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A special procedure to guarantee sound isolation in dwellings

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Brochures of newly built dwellings and apartments create many expectations about various qualities of the buildings. This also concerns the quality of the sound insulation. But what happens if the quality does not come up with expectations and one cannot come to an agreement with the contractor? Where can one get one's rights. In the Netherlands we therefore have the Home Warranty Institute (in Dutch: GIW). This organisation guarantees that the building fulfils the requirements of the Dutch Building Decree. In this paper the procedure will be explained. The topics vary from airborne and impact sound insulation between dwellings, the sound reduction of facades to sound levels produced by service equipment. The possibilities will be given to improve the sound insulation if the measured values do not satisfy the guaranteed values.

1 Introduction

Sales brochures of projects for newly built one family dwellings and apartments create many expectations about the qualities of the new buildings. This also concerns the sound insulation. But what happens if the quality is not as one expected and one cannot come to an agreement with the contractor? Where can you get your rights? In this paper we describe the procedure for this situation in the Netherlands, where the Home Warranty Institute (in Dutch: GIW) gives a guarantee that the qualities of dwellings and apartments are according to the Dutch Building Decree [1]. The normal procedure via a Cantonal Court or the Council of Arbitration for the Dutch Building Industry takes too much time and is too expensive for most inhabitants. How this procedure works for the sound insulation qualities, is the topic of this paper.

2 The Dutch Home Warranty Institute (GIW)

The "Garantie Instituut Woningbouw" (GIW) was founded in 1975 with the aim to stimulate the quality of newly built sale dwellings and apartments and to promote the confidence between contractors and buyers of newly built dwellings and apartments. Therefor the GIW frames regulation, in mutual arrangement with consumer associations and building organisations and the Association of Netherlands Municipalities.

The buyer of a newly built dwelling with a GIW guarantee is assured of the quality of his dwelling, the plan and of a reliable contractor. In case of something goes wrong, than the GIW-guarantee-certificate offers protection. So there is a low threshold settling of disputes and if necessary there is a guarantee in case of defects in the dwelling and in case of insolvency of the contractor.

There are three Associate Organisations (AO) that have the following tasks:

- judging and subscribing the contractors and the building plans
- the delivery on behalf of the GIW of the GIW-guarantee-certificates
- complaint-handling/ -mediation
- execution of guarantees (on behalf of the assurance company).

If no agreement can be reached about complaints between contractor and buyer, one of the two can start an arbitrage for the GIW. Nearly always the buyer is the one who starts the procedure.

2.1 The Arbitrage-procedure

In case of a complaint the buyer first has to inform the contractor and gives him the opportunity to repair the complaint. If the buyer wants to, he can send the complaints also to the GIW-organisation.

If the contractor does not repair the complaint satisfactory, the buyer or the contractor can refer the complaint to the GIW-Arbitration. In that case the following steps will be taken.

1. An inspector of the involved Associate Organisation acts as mediator for a period of six weeks, to solve the problem. If the mediation is successful, the procedure ends; if not, the procedure for arbitration is started.
2. The GIW appoints one of the ten arbiters, an authority in building and building justice, a secretary and an GIW-inspector. The inspector investigates the complaints on location and for special problems he can appoint an external specialist mostly for service equipment and/or sound insulation. The secretary controls the procedure and assists the arbiter.
3. The GIW collects the reports and organises an oral session in which both parties can get answers on their questions and the inspector and/or specialist can explain the report. Also the arbiter can ask questions to clear things up.
4. After ca 6 weeks the arbiter gives his judgement. If the complaint is verified, the contractor is sentenced to solve the problem. Mostly in the verdict a solution is given. The contractor can make his own, as long as he solves the problem.

2.2 The sound insulation guarantees

The sound insulation requirements are given in the Dutch Building Decree [1], They are described in table 1. The GIW also has a special requirement that every part of the building must be appropriate for its function, the so called "appropriate article". In sound insulation this is specially applied to noise of ventilation equipment. When ventilation equipment makes too much noise, it will not properly be used or even switched off, which leads to various health problems.

In the Dutch Building Decree there are no requirements for noise originating from equipment of your own dwelling.

Because of the many complaints about noise especially from (balanced) ventilation systems GIW has used the "appropriate" article to give rules for this type of noise according to the Dutch standard NEN 1070:1999 [2]. Since 2002 the L_{IA} for ventilation systems and other long term working service equipment, such as central heating and heatpumps must be equal or less than 30 dB. Since 2007 the GIW has an official integral system of regulations for service equipment for the design, the installation and the noise coming from your own dwelling according to class 3 of NEN 1070:1999. The Dutch government is also studying on new regulations for ventilation equipment, because there are much more investigations, that show that most equipment does not functioning correctly.

Type of sound	To living rooms and sleeping rooms	Other type of rooms
Airborne Sound insulation between dwellings	$R_A \geq 52$ dB	$R_A \geq 47$ dB
Impact sound insulation between dwellings	$L_{nT;A} \leq 54$ dB	$L_{nT;A} \leq 59$ dB
Sound Insulation of Facades	$R_{Atr} \geq L_{den} - 30 - 10\log(V/3S_f)$ $R_{Atr} \geq 20$ dB	-
Service equipment noise from outside the dwelling	$L_{I;A;k} = L_{IA} + 5\log(V/25) \geq 30$ dB	-
Airborne sound insulation in the same dwelling	$R_A \geq 32$ dB	-
Impact sound insulation in the same dwelling	$L_{nT;A} \leq 79$ dB	-
Sound absorbing materials in common areas	-	$A \geq V/8$ m²

Table 1 The sound insulation requirements, according to the Dutch Building decree [1]

2.3 Investigation method

The acoustical investigation on location is carried out according to the Dutch standard NEN 5077:2001 or :1997 [3] which is an elaborated version of ISO 140 parts 4, 5 and 7 [4] and ISO 16032 [5]. Also the used construction is investigated by means of drawings, pictures made by the owner during the building up and inspection. Special techniques were used such as listening with a stethoscope, measurements with accelerometers and detection of junction types, as far as necessary. The investigation has to answer two questions:

1. Does the measurement result satisfy the requirements?
2. If not, what are the possibilities to repair the situation so that it will satisfy the requirements.

Especially the second question asks knowledge about the used construction and their junctions.

The verdict in cases with sound insulation is strictly consistent with the satisfaction of the requirements. An airborne sound insulation with a value of $R_A = 51$ dB (which is one dB too low for living rooms) is not satisfying and has to be improved. This has consequences also for the designing of dwellings. Designing on the very requirements results in a 50 % chance on a negative result because of the measurement and the product uncertainty. This chance is too high. Therefore in all Dutch design aids, such as the Dutch Code of Practice NPR 5070:2005 [6] and the Reference details of the Dutch Building Research Institute (SBR) [7] the design criterion is to reach a value that is at least two dB better than the requirements. This gives with a reliability of 80% a 20 % consumer-risk, see also Gerretsen.[8]

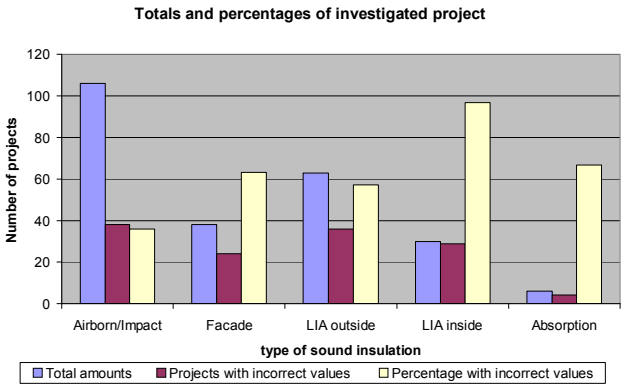

Fig 1 The distribution of the types of sound insulation and percentage of not satisfying the requirements

3 Results of the last ten years

In a period of time of ten years 201 projects were investigated in which sometimes only two dwellings were involved and sometimes more then 100 dwellings or apartments. It happens often that one person asks for GIW arbitrage and that in the case when the sound insulation does not satisfy the requirements, other buyers also claim the same improvements.

In fig. 1 the number of projects is given in which the different types of sound insulation are investigated. If in one project more than one type was investigated, they were counted for each type, so the total amount is more than 201. Also the number of projects is given with at least one not satisfying measurement result. From fig. 1 it also can be seen that airborne and impact sound insulation is the most investigated type with the highest percentage of results in according to the requirements. For the facade, the service equipment outside the dwelling and for sound absorption the percentage of wrong results is nearly 60 %. For internal service equipment this percentage is nearly 100 %. The

service equipment that gives the most problems, are ventilation systems, as well as balanced as only mechanical exhaust systems and heat pumps

What are the problems for the different types of sound insulation?

3.1 Facade insulation

In facade insulation there are two types of complaints :

1. Situations with environmental noise mostly from road and rail traffic.
2. Situations with no environmental noise, such as playing children or talking neighbours in front of the dwellings. ("as if they are speaking in my house").

Ad 1

For most of these situations an acoustical report is made for the design of the facade. Problems are in that case

1. Glass installed with a lower R_{Atr} or mufflers not in accordance with the advice;
2. No measures were taken at all;
3. Bad quality of sealing of gaps and joints.

Ad 2

The facade sound insulation in most cases does not come up to the minimum requirements in situations with no environmental noise of road , railway and aircraft traffic. In these situations the facade sound insulation must be at least $R_{Atr} \geq 20$ dB. This fact leads to an own research into this phenomenon. The following problems became clear :

1. Too much ventilation was installed.
2. There are two facts that lead to lower sound insulation of ventilation grates
   a) The angle of incidence
   b) The position nearby ceilings at the inside and/or the outside (balconies, galleries, see fig. 3). Both effects are described in EN 12354 part 3 [9], and till a few years ago the corrections for both effects were only used for ventilation mufflers. The investigation showed that the agreement between measurement and calculation improves significantly when both corrections were used also for ventilation grates.
3. In situations with small facade-areas and a large volume of the receiving rooms (and a relatively high ventilation) the acoustical quality of the ventilation grate must be higher than the mostly needed $R_{qA} \geq -2$ dB according to Eq.[1]. See also list of used symbols.

$$R_{qA} = D_{neA} - 40 + 10\log(q_v) \text{ dB} \quad (1)$$

Improvements are in these cases:

1. According to the prescriptions of the manufacturer reducing the opening of the ventilation grate or muffler to the required value;
2. Increasing the R_{qA}-value by another ventilation grate with a higher R_{qA} or by placing more absorbing material in the ventilation grates;
3. See 2.
4. In case of wrong types of glass, ventilation grates or mufflers, replacing the glass, ventilation grate or the muffler by the necessary type.

3.2 Service Equipment of own dwelling

In this case the ventilation system give the most troubles there are mostly four problems:

1. The equipment is not installed regularly
2. The ventilation box is placed against a wall with a mass less than 200 kg/m²
3. In the ducts the length of the acoustical duct is too short, see fig. 2
4. There is too less room for installing acoustical ducts, see fig. 2.

These problems can be solved by the following measures;

1. Installing the system correctly;
2. The systems can be placed against concrete ceilings, or can be placed on tables or heavy walls with a mass more than 200 kg/m²;
3. Making more room in vertical or horizontal direction for more ducts
4. Change the position in the floor or ceiling where the acoustical duct meets the ducts

For the newly built situation one can meet all these points by designing and building according to the new regulations of the GIW/ISSO 2007 [11].

Heat pumps give problems because of a bad vibration insulation in respect to the floor on which it stands. Sometimes there is also coupling to light-weight inner walls. In that case the vibration insulation must be improved with appropriate springs and improvement of the insulation of the place where the heat pump is placed.

3.3 Airborne and impact sound insulation

In most cases this type of sound meets the requirements. It also is the type of insulation that is most investigated in the Netherlands. Some problems appear more than once:

1. Airborne sound insulation between common areas in apartment buildings and living and sleeping rooms. Mostly the sound insulation of the entrance door has insufficient sealing of gaps or there is only an entrance door between the common area and the rooms.
2. The partition wall has too low a mass.
3. Sometimes the mass of a flanking part is too low or the junction with the partition construction is too rigid
4. Junction between the partition wall or floor with a window-frame leaks;
5. The cavity in a cavity wall of stone-construction is partly filled with (pieces of) concrete or other types of pollution. See fig. 4

The solutions for the above problems are:

1. Improvement of the sealing of gaps and/or using acoustical dropdown thresholds, adjustment of the hinges of the entrance door and the improvement of the sealing of gaps and diminishing the chink at the underside of the inner door.

2. Placing an acoustical lining in front of the partition wall, which give sometimes problems with reducing the room area and financial compensation.
3. If possible make the junction flexible or if this is not possible, place an acoustical lining. In case of light roof elements fit an extra heavy plasterboard panel against the roof element.
4. Close the junction with a sealant.
5. Cleaning the cavity via the facade with the aid of specialised concrete firms with special saws or long drills.

3.4 Equipment noise outside the dwelling

1. The most frequent problem is noise of elevators, especially because in the last ten years a change has taken place in placing the elevator machines: from a special machine room above the shaft to a place inside the elevator shaft. In that case the machine excites directly the shaft. Most problems can be diminished by changing the electronic start- and stop procedure, by making leaders flexible to the shaft. If the mass of the shaft is too low, an acoustical lining has to be placed in the apartments;
2. Toilet and drainpipe noise formed serious problems in case of horizontal displacement of the drainpipe with a "square" bend in combination with pipes with too low a mass. Pipes with a better insulation and more smooth bend are necessary;
3. Also automatic gates especially for garages gave to much noise because the gate mostly is fixed to the direct partition floor of the apartment above. Sometimes the gate is founded at the same foundation as the dwellings. A flexible junction or self supporting construction is needed;
4. Central ventilation systems of apartments give less problems. In one case the acoustical ducts were too short for the highest apartment, nearest to the engine. A new and longer acoustical duct has to be placed.

3.5 Sound absorption

In common areas in apartment buildings some sound absorption must be added, in total $A = V/8$ m^2. This forms mostly a problem in combination with the airborne sound insulation between a common area and a living and/or sleeping room. In most of the cases there was no absorption material at all. In most cases the solution is bringing in sound absorbing material with an $\alpha \geq 0{,}35$ against the total ceiling. The resulting reverberation time will be ca 1,3 s.

4 Conclusions

In cases that a situation does not satisfy the official Dutch building decree or is not in accordance with the "approved" article of the guarantee regulations, the GIW-procedure for complaints of buyers against contractors gives mostly a solution of the problem.

A simple and cheap procedure for the buyer makes that possible. In 54 % of the cases at least one value does not satisfy the guarantee requirements, which leads to condemnation of the contractor to repair the situation. Examples of measures are described above. Sometimes the outcome leads to new regulations especially for service equipment noise and new design aids for facade insulation.

Acknowledgement

The author acknowledges the GIW organisation for the corporation and confidence and his colleagues for their help to solve the problems of practise, especially R.A.A (Ruud) Hartman (†).

References

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[4] ISO 140, Acoustics – Measurement of sound insulation in buildings and of building elements, 1991-1998

[5] ISO 16032 Measurement of sound pressure level of service equipment in buildings, engineering method 2003

[6] NPR 5070, Noise control in buildings – Design aid for airborne and impact sound insulation for buildings in stony constructions, (in Dutch) 2005

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[8] E. Gerretsen, Interpretation of uncertainties in acoustic measurements in buildings, Proceedings of INCE EUROPE Symposium "Managing Uncertainty in Noise measurement and Prediction" Le Mans (France) 27-29 June 2005

[9] EN 12354 (3) Estimation of acoustic performance of buildings from the performance of building elements Part 3 Airborne sound insulation against outdoor noise

[10] GIW/ISSO publication 2007 Requirements for service equipment newly built dwellings and apartments 2007

List of symbols

A	Total sound absorbing area in a room in according with EN 12354 part 6 (m²)
D_{neA}	Normalised sound level difference for small elements according to ISO 140 part 3 (dB)
L_{den}	Sound level before buildings caused by road traffic, railway, aircraft or industrial noise (dB)

L_{nTA}	Normalised impact sound level according to ISO 717 part II (dB)
L_{IAk}	Characteristic sound level from service equipment in dB
L_{IA}	Normalized sound level from service equipment according to ISO 16032 (dB)
q_v	Ventilation capacity per unit lenght (1 m) of ventilation grate or muffler.($dm^3/(sm)$)
R_A	airborne sound reduction according to ISO 717 part I (dB)
$R_{A;Tr}$	Facade sound reduction according to ISO 717 part I (dB)
R_{qA}	Sound reduction, normalised on the ventilation capacity of a ventilation grate or muffler (dB) see Eq.[1]
S_f	Surface of a facade (m^2)
V	Volume of a (receiving) room (m^3)

Fig. 2 Balanced ventilation unit with too short acoustical ducts and also with bends with too much resistance, which result in too much noise. L_{IA} varies from 34 to 52 dB.

Fig 3 Ventilation grate near a ceiling outside

Fig. 4 The cavity of a cavity wall is near the ground floor no more a cavity. By cleaning the cavity the airborne sound insulation was improved from R_A = 46 to 59 dB.