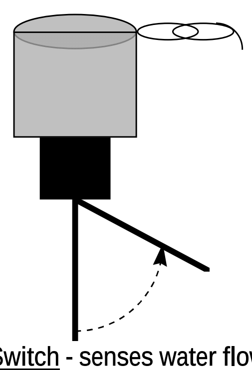
- System demand is ultimately determined by flow. When a building uses water, it is related directly to the activities and usage habits of people and machines within the building. Since we size all systems to develop pressure, this demand has already been taken into consideration and the system is built to keep this pressure requirement at a constant “pulse free” state. It only makes sense that, since pressure is constant and the flow varies (requiring additional pumping power), that the sequencing of pumps be directly related to a measurable demand flow. Current sensing relays measure this “work” (GPM) exerted by the motor through the pump impeller. In figure #13 we can see how this demand fluctuates.
- You are not required to use the flow splits as shown in the example. Sometimes it is possible to optimize (i.e.: reduce horsepower consumption) by using a 20/80 split, for example. Because we use current sensing relays and we have the option of determining where the split is made, we can choose whichever split fits the application best.

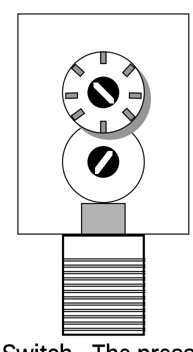


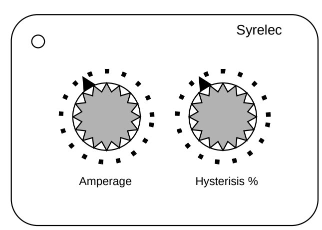

***Notice that by simply changing the flow split percentages, the pumps now follow the system demand more accurately. This is how to optimize power consumption with constant speed pressure booster packages. The system becomes, in essence, a variable flow package, choosing the best motor (or combination of motors) to run for a given GPM.***

## SECTION IV: SEQUENCING DEVICES

There are currently a multitude of choices for pump sequencing. The most popular of these are flow switches, pressure switches & current sensing relays. Below is a description of each and the type of measurement each utilizes.








Flow Switch - senses water flow against a paddle which is in the water stream. Paddle moves a "cam" within the body which actuates next sequence. This is an accurate means of measuring flow, however, can be subject to corrosion and obstruction. (Direct Measurement of Flow)

Pressure Switch - The pressure switch senses a drop in pressure and activates a device or relay. They are available in both single point actuation and differential pressure. This mode of control relies primarily on the pump curve characteristics as they relate to pressure output. (Indirect Measurement of Flow)

Current Sensing Relay - The relay monitors amperage draw created by the motor as the flow increases through the pump. This amperage is set to a specific "on" time based on engineer requested sequencing. It is an indirect measurement of flow, but highly accurate. (Indirect Measurement of Flow via amperage)

**PROBLEM 2:**

1. You are replacing a Duplex system which has a design flow of 200 GPM.
2. The system was designed around a 65/65 split.
3. The system pressure is based on a boost requirement of 50 PSI.
4. Analyze the difference between 65/65 split vs. 33/67 with a 15% redundancy factor.

| | 65%/65% | | | 33%/67% | |
|---|---|---|---|---|---|
| **Pump #1:** | **GPM** ________ | **H.P.** ________ | **vs.** | **GPM** ________ | **H.P.** _________ |
| **Pump #2:** | **GPM** ________ | **H.P.** ________ | **vs.** | **GPM** ________ | **H.P.** _________ |

**Considerations**

- Flow Switch - is in contact with the pumped fluid, therefore, it is subject to corrosion or obstruction. It can also fail mechanically. From a positive standpoint, the flow switch is a direct measurement of flow.
- Pressure Switch - is also in contact with the fluid and can be come clogged or fail due to corrosion. It is an indirect measurement of flow since it measures the pressure output of the pump as it relates to its curve. Suction pressures must be very accurate to facilitate an accurate sequencing scenario.
- Current Sensors - read the motor amperage draw as the motor works to generate flow through the pump. Since this “work” is directly proportionate to the flow the current sensor is measuring this in an indirect fashion, yet the amperage draw is very repeatable and highly accurate. Current sensors are not in contact with the pumped fluid, nor do they have any moving parts. They are also able to sense voltage change.

***A word about “non-overloading”…***

*Many engineers (through their association with HVAC systems) have become very careful about specifying pumps which are non-overloading throughout their entire flow curve. If we look at the desired sequence in a system, however, we would like to use as much of the motor as possible before activating additional pumps in sequence.(see Section III of this chapter) This allows us to conserve power by “managing the flow load”. With a “flow based” measurement system, this can easily be done, since the consultant can dictate (right down to the exact flow rate) where the next pump will activate. Pressure switch based systems can be fooled by changes in suction pressure (which change the pump performance at any point on its curve) and therefore are unreliable for this purpose. In a properly designed system utilizing FLOW based sequencing, the engineer can indicate that…”the system shall be non-overloading throughout its entire SEQUENCE OF OPERATION” rather than the individual pump curve.*