Compendium of hydraulics for heating technicians

Laurent Socal | Benedetta Grassi

IVAR PUBLISHING

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Foreword

The idea of creating this compendium stems from IVAR's desire to spread its knowledge on thermohydraulics, since the company has been operating in this sector for over thirty years.

In fact, IVAR was founded as an original equipment manufacturer for plumbing and heating systems, but our dream has always been developing more complex systems that I used to design myself. Today, IVAR designs and manufactures advanced and innovative hydronic solutions that are able to reduce complex installation procedures and energy consumption.

However, evolution in plant engineering requires more sophisticated skills and, consequently, the need for thorough training, along with the support of effective technical documentation for professionals.

We have always believed in training, and meeting Laurent Socal was decisive as a starting point for creating this manual. The need emerged to conceive a tool for heating technicians since, to our knowledge, no publication exists yet that can answer questions on hydraulics with a comprehensive approach, in a simple, direct manner.

This work is a compendium that fully illustrates all the theoretical aspects related to heating systems.

It is suitable for installers who want to further explore the practical applications they implement every day, as well as for heating technicians who want to refresh notions they already know, and also for students who are taking their first steps towards the principles of thermal engineering.

In conclusion, I would like to take this opportunity to thank all those who, with great professionalism and commitment, have supported this initiative.

Umberto Bertolotti

IVAR SpA President

1 INTRODUCTION

Operators in the thermal engineering sector in Italy have become a bit lazy. Some might think: 'there are no longer installers and boiler service personnel like there used to be.' Very few new centralised systems have been built since the 1970s in the residential sector. Centralised systems needed to be designed and installed very accurately. Then individual heating systems became popular. They required only basic installation and maintenance skills, so the number of technicians who were able to operate on centralised systems drastically decreased. The most common upgrade that is carried out on existing centralised systems is the replacement of the heat generator. Replacing a boiler is a rather 'simple' and easy job that should not raise any difficult issue, unless special circumstances apply. This is why it is often carried out informally and without a true design. A formal 'design' is drafted after the installation only in the event of an inspection or a request for documents by Public Administration. Italian Ministerial Decree 26/06/2015 had simplified the legal requirements for replacing heat generators. Until 2015, whenever a boiler with a power exceeding 100 kW was replaced, a formal energy audit was also required (preferably before the boiler was actually upgraded…). An energy audit is now mandatory only for modifications consisting in the 'renovation of heating systems' over 100 kW, which is very rare, since this requires that the generation, distribution and emission systems be all modified.

Today, things have changed somewhat.

- Since 2006, whenever a heat generator in a centralised system is replaced, indoor temperature control devices must be installed where missing, in order to meet current Italian legal provisions (minimum average seasonal heating efficiency).
- Italian Legislative Decree 102/14 made it mandatory to systematically install indoor temperature control devices and cost allocators in all existing buildings equipped with a centralised system. If the technicians involved in the installation process are not careful and competent when designing, installing, testing, commissioning, and servicing such devices, malfunctions and disputes are almost inevitable. In fact, before thermostatic valves can be installed, certain steps must be followed. These include pre-setting, correct sizing and programming (parameters) of the circulation pump, and commissioning the system (fine tuning of the heating curve) during start-up.
- Hybrid systems (a combination of a boiler and a heat pump) are often installed in new plants, which require very complex hydraulic layout, in order to manage the switching phase between each generator and optimise the operation of both.
- The use of ventilation and air conditioning systems is becoming more popular, but these systems are also more demanding when it comes to accuracy in the adjustments.
- Hydraulic circuits with a variable flow rate must be used in new buildings, in order to avoid excessive electrical consumption. Since heating energy needs in new buildings have been dramatically reduced, it is no joke that a new house could be literally heated

with the mere electric power used by oversized pumps!

- Electronic features have been added to many devices. These offer multiple possibilities in terms of configuration and control. The most obvious example is electronic pumps. To make the most of them, they must be thoroughly understood.
- Several types of self-regulating control valves are available, each with its own particular function. Specifically, the use of differential pressure regulating valves is becoming more and more popular.

These are all situations that require a good knowledge of thermal engineering, plumbing, and hydraulics. The knowledgeable use of modern devices may solve problems and malfunctions that have persisted over time and never been eliminated, such as poorly heated areas, excessive imbalances and more. Otherwise, the potential provided by the technologies that are readily available might not be properly taken advantage of, or worse, it may lead to serious problems. Unfortunately, plumbing and thermal engineering are rather neglected topics in the teaching in Italian schools.

This compendium also illustrates design aspects which include the sizing of hydraulic circuits. Sizing is also becoming a more challenging process. Components for a variable-flow hydraulic circuit cannot be chosen only based on maximum load, but their partial load operating conditions must be verified as well, which also affects energy performance.

Installers must then *commission* the system. How can a system be correctly commissioned without fully understanding how it works?

It is important to know that what we are dealing with here is just a part of the comprehensive commissioning procedure, that is, final inspection, setting, verification and hand-over. Today the term ‘commissioning’ is used to indicate the entire construction process of a building, from assessing the client’s needs to design, installation, verification, setting to work and hand over. Continuous commissioning also includes periodic performance inspection during operation life.

Things might look complicated, since there are many ways to design a hydraulic system. Multiple solutions are possible and a precise strategy is required, in order to know what decisions should be made. Controls may handle several situations, but they also have their limits.

Another complication is the lack of measuring instruments installed in hydraulic systems. You cannot become an expert in the field by just observing the pressure and flow values of a system in the daily routine. The water that flows through the pipes of an hydraulic circuit cannot be seen from the outside. If you observe a 'working' heating system or hydraulic circuit, everything looks steady, there is no immediate evidence of what is happening in the pipes.

Therefore, this compendium addresses designers, installers, and maintenance technicians who wish to review, confirm, and update their basic knowledge in hydraulics, in order to better understand the circulation of water in HVAC systems.

It, however, does not contain complete solutions for specific problems. The expertise of a technician cannot be limited to what has been learned in school or in books. It must grow with time and experience.

If you lack solid basic knowledge, your experience will only amount to a cluster of uncorrelated information, such as assuming: 'if a certain thing happens, it is usually because of that'. You decide which parts to replace based on the fact that 'this is what usually solves this problem'. However, if the problems cannot be resolved, or new problems arise, then you are lost. This sort of approach is based on superficial factual knowledge. If you are instead able to analyse what happens and correctly understand the causes and the effects, it will be much easier to put the information you gathered in order and, therefore, be able to examine new cases and find new solutions.

If we make a comparison with car workshops, we can take into consideration a 'spare parts mechanic' whose approach is: 'If this happens, then that part must be changed.' If he cannot solve the problem the first time, then he just tries to change another part until he finds the right one. Instead, a real mechanic analyses the problem, identifies the actual cause and might realise that, not only must the broken part be changed, but other fixes and or settings must be carried out as well to prevent a new failure. A broken part may not be the root cause of the problem but only the weak element that has suffered the visible consequences of a more general problem.

A 'spare parts technician' will hardly understand that, with a few simple adjustments, even by just turning a few screws or setting a different parameter, consumption can be reduced.

The time spent in a class, or that is spent reading a book like this one, is just a starting point for the training process, an invitation to reflect, and a series of tools required to understand hydraulic systems. The best training course involves thousands of hours of work per year (with your brain switched on and connected), applying and verifying the theoretical knowledge that was learned.

This book tries to provide a collection of tools so that you may reach a better understanding of what goes on inside pipes in a hydraulic system and to encourage the reader to be always curious. The greatest satisfaction for a technician should be that of being able to say: 'This system now works well, and I know why it does', or if a problem occurred: 'It is now working, again, and I now know why'.

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