Manufacture and installation problems in modular heat generators

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Abstract. This report deals with some practical cases of application of chapter R.3.F of the "Raccolta R", 2009 edition, and the technical information drawn up by INAIL, attached to the note INAIL no. 60202 20/05/2015.0003445. The cases examined relate to both the approval of modular heat generator prototypes and their commissioning tests. In particular, some represented errors in the design and installation of the systems could nullify the safety indications provided by Raccolta R and by the aforementioned note.

1 Introduction

Technological innovation, environmental issues (reduction of consumption, increased efficiencies, and consequent reduction of emissions into the atmosphere) and, last but not least, the tendency to centralize heat production, together with its accounting and installation of thermostatic valves, in buildings with multi-family housing, have favored the spread of modular generators.

Thanks also to the electronic management of the working, this kind of generators has the peculiarity to optimize efficiencies according to required powers and/or delivery temperature (also condensation of steam contained in fumes, aspect considered in almost all of the modular generators currently produced, contributes to the improvement of efficiency in plants working at low temperatures).

Heat generator efficiency is given by the ratio between heat flow actually transferred to the fluid (useful potential) and the total heat flow released by combustion in the boiler (firebox potential). Heat flow transferred to the fluid must be obviously sufficient to cover the total heating requirements of the building in maximum load conditions, gross of all inevitable pressure drop (distribution, thermoregulation and emission efficiencies).

It should be noted that, for a traditional generator, efficiency assumes high values (around 90%) only in operating conditions of the generator (tendentially at maximum load). Average efficiency of a traditional generator, in the heating season, is normally much lower due to numerous factors, among which, the medium load to which it is subjected is of particular importance.

During normal working, the variability of loads respect to the maximum design value, which may depend on climatic factors (outdoor temperatures higher than design minimum), on presence of indoor loads in the rooms to be heated, on reduction of demand by users (presence factor), together with an eventual oversizing of generator, ensure that it often

operates at low load and therefore also at low average efficiency values.

In modular generators premixing burners are normally installed in each individual module; by optimizing the air/gas ratio in all working conditions, they allow high efficiencies even at loads significantly lower than the maximum. In addition, since each individual module represents a part of the entire generator, reduced load values for a single element correspond to an even smaller fraction of the total potential; thus, for example, in the case of a generator consisting of four modules, the working of a single module at 20% of its load (with still appreciable efficiency), is equivalent to the working of the entire generator at 5% of its total power.

This means that power can be "modulated" over a much wider range, while still maintaining high efficiencies. Furthermore, electronic management of modular generators can distribute the power required, among the various modules, at a given time, so as to optimize the efficiency of the entire generator.

With such generators, therefore, the losses due to intermittent working or low load, are considerably reduced and the average seasonal efficiency is consequently increased.

So the improvements in terms of energy saving and reduced polluting emissions, in addition to practical aspects such as the speed and simplicity of installation, the reduced dimensions and last but not least, also the possibility (within certain limits) to boost successively its installed power, have increased, in recent years, the interest of producers of heat generators in this technology to a considerable extent and, consequently, its production and circulation in the market has been increased.

It was therefore necessary to adapt the "Raccolta R", which in the 1982 edition did not include this technology, with the addition, in the new 2009 edition, of a specific chapter.

2 Chapter R.3.F. (2009 Edition) of "Raccolta R"

According to chapter R.3.F a thermic element consist of a heat exchanger and a burner. One or more functionally dependent thermic elements constitute a thermic module. One or more thermic modules, working individually or simultaneously connected to a single hydraulic circuit, constitute a single modular heat generator (Figure 1) if the indication of the same chapter R.3.F are observed. Otherwise it falls into the type of generators in batteries.

Being able to consider the generator as modular, rather than as the installation of generators in batteries, allows a simplification of the plant, with respect to the provisions of chapters R.3.A. and R.3.B of Raccolta R.

Modules manufacturer can:

- assemble the individual modules, making up the modular generator, by connecting them hydraulically and electrically in his factory and then supply the modular generator complete with all accessories under a single casing,

or

- provide individual thermic modules, complete with technical documentation, which will be assembled by an installer in order to obtain a modular generator as designed by the manufacturer. Technical documentation must clearly identify the variability limits of the representative family of the modular generator and it is necessary to provide the summary schematic drawings (including the drawing number, any revision and date of issue) indicating all the electrical and mechanical components, the relative dimensions and the connections designed to ensure proper operation and safety.

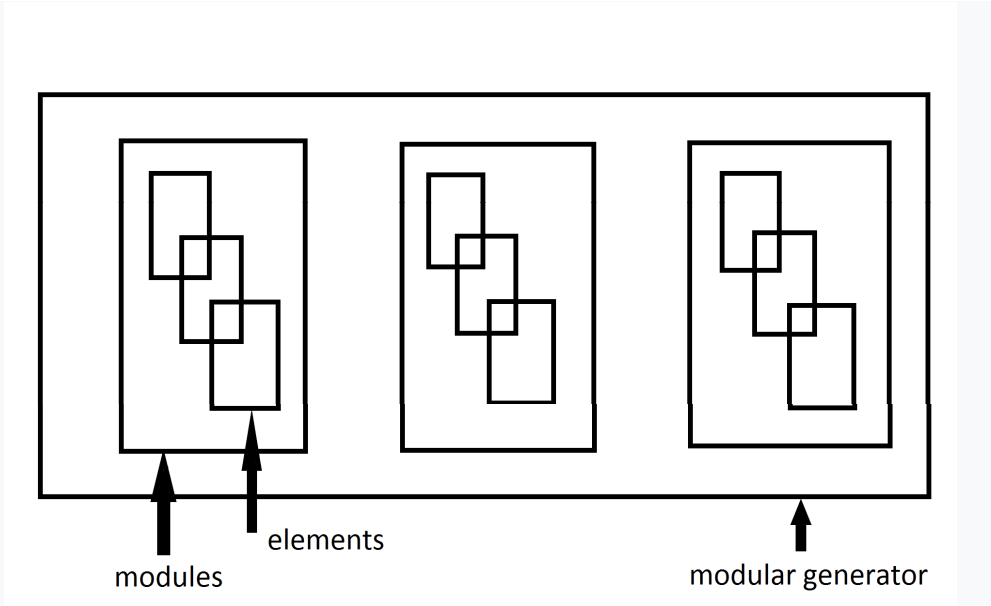

Fig. 1. Explanatory diagram of the definition of modular generator provided by Raccolta R.

Manufacturer submits the prototype to the Unità Operativa Territoriale INAIL competent for the territory, which assesses compliance with chapter R.3.F.

3 Technical indications for verifying the compliance of modular generators

With note no. 60202 of 20/05/2015, the Dipartimento Innovazioni Tecnologiche of INAIL (DIT) has issued technical and administrative indications useful for the approval of prototypes of modular generators, an activity that INAIL carries out under an exclusivity regime. These indications became necessary since the competence for the approval of prototypes became a territorial competence, compared to the previous situation which saw the Dipartimento Innovazioni Tecnologiche itself as the sole agent of the function. In these technical indications, the main characteristics of modular generators are reiterated and clarified in relation to:

- installation and characteristics of safety, protection and control devices;
- preparation, following risk analysis, of the appropriate safety measures to ensure that in all working conditions, including predictable anomalies, the working parameters of the individual modules do not exceed the values specified in the design;
- specifications on the content of technical report;
- connection of the water circuit of the individual thermal modules to the expansion system and to the safety, regulation, protection and control devices;
- generator assembly and module interception;
- post circulation device for waste heat disposal.

For the administrative aspect, to obtain the approval of a prototype manufacturer has to request it to Unità Operativa Territoriale of INAIL competent for territory (UOT), according to the model of application prepared, attaching the following documentation:

- shop drawings;
- technical report;
- use, assembly and maintenance manual relating to the modular generator as a whole and to the individual modules that are part of the modular generator, with also indication of the spare components, the necessary indication for a correct hydraulic, electrical and mechanical assembly of the components supplied by manufacturer in the case of a generator that is not part of a single casing, and all the indications for the possible interception in safety of individual modules;
- electric connection diagram, with electrical characteristics of use;
- copy of the certifications of the individual modules relating to directives 2009/142/CE and 92/42/CEE;
- copy of the certifications relating to safety and protective devices which are not part of the individual modules. The certifications must show the data reported in the INAIL/DCC note prot. 1539 of 11/03/2011 [1];
- test programme to be carried out.

Once the documentation has been examined, the UOT technician goes to the manufacturer in order to verify the conformity of the prototype with the documentation provided and performs the tests required by the programme. Following a favorable outcome, he shall issue a certificate of approval of the prototype, in accordance with the model prepared by DIT, which shall be valid for five years.

4 Problems found during inspections

During some homologation verifications of heating systems powered by modular generators and during the approval procedures for five prototype modular generators, we evidenced some problems in the application of the above-mentioned technical rules which deserve further study.

4.1 Installation of safety, protection, and control devices

One problem is related to the application of paragraph 2.2 of Chapter R.3.F. of Raccolta R which fixes a distance not exceeding one meter for the installation of all safety, protection and control devices, if not installed inside the coating. The ISPESL Note no. 102/99 [2], which wrote down in the Raccolta R Edition 1982 the first rules on modular generators, shows an example of a layout (Figure 2) in which the above-mentioned devices have to be installed within the distance of one meter from the edge of the coating of the last thermal module.

This layout was not proposed again in the 2009 Edition of Raccolta R, probably because, as can be seen in Figure 3, for some types of modular generators it would not be possible to respect the 1 metre distance, as the connection of an individual module with the common flow pipe (manifold) is already almost one meter.

Moreover, as the modules work as needed, the last module is not always necessarily working, so it would not be logical to calculate the distance of one meter as in Figure 2.

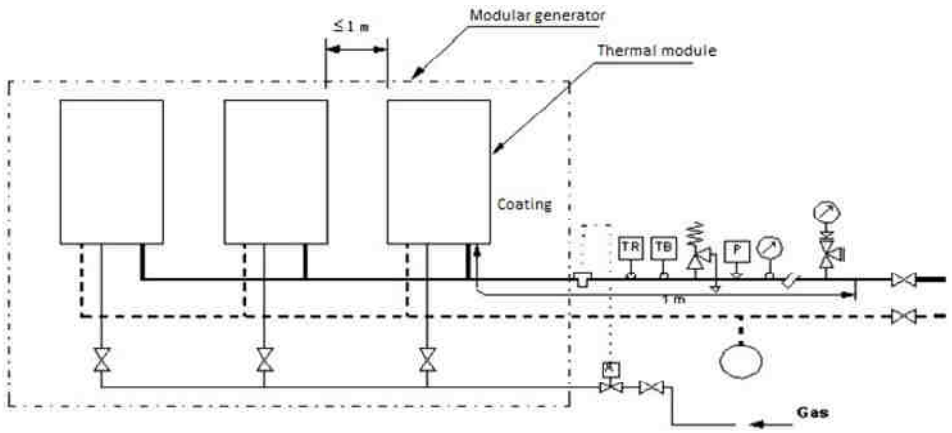

Fig. 2. Modular generator layout with the wrong indication of the threshold distance of one meter. From "ISPESL Note no. 102/99".

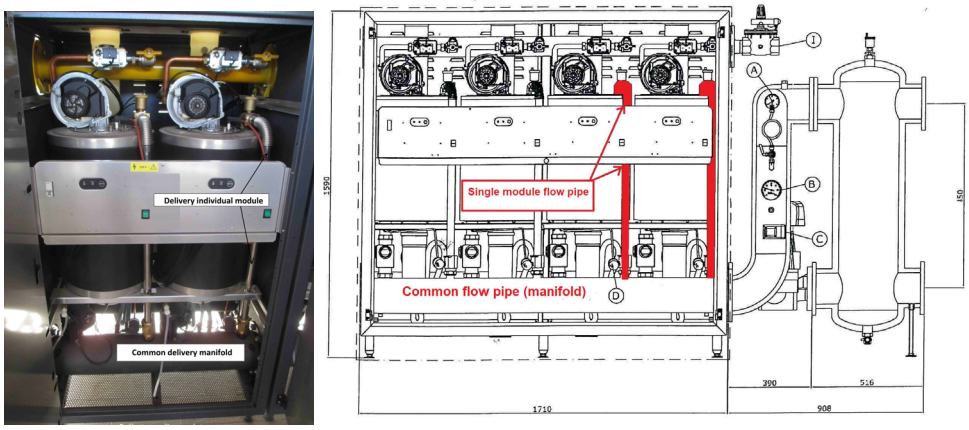

Fig. 3. Example of real modular generator: the flow pipes are almost meter long.

The one meter distance must therefore be counted literally "…immediately downstream of the last module, within a distance, outside the coating, of no more than one meter…" [3], where the coating should be understood as that of the entire modular generator as in Figures 4, 5 and in particular of Figure 6 which shows the case of modules supplied complete with a cabinet for outdoor installation and where it is possible to install the devices listed in chapters R.3.A and R.3.B only outside the cabinet itself.

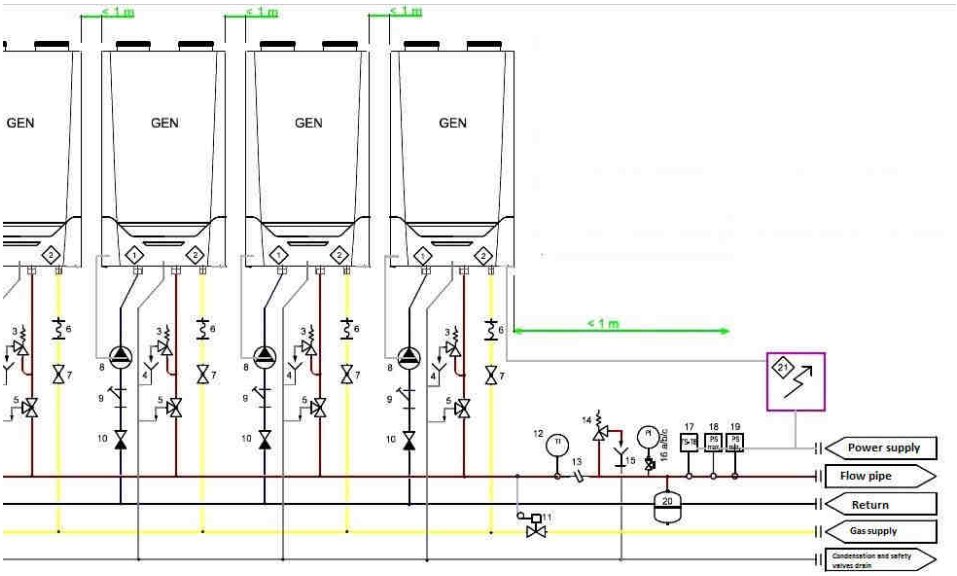

Fig. 4. An example of a correct measurement of the distance of one meter within which to install the safety devices.

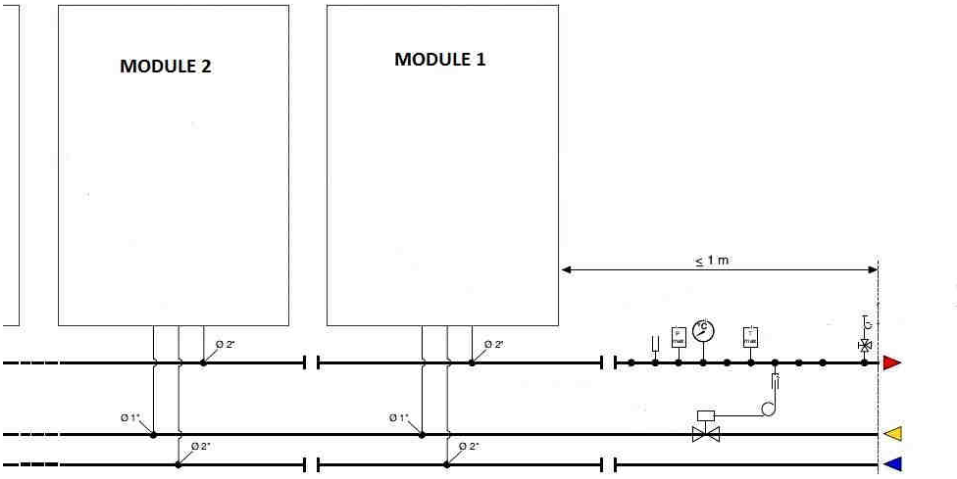

Fig. 5. Another example of the correct measurement of the one-meter distance within which to install the safety devices.

Fig. 6. Modular heat generator supplied complete with a containment cabinet and a hydraulic separator.

4.2 Testing of prototype

During the prototype approval checks, some manufacturers may request to carry out the verification only on one module instead of all modules that form the entire generator (Figure 7). This request does not comply with Chapter 6 of the "Technical indications for the verification of modular generators" [4] which expressly requires the applicant "to make available the complete modular generator for each prototype or in any case the representative configuration of the complete generator". To avoid unpleasant surprises during the inspection, it is therefore necessary to verify that the manufacturer sends the test plan to the local UOT.

Fig. 7. Incorrect configuration for submission to the approval verification of a modular heat generator. There are two modules instead of all eight included in the generator.

4.3 The user manual

Among the documents that the manufacturer must submit to INAIL for the approval of the prototype there is also the user, assembly, and maintenance manual.

This document needs to be examined very carefully by the verifier as it is sometimes approximately designed as the manufacturers often take for granted some specifications that installers might not know about the modular generators they are going to install. So, it is fundamental to verify that all the installation operations and the complete list of all parts making up the assembly kit are accurately described in the manual, in accordance with Chapter 5 of the "Technical indications for the verification of modular generators" [4]. Sometimes we found modular generators that were not installed correctly due to the lack of clarity and/or to the extreme conciseness of the installation manual. Some manuals had schematics that had not been updated to the technological evolution of the electrical boards of the individual modules. Consequently, the installer could not comprehend them correctly. Since each type of module usually has its own manual, during the prototype approval verification it is recommended to check the coherency among the manuals, both that of the individual module and that of the installation kit of the entire modular generator. Special care shall be taken when the manufacturer does not supply all the components of the installation kit. In such cases, the dimensioning and the characteristics of the missing components must be reported in the user manual, according to the configuration of the modular generator to be installed.

4.4 Assembly of the generator and interception of modules

Another problem concerns the installation of modular generators if they are not supplied already assembled by manufacturer. In these cases, as mentioned in the previous paragraph, the manufacturer must provide the detailed construction drawings both with indications of electrical and mechanical components, and with dimensions and connections between them. First, it should be noted that these drawings are not always precise and exhaustive. Therefore, for his own convenience or needs (i.e., installation in small spaces), the installer might decide on his own to install manifolds of small dimensions or to mount the interceptions under a single module. Part of the reason for this last error is that any interception of the individual modules is proposed by various manufacturers (and accepted by INAIL during the prototype approval phase) sometimes with three-way valves on the flow pipe of the individual modules and with two-way valves on the returns, other times with three-way valves on the return and the two-way valves on the flow pipe (independently of any other proposed measures and/or the positioning of the module expansion vessel). All those different solutions an installer has to deal with lead him to mistakenly believe that, once the size and material of the connecting pipes of the individual elements have been respected (deliveries and returns to and from the common manifolds), it is possible to install the three-way valves indifferently on the flow pipes or return pipes.

Therefore, it would be better to direct all manufacturers towards a single determined solution if they decide a module (or an element) is to be intercepted.

Considering that the safety, protection and control devices and the expansion vessel, referred to in Chapters R.3.A. and R.3.B., must be installed on the flow pipes (paragraph 2.2 Chapter R.3.F.), and that there must be no interceptions between each module and above mentioned devices (paragraph 3.1 Chapter R.3.F.), the possibility of installing a three-way shut-off valve (paragraph 3.2 Chapter R.3.F.) should be explicitly indicated only on the flow pipe of the single module (or element).

It is also worth remembering that the dictates referred in the ISPESL Note 102/99 [2] (circulation control or expansion and safety against overpressure upstream of two-way interception, depending on the water content of the elements) should no longer be considered, as that Note has been repealed by INAIL Note no. 60202 20/05/2015.0003445.
An additional problem concerns the post-circulation device for the disposal of the residual heat (paragraph 3.3 Chapter R.3.F), which is possible only if the connection of all modules to a single closed hydraulic circuit is guaranteed (paragraph 1.1 Chapter R.3.F). Therefore, if the manufacturer does not provide a hydraulic separator or a heat exchanger (primary complete closed hydraulic circuit), according to annex 2 of INAIL note no. 60202 20/05/2015.0003445, he must indicate all fundamental characteristics to identify the correct component to use in the installation manual, in addition to all information necessary for proper assembly and use. Unfortunately, it has been found that manufactures often do not take into consideration this fundamental safety aspect.

One safety rule prohibits interposing interceptions, filters, sludge removal systems, non-return valves and other accessories between a generator and the expansion system. It would be better if this same safety rule were applied also to modular generators, between its modules and the expansion system.

5 Conclusions

Our operational experience, which allowed us to highlight the issues reported in this publication, let us fully confirm the dictates of the INAIL note no. 72000 26/01/2018.0000774 [5]. INAIL primary objective is the prevention of accidents, only a joint effort by manufacturers, installers and verifiers can achieve this goal which has a high social value. In fact, this same goal will allow us to also protect both the companies and the users.

References

1. INAIL Dipartimento Certificazione e Conformità di Prodotti ed Impianti. Note prot. 0001539 of 11/03/2011
2. ISPESL. Circular no. 102/99 del 13/12/1999
3. ISPESL. Raccolta R, 2009 Edition
4. INAIL Direzione Centrale Ricerca. Technical indications for the verification of modular generators. Annex 2 to note no. 60202 20/05/2015.0003445
5. INAIL Direzione Centrale Ricerca. Note no. 72000 26/01/2018.0000774
6. INAIL Direzione Centrale Ricerca. Note no. 72000 18/05/2021.0003109