ARMSTRONG

Saving Energy by Piping Configuration

White paper

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SAVING ENERGY BY PIPING CONFIGURATION

In the commercial building community of contractors, design engineers, and building managers, it is naturally well understood that installing a larger number of pumps than necessary to produce the system design flow, increases installation costs. However, it is not as widely understood that larger numbers of pumps may also increase energy costs; even when the redundant pumps may be intended for standby operation only.

Let us examine some samples by comparing the energy use of 2 pumps for duty/standby operation in a conventional piping arrangement against a single pipe 2-pump unit with the same design flow and head conditions. We will assume the duty pump of a 2-pump duty/standby application operates in single straight-through piping configuration which will be equivalent to the single pipe 2-pump unit or any single pump application. The energy losses in the standby pump piping will be the focus of this investigation. We will select the same pumps for each piping configuration to concentrate on the piping effect on energy use.

System requirements:

2-pump duty/standby installations could drop piping from a header to each pump; however piping costs usually prohibit that from happening. A recommended alternate is to drop one pipe to within a comfortable distance from the duty pump and, as an example, install a straight-tee and continue, with appropriate fittings to the duty pump inlet. A horizontal pipe of comfortable length for pump service, is then connected to the tee and turned to the standby pump by a 90° long-radius elbow to continued on with the appropriate fittings to the standby pump inlet. The discharge piping, other than discharge fittings instead of suction fittings, will mirror the suction piping, using a second long-radius elbow and straight-tee.

The difference between the duty pump and standby pump piping is that the standby pumped fluid needs to turn at each tee-branch and each long-radius elbow. This piping arrangement does not come without costs in reduced performance efficiency.

FIG 1. 2-PIPE 2-100% DUTY/STANDBY

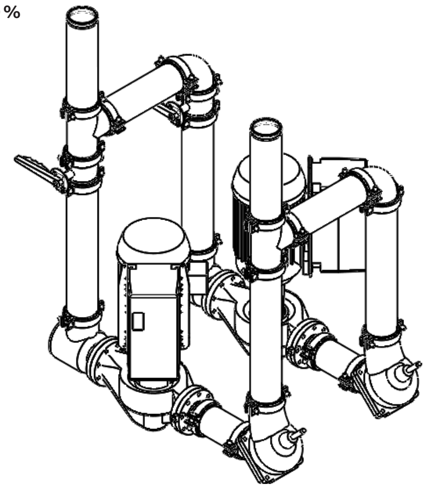
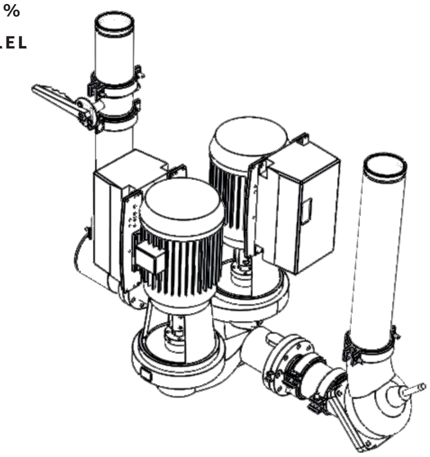


FIG 2. 1-PIPE 2-50% TO 2-100% PARALLEL PUMPING



Schematics:

FIG 3. 2-PIPE 2-100% DUTY/STANDBY

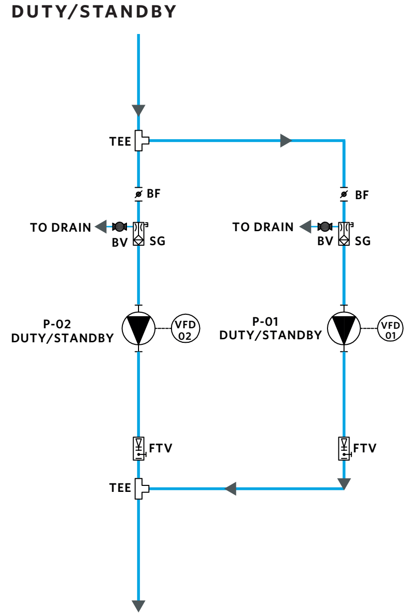
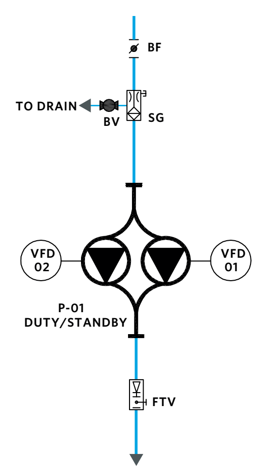


FIG 4. 2-50% TO 2-100% PARALLEL PUMPING



The added fittings in the standby unit piping (2*straight-tee & 2*long-radius elbow in our samples, can be converted to 'equivalent pipe length'①. This equivalent pipe length can then be easily translated into piping friction loss①. This added friction loss will require increased motor power for the required flow; higher than the duty pump or the single pipe 2-pump arrangements. See **TABLE 1**, below

TABLE 1 : Added pipe friction from required duty / standby pipe fittings

RANDOM SYSTEM CONDITIONS			FLANGED FITTINGS_EQUIV PIPE-LENGTH		
Design flow	**Design Head**	**Pipe size②**	**90° Long Rad Elbow - Equiv pipe length**	**Tee-Branch - Equiv pipe length**	**Total added pipe friction D/S-2 tee-2 elbow**
210	65	3"	5.1	17	3.8
300	20	4"	7	22	4.9
350	35	4"	7	22	4.9
400	65	4"	7	22	4.9
400	85	4"	7	22	4.9
470	70	5"	8.9	27	2.8
600	40	6"	11	33	4
650	55	6"	11	33	4

① Friction Losses determined from Deming Crane Bulletin 90

② Complying with ASHRAE 90.1 for 4400hrs VFS (Variable Flow System)

TABLE 2 : Added pipe friction from required duty / standby pipe fittings

OPERATION EFFICIENCY			
50% avg load hp_single pipe (Tango, dA or D/S duty pump)③	**50% avg load hp_standby piping (w/ added ftgs)**	**Total for 50% duty & 50% standby operation**	**System energy savings**
1.58	1.70	1.64	3.66%
0.56	0.65	0.61	7.44%
1.06	1.22	1.14	7.02%
2.35	2.84	2.60	9.44%
3.10	3.29	3.20	2.97%
3.18	3.33	3.26	2.30%
2.11	2.33	2.22	4.95%
3.17	3.34	3.26	2.61%
Average single pipe efficiency [50% of time]:			**5.05%**

The first column in **TABLE 2**. above, indicates the motor power require to pump the sample system at 50% average load flow & head through each of the sample HVAC system piping, which is detailed in **TABLE 1**. (Note that the 50% average system conditions are determined from a quadratic pump operating curve, based on 40% [Hmin] of the design head [Hd] at zero flow origin and ending at the design conditions point [Hd / Qd]. At 50% load, the full load flow will be reduced to 50% and the head to 55% of the design conditions. [(Hd-Hmin)*(50%)^2+Hmin]

The second column in **TABLE 2**, indicates the motor power requirement through the standby unit leg of the duty / standby piping (**FIG 1** & **FIG 3**) when the friction loss created by the added tees and elbow fitting are considered.

The third column in **TABLE 2**, reduces the motor power increase between columns 2 & 1 by 50%, as a standby unit would, generally, operate for only 50% of the system operating hours.

The final column in **TABLE 2**, indicates the ratio between the standby unit piping losses and the single pipe arrangement, for the duty pump or the single pipe 2-pump unit (Tango & dualARM). The 50% average load results indicate an average saving of 5% for the random sample units. (2.3% low to 9.4% high)

③ See first column of **TABLE 2**:

- 50% average system flow is a reasonable value for North American HVAC systems
- Tango and dA (Abbreviation for dualARM units) are pump types that house 2 pumping units within a common casing, sharing a single casing inlet and single outlet connections
- D/S duty pump indicates a straight-through piping with the same friction losses as the Tango & dA units

Point of interest:

Some designers may prefer to 'even-out' the friction in each of the duty and standby legs. Many design the piping like **FIG 5** and **FIG 6**, below, which should successfully even-out the resistance in each leg; however, this will end up doubling the added energy costs over the values indicated in the last column in **TABLE 2**. (5% average power increase at 50% load) The resistance in the duty & standby added fittings would reflect the values in second column of **TABLE 2**; averaging 10% increase in motor power requirement at 50% average load.

FIG 5. DUTY / STANDBY WITH EQUAL FRICTION

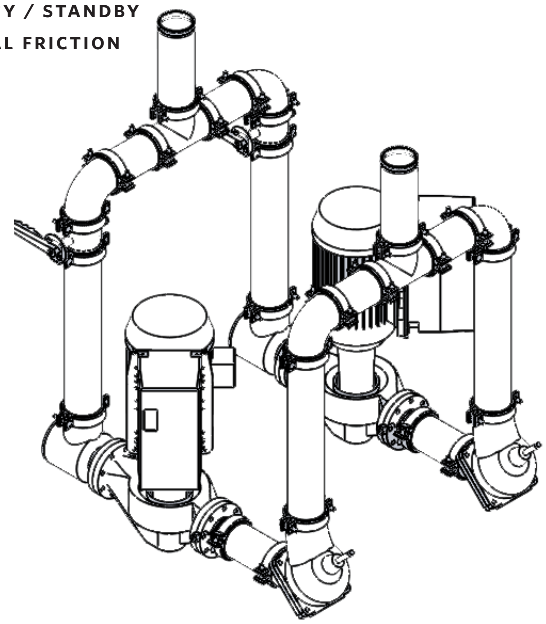
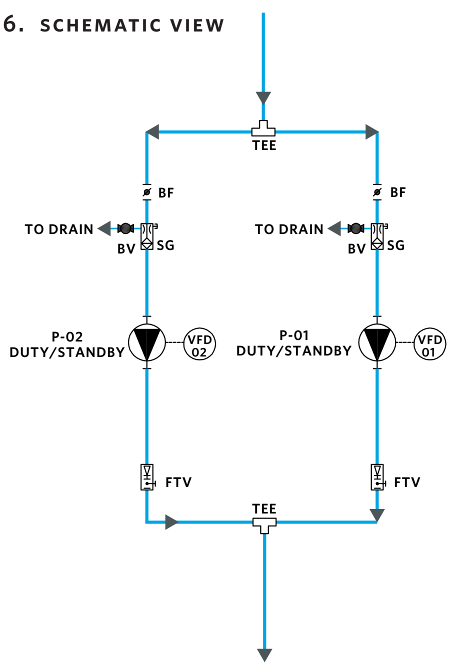


FIG 6. SCHEMATIC VIEW



SUMMARY

We are no longer tied to 'traditional' pumps and piping solutions for HVAC systems. There are new, innovative ways to create customer value, for contractor and building owner clients, through reduced installed cost and lower life-cycle costs,. Some of the key items that help support optimum value are:

1 Modern pump design with ultra-high efficiency motors

2 Proper pump selection for the system conditions that optimize customer value

3 Reduction in installed costs from smaller vertical pumps that use less piping and fittings

4 Reduction in life-cycle costs with pumps selected for the building and system load profile and that comply with system redundancy needs

5 Auto-reduction in speed to prevent over-pumping the design flow value

6 Intuitive on-board controls that optimize motor power for real-time system conditions

7 'Plug & Play' technology for energy savings, and tenant satisfaction, immediately equipment is installed

Where pipe configurations are concerned, it is recommended that maximum recommended flow per pipe size and minimum pipe drops to pumping equipment is adhered to. The latter recommendation is made easier today by installing pumping equipment containing 2*50% of design flow units, or 2*60% ... up to 2*100% of design flow units in a single casing, requiring one installed piping.

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