New Dutch Code of Practice NTR 5076 for equipment noise in dwellings and apartments

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Summary

During the last decade there were very often complaints about noise from ventilation systems {45 dB or more in living rooms is no exception) which induces wrong use of this equipment which causes healthy problems. Also the nearly zero energy policy for dwellings will also create new service equipment, which can create such high sound levels that they may not be used properly. With that purpose the Dutch government gave new requirements for this topic. Apart from this the old Codes of practice on equipment noise were outdated and need to be renewed due to changes in equipment technique and building methods. Therefor the Dutch standard organization (NEN) and the Dutch Knowledge Institute for the equipment sector (ISSO) join forces to produce a new code of practice: NTR 5076 Equipment noise in terraced houses and in apartments.

In the presentation the Dutch requirements on the maximum sound levels of service equipment will be explained and the developments in the last 20 years and the principles will be described for both the equipment part and the building acoustic part because they interact in order to reach a maximum or lower level of 30 dB for the following equipment:

ventilation systems, individual and collective, waste water and water supplies, heating and heat pump systems (2020 Nearly zero energy) and automatic garage doors.

New measurement results were incorporated. The starting points are the sound power level L_W of the equipment and the characteristics of sound propagation in equipment parts. Together with the sound insulation characteristics of building elements and the indirect sound transmission between rooms “the building acoustical part” the allowed sound levels in rooms can be reached

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1. Introduction

During the last decades there were often complaints on the sound levels and the use of ventilation systems in dwellings. In the nineties of the last century this problem of loud ventilation systems was known [1], but because of the principle: “You can switch off noisy systems of your own dwelling any moment you like it”, the central government gave no requirements for these items. In the last decade it became clear that the noise of ventilation systems lead to unhealthy situations in buildings. (You only tolerate the noise of the ventilation system when there are more severe problems: humid bathrooms and unpleasant scents in the kitchen/living room). Therefor in the new Building code of 2012 requirements were given.

Because of the new European requirements on “nearly zero energy in 2020”, new service equipment will be developed for heating, cooling and ventilation. It must be avoided that the inhabitants do not use the new equipment in a proper way because of too much noise.

A third development is the fact that the 15 year old Codes of practice for various types of service equipment were becoming out of date. Because of new knowledge, the change from central to individual equipment(heating and ventilation), new principles for equipment and the changes in building technics, these codes of practice had to be renewed. The Dutch Standard organization NEN and the Dutch knowledge center for the equipment sector ISSO joined forces for a new code of practice NTR 5076:2015[2] and bring together the knowledge in the acoustic and the equipment field. The principles and some examples will be given.

2. Classification schemes and relation to legal requirements

The Dutch building codes since 1992 only give requirements for service equipment from outside the dwelling. Since the Dutch classification scheme of NEN 1070:1999 which was originally meant to determine the acoustic classification of a dwelling on a voluntary base, this standard is used as the base for legal requirements and for guarantee purposes. The classification is from Class 5 (the lowest) to Class I (the highest level). The requirements of the legal requirements were equal to Class 3, except impact sound insulation which was in class 4. That's the reason why in 2003 the requirements for impact sound became 5 dB more stringent to reach class 3.
As mentioned above there were no legal requirements for service equipment before 2012. In 2007 ISSO and the Dutch Guarantee Institute of Housing (GIW)[3] used the classification scheme to lower the high percentage of complaints about (noise of) equipment of your own dwelling. In this publication also other requirements were given for better functioning. Equipment noise Class 3 in your own dwelling needs an A-weighted equipment noise level L_{IA} of 30 dB or lower is required. Because of the complaints and high percentage of badly installed and noisy equipment the government ordered the same level in 2012. Because one of the starting points of the Dutch Building code is that the requirements are independent of the division of a dwelling, in the Netherlands the characteristic A-weighted equipment level L_{IAk} is used according to the equation (1):

$$L_{IAk} = L_{IA} + 5\log(\frac{V}{V_{ref}}) \qquad (1)$$

In which
L_{IA} The A-weighted equipment sound level [dB]
L_{IAk} The characteristic A-weighted equipment sound level [dB]
V The volume of the receiving room [m^3]
V_{ref} The reference volume of 25 [m^3]

L_{IA} is the A-weighted level, normalized to a reverberation time of 0,5 s measured in the octave bands from 63 Hz to 8000 Hz.

The requirement is stated in formula (2) :
$L_{I;A;k} \leq 30$ dB. (2)

The new code of practice is intended as a help in designing and installing equipment and controlling the quality of performance at the end of the building process.

3. General starting points

The starting points for the code of practice are as follows:

1. the sound power levels of the equipment itself;
2. the design of ducts and pipes with respect to the propagation of the sound into the receiving room;
3. the sound in the source room which is propagated via the direct partition wall or floor into the receiving room;
4. the sound that is propagated through doors and landings to the receiving room (indirect sound transmission;
5. The construction sound through the direct mechanical connections of equipment with the building structure.

Ad 1Sound power levels

When the apparatus is performing in several conditions, the sound power levels of these conditions have to be known. They are mostly a part of the information that is given by the supplier according to international standards

Ad 2 Sound propagation in ducts and silencers

For the sound characteristics of silencers the results of laboratory measurements according to EN-ISO 11691 and 7235: 2009 are used. The propagation of sound in ducts is calculated according to the Dutch publication ISSO 24:1991[4]

Ad 3 Sound insulation of materials

Known values of sound insulation of materials (R'_w +C) according to EN ISO 10140:2010 and measurements in situ.

Ad 4 Indirect sound transmission

The theory of EN 12354-1:2000 is used with values from in situ measurements of doors, halls and landings[5]

Ad 5 Construction noise

By connecting the equipment to heavy constructions or by placing the equipment on appropriate vibration isolators it is possible to diminish this sound in a proper way.

For the calculations and the guidelines there is a tolerance of 2 dB as is also used in the other Dutch codes of practise (NPR 5070 and NPR 5086). Because there is no tolerance with respect to the measurement result to the requirements designing on the legal requirements will lead to approximately 50% of the results that do not fulfil the requirements.

In the next chapters various types of equipment with various characteristics will be treated.

4. Ventilation systems

In practise there are three types of mechanical ventilation systems:

1 mechanical supply and natural removal
2 natural supply and mechanical removal
3 Mechanical supply and removal

Mechanical supply and natural removal

The systems in the Netherlands for this type of ventilation are not central but are placed in living rooms and bedrooms itself. In this case there is one source because it is not possible to measure the individual sources in the system apart separately. Figure 1 shows the allowable sound power level as a function of the volume of the receiving room to derive what apparatus can be used in a specific case. It must be checked that the ventilation capacity (0,9 S with S the surface[m^2] of the receiving room [dm^3/s] is.

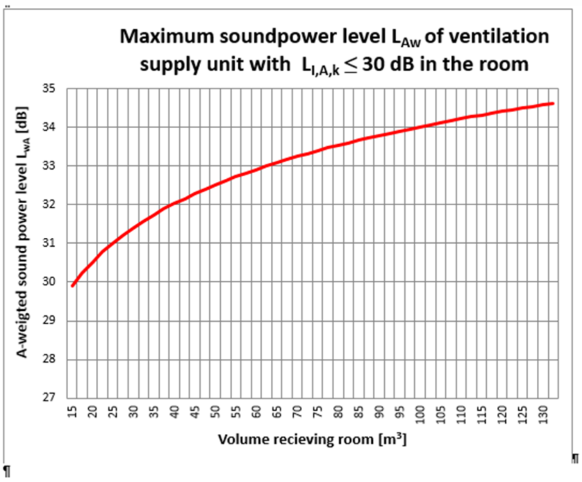

Figure 1 Design tool for determining the maximum sound power level of a ventilation system, placed in the receiving roomas a function of the volume of the receiving room. The sound power level must be under the red line

Natural supply and mechanical removal

For this type a central unit is placed in the attic or in a special storage. Units are in use with a single fan. The used ones of the last 20 years produce too much sound, but when the new legal requirements on L_{IAk} came into use, it is expected that new units will be developed by industry with lower sound power levels (L_w re 10^{-12} W). It was decided that 4 levels in steps of 5 dB were used and that for each level the measures were calculated. Four typical Dutch situations with respect to the placing of the unit are described:

1 In the attic

2 In the attic with an enclosed bedroom on the attic;

3 There is a door of the storage to the hall and or landing and a wall between the storage and the receiving room;

4 The storage has a door and a wall directly connected to a receiving room.

In most cases ventilation valves are placed in the living room with kitchen, bathroom and the toilet.

The total ventilation capacity for all situations was determined on 225 m^3/h with a pressure loss of 100 Pa. These conditions fulfil in most cases the legal ventilation capacity requirements. For the determination of the working point of the unit the characteristics can be used such as is given in figure 2.

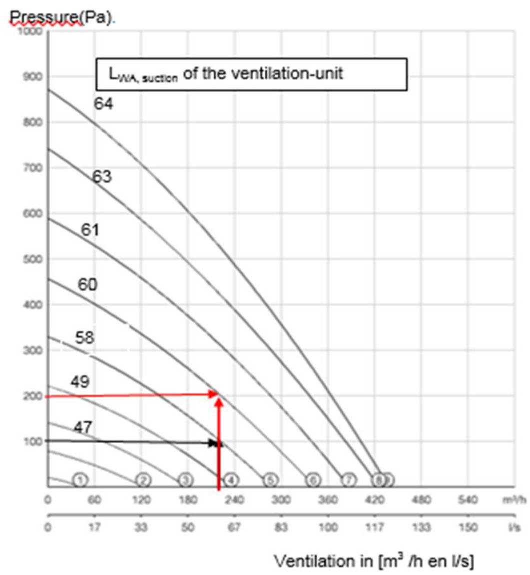

Figure 2 Determination of the working point for a ventilation system the point 225 m^3/h | 100 Pa has a two dB lower sound power level than 225 m^3/h | 200 Pa

Because there is now a legal push to improve ventilation systems which will lead to systems with lower sound power levels. The situations are calculated for systems with a various L_{WA} between 48 and 63 dB in the outlet of the dwelling.

The measures for situation 1 are less severe than the other situations. Measures that can be taken, are:

- Normal honeycomb hardboard doors with a slit underneath the door of 10 (15 dB) or 20 mm(12 dB). or a door with R'_w +C =34 dB (for situation 4).
- Sound insulation of walls with an R'_w +C of 28 to 35 dB
- In most cases an extra envelope of 18 mm multiplex, or plasterboard can be used as an alternative
- Lengths of silencers of 0,4 to 1 m in the sucker suction side and 0,25 to 1 in the supply side.
- For case 4 it is the most preferred solution to place the unit and the silencers in a casing of 18 mm plywood,. as mentioned above.

Mechanical supply and mechanical removal
The same principles are used as in the previous paragraph. Now there are two fans and the incoming air is warmed by the outgoing warm air by a heat exchanger. In all bedroom and living rooms there are supply ventils and in the living rooms, the bathroom and toilets there are removal ventils.
The situation is more complex because of the high sound power level especially in the supply ducts to the rooms, and the supply ventils in each living and bedrooms.
For this situations the L_{WA} of the supply side of the unit is 67 to 52 dB in steps of 5 dB.
The same principles of the measures have to be taken, only more severe:.

- Normal honeycomb hardboard doors with a slit underneath the door of 10 (15 dB) or 20 mm (15 dB) or doors with 37 dB.
- Sound insulation of walls with an R'_w +C of 28 to 37 dB
- Lengths of silencers of 0,75 to 1,4 m press into the dwelling and 0,5 to 1,2 in the removal side and 1,2 to 0,5 m in the press side to the outside.
- For case 4 it is the most preferred solution to place the unit and the silencers in a case of 18 mm plywood. It is better to avoid case 4 in the design stadium.
- In all cases it is necessary that the silencers are mounted in a straight line without any curve

5. Waste water systems

For this type of service equipment another method is followed: there is a computer program in which the influence of various factors is quantified. This program is based on measurements in a laboratory situation of Peutz BV in charge of ISSO, TVVL, the organisation of installation companies, and suppliers of waste water systems and of building materials.[6] and [7] The computer program named Soundspotsimplus, describes the sound transmission to rooms under the toilet, next to the toilet and rooms with a horizontal pipe after a curve above a lowered ceiling. See figure 3.

The parameters for the airborne sound are

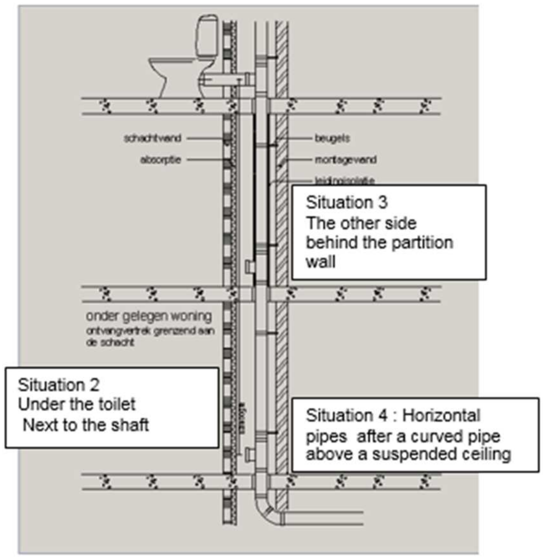

Figure 3 The situations 2 to 4 that can be calculated with SoundSpotSimPlus. The first situation is when the room is not next to the shaft.

The influence of the following factors can be calculated :

1. The various types of pipes;
2. The presence of a change in direction;
3. The presence/materials around the pipes;
4. The material(s) of the shaft (from bricks to plasterboard configurations);
5. The dimensions of the shaft;
6. The presence/amount of absorption in the shaft;
7. Surface area of the shaft in the receiving room;
8. The volume of the receiving room.

For the construction sound the following parameters are important:

1. The mass of the construction on which the clips are fastened

2. The type of clips, with or without rubber inlay

The program calculates the L_{IA} and L_{IAk} in the receiving room and it is easy to see the consequences of changing parameters such as the type duct and the type of shaft.

There is however one situation that the program does not calculate: situation that the shaft does not border the receiving room. This is the best situation for a good design. In lightweight buildings this is the only way to meet the requirements.

A special type of waste water systems are reservoirs for waste water with pumps. The measures for these pumps are a maximum velocity of 2 m/s in the pipes and it is needed to place this equipment as far as possible from living and bedrooms.

6. Water supply systems

The conclusions of a study by Peutz [8] of the sound radiation of various walls in which various water pipes are mounted, are the basis for this part. Also recommendations about water hammer are embedded Also some recommendations from older codes of practise are still in use especially for pressure boosting.

In the Netherlands the water supply ducts in apartments are placed in vertical shafts and are transported in horizontal direction via screed and finally via walls to cranes. The main measures are :

- Water velocity ≤ 2 m/s in ducts
- Use of appendages and taps with $L_{ap} \leq 20$ dB conform EN-ISO 3822
- Against water hammer (see also [8])
    - o Ducts as short as possible between appendage and branching;
    - o Water velocity lower than 1,5 m
    - o Ducts made of synthetic materials are better than metals (copper or steel)
    - o In case very quick closing taps of example washing machines use a special damper against water hammer
    - o For special cases literature is available on this topic.
- In pipes of synthetic materials the water velocity must be lower than 1,5 m in case of narrowing in the pipes;
- The pressure in the pipes ≤ 3 Bar;
- Use flexible connections between ducts and taps such as flexible ducts.

The measures for water pressure boosting systems do not changed and are the same as in the old code of practise. See figure 4

Figure 4 Measures for water pressure boosting systems : The pumps are placed on vibration isolators (green arrows) and the pipes are separated by compensators (red arrow) from the pumps

7. Heating and hot water equipment

During the last decades there was a change in heating systems in apartments from collective to individual systems as is the case in most terraced houses The remaining collective systems are district heating systems, which give low sound levels in the dwellings.
Most individual heating systems are High Efficiency (ca 107 %) systems. Because of the nearly zero energy policy of Europe heat pumps will be used increasingly.

For this type of equipment the measures are :

- Isolate the vibrations of the systems by placing the apparatus on vibration isolators with a resonance frequency in the order of 10 Hz
- Isolate the vibrations of the pumps by placing flexible ducts between the pumps and the rest of the dwelling.
- Calculate the needed sound insulation between the storage room and the receiving room as described in chapter 4 for the direct and the

indirect sound transmission. The sound power level of these systems is for the starting point.

For the design of all service equipment a good cooperation between the various disciplines and the architect is necessary, so that there is enough space for all equipment in the storage.

8. Automatic garage doors

Inhabitants that are living in the neighborhood/next to automatic garage doors, complain very often about the noise of these doors because of bad performances and no (good) measures taken to restrict the sound levels. There for, although there are no legal requirements for this type of service equipment, various types of automatic garage doors are described. to reach $L_{I;A;k} \leq 30$ dB, the same level as for elevators. A set of measures is given to reach $L_{I;A;k} \leq 30$ dB, the same level as for elevators:

- With frequency controlled electric motors the movement of the door starts and stops slowly, so that there are no shock movements with high sound levels.
- Vibration isolation of the bearing construction on foundation
- Use of plastic wheels instead of metal wheels especially in metal guides.
- Placing the whole construction inclusive motor on a portal construction which is completely free from walls and ceiling.

9. Inspection and controlling

In Appendix A a method is given for inspection of service equipment and a quick measurement method for non-acousticians such as employes of equipment consultancies and companies. Only the dB(A) value has to be measured and a correction for reverberation time together with the room volume (the term 5 LOG (V/25)) using one table. Special attention is given to background noise and to avoid it, when the difference between the level of background noise and that of the equipment is too small. Sometimes the equipment level inclusive background noise fulfils the requirements. In that case the equipment level complies.
The appendix B gives information about the Dutch classification system of NEN 1070:1999.
Appendix C gives a table of sound insulation values of walls and door constructions in octave bands and in R'_w+C.-value.

Appendix D describes the Dutch standard for dwellings that are used for various types of energy-calculations. They can also be used for other purposes.

10. Conclusions

With the new Dutch Code of Practice 5076 there are guidelines to design and control the sound of service equipment that has to fulfil the Dutch Building Code. Special attention is given to the new requirements for service equipment of your own dwelling.

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Literature

[1] H. Versteeg en L.E.J.J. Schaap "Research on ventilation and radon concentration in dwellings" LBP report R043113A2.hv 1999 in order of Novem BV

[2] NTR 5076 "Sound of service equipment in terraced houses and apartments" ISSO Rotterdam and NEN Delft April 2015

[3] GIW ISSO 2008 :Design- and Mounting advices for newly built terraced houses and apartments

[4] ISSO Publication 24 : "Sound of Equipment : calculation methods" ISSO 1990

[5] F. de Roo, W.G.M. Beentjes B.J.G. Jansen Indirect sound transmission via doors (Internoise 1981 Amsterdam page 431 to 434 and Report 6194/1982 Bouwcentrum Rotterdam

[6] Report RA 708-5 "Sound from vertical waste water systems in shafts" Bureau Peutz 2005

[7] Report ARA 858-3-RA "Acoustical investigations to horizontal waste water systems above suspended ceilings" Bureau Peutz August 2011

[8] Report RA 858-1 "ST-19 Sound insulation of plumbing and sanitary equipment: 2a Laboratory measurements in water supply ducts caused by water velocity and armature" Bureau Peutz July 2009

All publications are in Dutch except publication [5]