Sizing of Hydro Multi-E pressure boosting system with improved operational security and energy consumption for commercial buildings

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Introduction

Modern societies depend on the secure delivery of clean water at constant pressure. Demographic patterns show increasing urbanisation, which means that new commercial buildings are larger than ever. System safety and low energy consumption are not simply a customer requirement. It is expected that the products provided can live up to the stringent engineering standards and health and safety requirements.

Hydro Multi-E based on the new MGE model H/I/J offers a wide range of features and intelligent functions, which can help not only to reduce the energy consumption but also ensure system- operation and safety.

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Purpose

The purpose of this document is to shed light on how a pressure-boosting system is sized using Grundfos tools. In addition, system safety and lower energy consumption based on the features and functionalities of Hydro Multi-E with the new MGE model H/I/J, is covered in this document together with their applicability to hospitals and other commercial buildings such as hotels, schools and high rises.

Background

Sizing a pressure boosting system for a commercial building is not always straightforward. There are many aspects, which have to be taken into account during the process such as fluctuating inlet pressure, zone operation, backup pump etc. Furthermore, when looking at the consumption- and load profile the mix of end-users in the building has a huge impact when choosing the right system for the application. Residents in an apartment building use water during the entire day all year round, but water demand in an office building is more limited. However, if a building design has both apartments and office floors, then it would be sensible to consider dividing the water supply into zones, so that one system handles the apartments. This could result in energy savings and greater comfort.

Problems with sizing

Sizing a system can be done in many different ways. Some are based on standards and guides, while others are simply sized out of experience and gut feeling. The problem with most of these methods is that the result is frequently oversized systems. It would obviously be a problem if it was a single pump, because then it would be easy for the end-user to see if it continues to operate at low speed and therefore low energy efficiency.

Pressure boosting systems are more forgiving when it comes to oversizing since there are several pumps to share the workload, so the high energy efficiency will still often be obtained but the full potential of the system will never be utilized, meaning that all the pumps in the system will not be in operation at once.

There are several other reasons for over-sizing. Legislation in some countries requires one or more pumps as backup. In other cases, it is done for safety reasons or to cater for future expansion.

When operating commercial buildings it is crucial to achieve high operational security and general system safety, while saving energy in the process. Being able to keep the water flowing means securing not only the system itself but also the protection of the pipe work in the building. Operational security can be achieved in different ways depending on the system in question. If the system has one controlling unit then adding a backup pump will solve the problem if a pump is unavailable, but not if the controlling unit itself is unavailable. For this reason, some systems have one separate backup pump, which can cover the entire demand of the system if for some reason the system is not operational.

Protection of the pipework in the building is also important to improve the system safety and ultimately help to improve the operational security. Lowering the pressure to take into account the friction loss experienced at high flow will help to reduce stress in the pipework, which could lead to pipe bursts. Another way is simply to reduce the number of hours the pumps are in operation by using a small diaphragm tank, which will allow the system to shut down completely in low consumption periods.

Sizing the system

The overall sizing process can deal with commercial building but the following example is based on a hospital. Before the system can be optimised it has to be sized accordingly to the hospitals requirements. The sizing process follows DIN1988-500 through Grundfos Product Center.

System requirements

The information needed to size the system correctly is found or calculated based on the list and table below.

- Highest tap location is 55m above ground level
- Pressure at end-user must be minimum 20m
- Inlet pressure is fixed at 20m
- Pressure loss in the system is 3m
- Consumption period is 365 days
- 116 beds

The calculations

The total annual water consumption is based on the water consumption required for each bed.

$$Q_{year} = 300 \times 116 = 34800\, m^3/year$$

The consumption per day can then be calculated.

$$Q_{day} = \frac{34800}{365\ days} = 95.34\, m^3/day$$

When sizing a system the maximum consumption factor (fd) also has to be taking into account.

$$Q_{day,max} = 95.34 \times 1.2 = 114.41\, m^3/day$$

The max flow rate for each bed is found in the table, but for good measure, this is how it is derived:

$$Q_{hour,max} = \frac{114.41 \times 3.0}{116 \times 24} = 0.12\, m^3/h$$

Finally, the max flow rate for the entire hospital is calculated.

$$Q_{hour,max,total} = 0.12 \times 116 = 13.92\, m^3/h$$

Choosing a system

Next step is to find a system based on the required flow from the calculations, the required head from the system requirements together with other information such as inlet pressure, friction loss etc.

The procedure for choosing an appropriate system using GPC (Grundfos Product Center) will not be covered in this document, however all the information to do so is present.

The system the rest of this document will based on is a Hydro Multi-E 2 CRIE 5-9. (98486772) See picture on front page.

Consumer	Unit	Q_{year}	Consumption period d	Q_{day}	fd	$Q(m)_{day}$	ft	Max. flow rate
		m^3/year	days/year	m^3/day		m^3/day		m^3/h
Residence building	Residence (2.5 persons)	183	365	0.5	1.3	0.65	1.7	0.046
Office building	Employee	25	250	0.1	1.2	0.12	3.6	0.018
Shopping centre	Employee	25	300	0.08	1.2	0.1	4.3	0.018
Supermarket	Employee	80	300	0.27	1.5	0.4	3.0	0.05
Hotel	Bed	180	365	0.5	1.5	0.75	4.0	0.125
Hospital	Bed	300	365	0.8	1.2	1.0	3.0	0.12
School	Pupil	8	200	0.04	1.3	0.065	2.5	0.007

fd: Maximum consumption factor, day
ft: Maximum consumption factor, hour

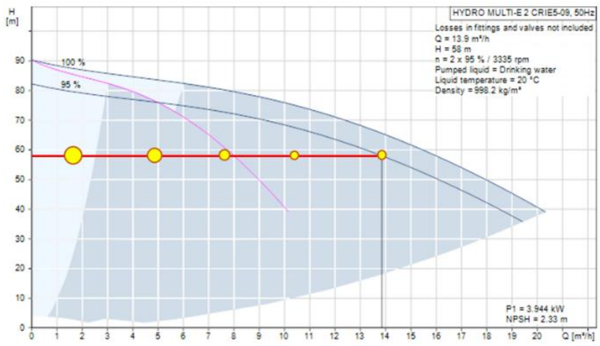
Optimization of the system

Set point influence

The Hydro Multi-E based on the new MGE model H/I/J has a function called “Set point influence”. This function is a way to reduce or increase the set point based on a pressure, temperature or flow measurement etc.

In this particular case, it is used to reduce the set point based on a flow measurement to take into account the friction loss of 3m experienced at maximum flow.

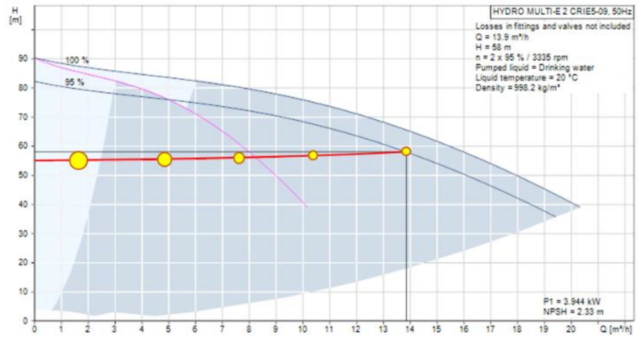
The diagram below shows the pump curve for the chosen system running at constant pressure. The red horizontal line indicates the constant system operating pressure. The five yellow circles taken from a standard load profile for a commercial building should not be seen as specific duty points, but are more an indication of the flow within which the system normally operates. The bigger the circle, the higher number of operating hours in that flow area, which means that the system often operates in the low flow area where the energy saving potential by reducing the set point is highest.



Based on the sizing process in Grundfos Product Center the annual energy consumption calculation at constant pressure is made.

Annual energy consumption without set point influence:
10845kWh

The pump curve below shows the adapted pressure curve when the friction loss is taken into account in the sizing process.



The pressure is automatically lowered when the flow decreases to make up for the 3m of friction loss which is experienced at the highest flow.

Based on the new scenario the annual energy consumption is calculated in Grundfos Product Center.

Annual energy consumption with set point influence:
10447kWh

Now that the two scenarios are known it is possible to calculated the potential annual energy saving.

$$\mathbf{10845 - 10447 = 398}\boldsymbol{kWh} \approx \mathbf{3.67}\%$$

The calculation was also done with a friction loss of 6 and 9 meters and here the savings were even higher.

$$\boldsymbol{Saving, 6m\ friction\ loss} \approx \mathbf{7.49}\ \%$$

$$\boldsymbol{Saving, 9m\ friction\ loss} \approx \mathbf{13.52}\ \%$$

By looking at the friction loss in a system a considerable amount of energy can be saved by simply using the set point influence function which is available in Hydro Multi-E based on the new MGE model H/I/J.

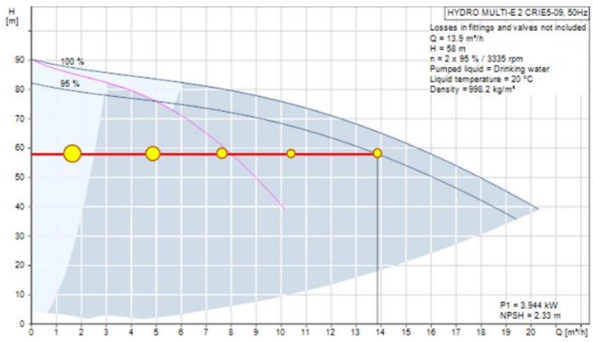
Optimization of the system

Stop function

All pressure boosting systems with a least one frequency-controlled pump have the stop function enabled, including Hydro Multi-E based on the new MGE model H/I/J.

The stop function is used to shut off the pumps during low consumption periods to save energy. The main component is the diaphragm tank, which is used as a water storage tank to take care of the small water demand there might be in e.g. the night time. As the water level and pressure in the tank drops the system will turn on for a short period of time to raise the pressure and fill the tank with a portion of water. During this low flow operation the total run time of the system will be lowered thus saving energy.

It was established on the previous page that the system spends most of the time operating in the lower part of the flow spectre. Based on the load profile information from Grundfos Product Center it is stated that the system operates 9 hours every day in the low flow area, which is indicated with the yellow circle on the left.



Assumption

The flow where the system activates this function is lower than indicated on the illustration. As standard it is 5% of a single pump's rated flow, which in this case is 5% of 6.9m^3/h = 0.345m^3/h.

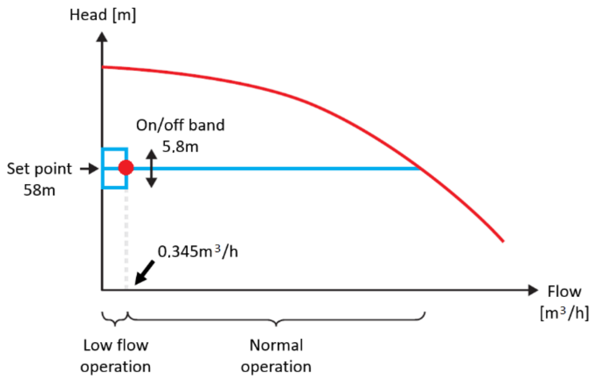
The system is obviously not operating 9 hours at or below this rate of flow and therefore it is assumed that 4.5 hours is in the low flow area to be able to calculate a potential energy saving.

It is necessary to look at the system in two different scenarios to find the saving.

- Stop function disabled/without a tank
- Stop function enabled/with a tank

Stop function disabled

To be able to calculate the energy consumption we use the worst-case scenario, meaning that the duty point will be fixed at 0.345m^3/h and 58m of head as the red dot in the illustration below shows.



It is now possible to find the energy consumption at that duty point by using Grundfos Product Center together with the operating hours of 4.5 hours every day.

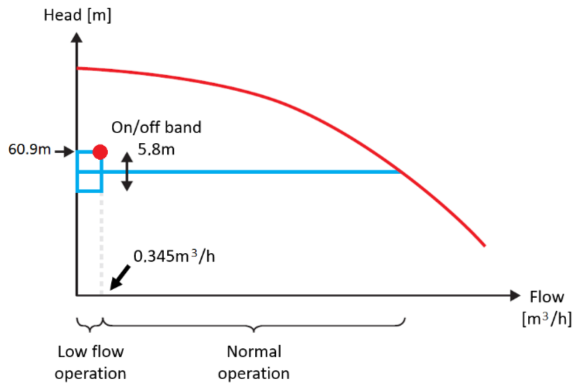
Annual energy consumption without the stop function disabled:

874.29kWh

Now the second scenario will be covered to find the difference in energy consumption and finally identify the yearly saving.

Stop function enabled

Once again, to be able to calculate the energy consumption the worst case in the scenario has been used, meaning that the duty point will be seen as constant at 0.345m^3/h and 60.9m of head, which is where the pump will be operating during the tank filling process.



Since the pump is not running all the time it is needed to find the actual operating time. Based on the flow, tank size and filling process it is estimated that the system will go through the cycle 250 times pr. hour where around 1/3 is pump run time and the remaining 2/3 of the time is drainage of the tank.

Annual energy consumption with the stop function enabled:

332.99kWh

The potential energy saving can now be found be looking at the difference between operating the system with or without the stop function enabled:

$$\mathbf{865.60 - 332.99 = 541.30}\boldsymbol{kWh} \approx \mathbf{5\%}$$

The stop function is enabled on all pressure boosters systems having at least one frequency-controlled pump, which means that the energy saving obtained is already part of the standard Hydro Multi-E with the new MGE model H/I/J.

System control backup - Multi Master

Being able to keep the water flowing at all times is very important in all installations and applications. Today, there are several different ways of handling this, such as using a separate single backup pump if the main system is unavailable. Another alternative could be to have two identical systems so that if the main system is unavailable then the other system will take over the workload. Both of these solutions will get the job done, but the cost of acquiring a backup pump could be high and an identical system even higher. Another disadvantage would be the need for more maintenance and space for the additional pump or system.

The new Hydro Multi-E has a very unique feature, which allows the system to keep operating even during a fault situation and therefore the need for a backup pump or system is eliminated.

The control of the system lies within the pump software, meaning that each pump could act as the controlling unit.

The only thing that is needed is a feedback sensor connected to each pump in the system, so each pump could take over as the controlling unit and command the other pumps in the system to start, stop etc.

From the factory, the system is configured as standard with two feedback sensors on 2, 3 and 4 pump systems. As an option, a feedback sensor can be fitted on every pump in the system for full redundancy, so potentially each of the four pumps can act as the controlling unit.

The Hydro Multi-E handles fault situations in a refined way without the end-user noticing any change in the comfort level. A few of the fault situations handled by the Hydro Multi-E are listed below.

Fault situation 1

If the feedback sensor fails on the pump that is acting as the controller, then control of the entire system will automatically switch to the next pump in the system fitted with a feedback sensor. The system keeps running as though nothing had happened. The faulty pump will indicate a sensor fault, but it can still run based on the commands coming from the new pump in control.

Fault situation 2

If a pump is turned off for maintenance or is unavailable for other reasons, then the control of the system will again switch to the next pump with a feedback sensor and keep the remaining pump(s) operational.

System safety - Pipe filling

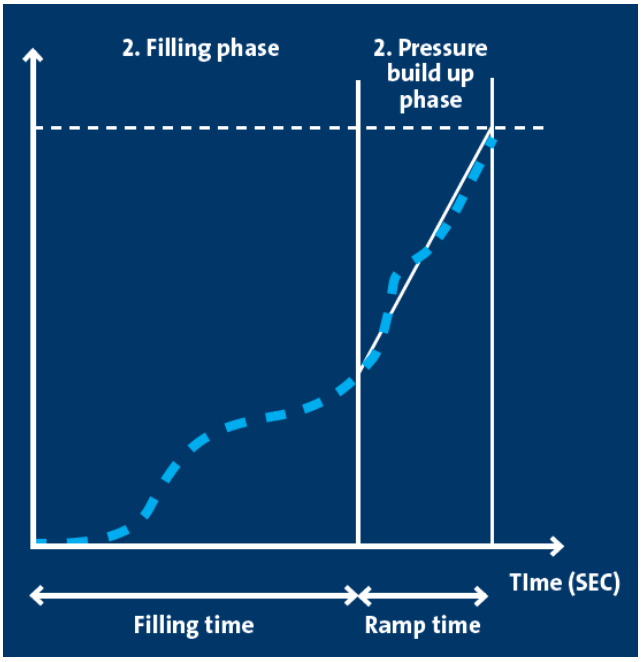
For some, protection of the pipework in an installation is more important than lowering the energy consumption. If a pipe bursts in a hospital, it could not only be a costly affair, it might be hazardous for the patients if they have to be relocated to a different part of the hospital or even to a different hospital.

During commissioning, a way of filling the empty pipes could be to manually raise the pressure gradually until the pipes are filled and the air is pushed out of an open water tap furthest away or at the top of the building.

When the system is for some reason unavailable and the water level in the piping drops due the natural water consumption in the building, then a vacuum might occur, which could result in pipe bursts when the system comes back online and the pipes are rapidly filled. This could be handled by installing an automatic anti-surge valve at the far end or at the top of the building. The valve lets air in or out to counteract generated vacuum or overpressure in the pipework.

If the anti-surge valve is combined with the pipe filling function on the Hydro Multi-E then the protection of the pipework is automatically ensured.

The pipe filling function has two different phases.



Phase 1 – Filling
A number of end user-defined pumps runs to fill the pipe to the required pressure. This pressure should correspond to the height of the riser pipe so that it is completely filled but not pressurized at the top.

Phase 2 – Pressure build-up
When the filling phase is complete the pressure build-up phase will begin and the pressure is slowly raised towards the required set point.

Conclusion

Sizing

When sizing a system it is necessary to remain critical and use a recognized sizing method to avoid oversizing. It is not only a problem to offer a system, which is too big to handle the job at hand, but also undermines the ability to compete with other manufacturers.

Energy saving

The stop function and set point influence available in the Hydro Multi-E based on the new MGE model H/I/J can save a considerable amount of energy.

Stop function

In this particular case, the energy saving between running with or without the stop function enabled is **5%.**

From factory, the tank size is pre-defined based on the desired number of starts/stops.
The potential energy saving could be higher if a bigger tank is chosen, but it has to be held up against adding cost to the system, the space the tank occupies and how big the potential energy saving is, which makes it a balancing act.

Set point influence

There could lie a huge hidden energy saving potential in most commercial buildings. The friction loss might be considered to be a challenge, but the most common solution is simply to increase the constant pressure level to counteract the loss.

The set point influence will lower the pressure when the flow decreases to take into account the declining friction loss when

Counteracting the friction loss by lowering the pressure as the flow drops, the savings with the set point influence function are:

3 meters of friction loss – **3.67%**
6 meters of friction loss – **7.49%**
9 meters of friction loss – **13.52%**

System control backup - Multi master

Operational security is an important factor in all commercial buildings. The Hydro Multi-E based on the new MGE model H/I/J has a unique feature that makes every pump in the system a potential “controller”.

The system will keep operating in a fault situation as long as there is a functional feedback sensor.

Pipe filling function

System safety is another crucial part of any commercial building. A burst pipe in a building could have great consequences for the building itself but also for the people who live in or use the building. The pipe filling function on Hydro Multi-E with the new MGE model H/I/J ensures that filling pipes and the pressure build phase during e.g. commissioning or loss of power happens slowly to avoid any water hammering which could lead to burst pipes.

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