IMPORTANCE OF EVALUATING TEMPORARY NOISE SOURCES

Zoltán Hunyadi

Budapest University of Technology and Economics, Department of Building Construction,
Műegyetem rkp. 3. K build. II.27/a., H-1111 Budapest, Hungary
zhunyadi@epsz.bme.hu

Abstract

The gas-turbine reconstruction of a particular thermal power station took place in an industrial area extending among dwelling area. A part of the dwelling area suffered from a significant noise load during the former obsolete apparatus was operating. However, the noise protection design – in order to abolish the former complaints – only focussed on the noise protection of the dwelling area had already been under the industrial noise load. The new technology was installed into a building considerably further. The noise protection design of the terminal constructions and chimney shut down with an adequate result, but focussed on exclusively the territories charged before. In addition, the sizing only concentrated on examining and noise control of the apparatus emitting permanently. Although the temporarily operating equipment were also supplied with noise control constructions, after the commission of the power station, new residential complaints were drown up. According to the residential complaints, the monitoring measurements ordered by the operator detected that the temporarily operating equipment overran the noise limit at those territories, which are on the other side of the power station and had not been suffering from noise charge. It turned out, that the period time of the temporarily operating equipment was significantly undercounted, and it totally filled – moreover exceeded – the estimation time of the night period, and become a determinate noise source. Besides, the noise sources emitting a high amount of steam in a short time caused such a noise phenomenon – really disturbing , according to subjective opinions – which has a significant and negative influence on noise spread, and made the evaluation of enquiries more difficult.

INTRODUCTION

Good lessons can be drawn from seeing through the implementation of the power-plant reconstruction procedure. Partly because the planned program — the selection between equipments to be refurbished and to be purchased as new — has been changed in the meantime, partly because at the beginning of the planning not enough

importance was attached to the transitional operating modes, which proved to be determinant regarding the noise emission later on.

The ground of the power-plant is bordered by industrial sites from three sides and by an inhabited area from the fourth side:

- from the north a 10 storey panel technology housing estate and self-contained houses to the east of them,
- from the east a metal-working factory (operating only in the day-time),
- from the south an industrial building of a chemical research institute,
- from the west the site of a continuously working chemical plant.

Further the site of the chemical research institute bordering the power-plant from the south more areas of self-contained houses can be found.

ACOUSTIC REQUIREMENTS

The authorized Environment Protection Inspectorate defined 15 years ago such noise load limits for the area, which exactly correspond to the noise emission regulations of the presently effective decree.

Table 1 — Noise load limits for the area

Estim. point	Area	*Noise load limit, L_{NL} (dBA)*	
		day (06-22h)	*night (22-06h)*
M1	N — 10 storey panel technology housing estate	55	45
M2-3	NE — institutional area	60	50
M4	NE — self-contained houses	50	40
M5-6	E — industrial area — metal-working factory	70	
M7	S — industrial area — chemical research institute	70	
M11	W — chemical plant	70	

The actual environmental noise load before the reconstruction can be characterized as a significant excess of the nightly noise limit by 10 dB was experienced on the estimation point M1 located to the north from the power-plant and in front of the panel technology house (2 m in front of the façade on the fifth floor level).

OVERVIEW OF THE INVESTMENT PROCEDURE FROM A NOISE PROTECTION POINT OF VIEW

The reconstruction of the power-plant was carried out primarily because of the actual need to replace the age-worn generating equipments, but an important aspect was also to reduce the noise load excessing the limit caused to the near-by dwelling-houses. Several comprehensive acoustic examinations were carried out during the planning and installation of the facility in order to reduce the environmental noise load. We survey some of these in the followings.

The preliminary environmental impact study

In the preliminary environmental impact study a new 70 MW combined cycle gas turbine unit was proposed to be built in. Besides the heat recovery boiler attached to the gas turbine, the installation of a 120 t/h capacity steam generator and keeping the steam generator, steam turbine and both hot-water boilers of the old power-plant as stand-by equipment were proposed. For the new building the southern part of the ground of the power-station was proposed, located far from the existing installations and the 10 storey dwelling-house which suffered earlier from the highest noise load, near to the border to the ground of the chemical research institute being classified as an industrial site.

The calculations of the noise load for the planned circumstances were accomplished for three points:

M1 in the northern direction on the higher floors of panel technology house (these are not in noise shadow),

M4 north-eastward on the area with self-contained houses, 2 m in front of the façades of the houses and in 1,5 m height,

M7 in the northern direction at the common fence of the power-plant and the chemical research institute, in 1,5 m height.

In the calculations only the effects of the noise sources in the building were taken into account. *Only the variation of the operational parameters with the concurrent operation of every noise sources was examined*, the noise emission in the temporary operating modes was not dealt with**.**

The thorough environmental impact study

The thorough environmental impact study approved that the new building must be located as far from the panel technology dwelling-house as possible. As the most important noise sources of the new building the gas turbine, the heat recovery boiler, the steam generator and the 81 m high chimney of the gas turbine, located on the roof of the building were considered. The required sound reduction of the roof- and façade-structures of the main building (R'_w=32 dB and R'_w=36 dB) were determined. For checking the noise emission also the M1, M4 and M7 estimation points were envisaged. Regarding the environmental noise emission — taken into account the noise limits and the use zoning — the affected zone of the power-plant was determined as of (*Figure 1*).

The study didn't concern the areas with self-contained houses in neither the southern nor the western direction which should have increased protection against noise, and the additional and temporary noise effects of the different modes of operation and their changes were also not respected.

Realization agreement

The realization agreement briefly recites the main units to be carried out during the reconstruction, and emphasizes among the planned goals that the power-plant operates in a combined mode, provides the housing estate near-by with steam energy

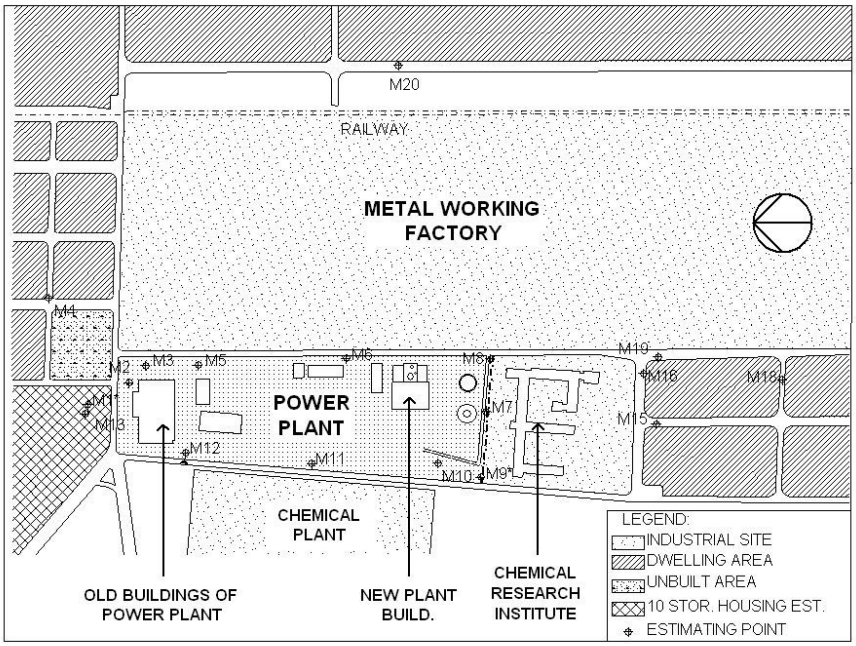

Figure 1— The supposed affected zone of the power-plant

and joins therewith the nation-wide electric network as a peak-load power-plant. It is stated that

- 100-150 start-ups are envisaged yearly,
- the gas turbine and the steam generator will be nights stopped,
- several substantially different modes of operation will be discerned (full load, partial load, operation with auxiliary steam generator and gas turbine).

Because of the numerous start-ups the use of the so called "starting valve" becomes an everyday practice (operation mode). The planned nightly stopping of the gas turbine forecasts that the intermittent operation of the starting valve will happen at dawn which is critical from the point of view of the noise protection.

THE CRITICAL NOISE SOURCES OF THE POWER-PLANT RECONSTRUCTION

The complaints of the inhabitants against noise stated that the most disturbing noise source of the power-plant is the *starting valve of the gas turbine.*

The starting valve of the gas turbine is located on the + 29 m roof level of the new building, at the socle of the chimneys. It comes into action when starting the gas turbine, and discharges 71 bar pressure ~500°C temperature steam into the environment. The quantity of the emitted steam varies with time, the valve is fully open in the last 10 minutes of its operation and the noise emission is the most intensive in these periods.

A similar starting valve operates when starting the steam generator, this is located on a lower level roof of the building. According to the preliminary information, this emits less noise, and its role in the environmental noise load is reduced also by the fact that a higher part of the building screens it partly. The equipment has lower capacity and therefore the starting valve operates only during a shorter time.

As we observed preliminarily and subjectively, another determinant and continuously operating noise source is the *exhauster of the feed storage tank* on the 29 m roof level of the new building. Its noise emission is lower during the constant load of the power-plant, but increases when changing the mode of operation. According to subjective observations, the noise source is undirected, its noise spectrum is nearly stationary.

As opposed to the above mentioned noise sources, the noise emission of the outer boundary constructions of the new building can not be determined by measuring it, because of the continuously operating external noise sources. The noise emission of the outer boundary constructions could not be sensed by subjective observation in the environment of the new building. In respect that a part of the wall structure of the hall is made of light construction wall panels having an Rw=32 dB sound reduction index, we made sure of the magnitude of the noise power loading the wall structures by an indoor measurement: the average A-weighted sound pressure level of the hall is L_{Ap}= 76,3–77,1 dB, it doesn't contain any narrow-band component. Based on the above the noise emission of the outer boundary constructions of the building can be eliminated.

We carried out near-field zone measurements to identify and characterize the noise sources and examined the noise load of the estimation points in the dwelling area.

CHARACTERIZATION OF THE MAIN NOISE SOURCES

The high quantity and high temperature steam output from the starting valves caused measuring difficulties, therefore we had an opportunity only for a limited number of measurements.

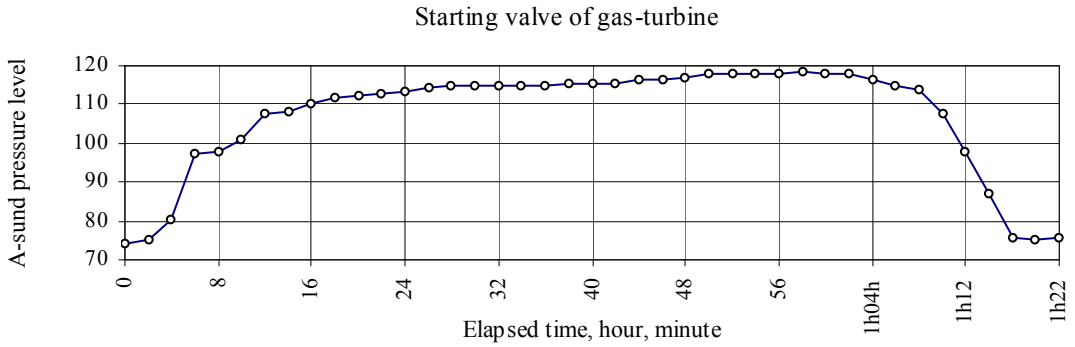

*Figure 2 — A-sound pressure level time-curve of gas-turbine starting valve at 4*m

Although the starting valve operated in altering periods, it functioned as a determining noise source for 60-70 minutes length of time. In spite of the fact that the valve is fully open only in the last 10 minutes of its operation, the A-weighted sound pressure level registered in a measuring point in a 4 m distance varied in a range between 110-120 dB during 60 minutes, the average A-weighted sound power level of the most noisy half-hour was L_{wA} = 134,5 dB. When examining more duty cycles, the noise emission of the equipment was constant within the range of error of measuring. The power-plant operates in fact as a peak-load power-plant (it is started up to satisfy the peak-load demands of electricity).

Within the operating period of the starting valve of the steam generator ca. 20 minutes deliver significant environmental noise load, this is shorter than the nightly estimation period. Parallel to the opening of the valve the power of the noise source increases significantly, but its sound power level remains by ca. 17 dBA lower than that of the starting valve of the gas turbine.

The noise emission of the *exhauster of the feed storage tank* on the roof of the building can be characterized by a lower noise emission at a constant load of the power-plant and by a shorter (ca. 10 minutes) period of higher noise emission following the load changes. The noise spectrum of the equipment is nearly stationary, it doesn't contain any narrow-band component, its A-weighted sound power level varies between L_{wA} = 104,5 - 114 dB.

ENVIRONMENTAL NOISE ON THE ESTIMATION POINTS

Not only the noise load caused by the constant noise sources, but also that of the temporary noise sources must have been examined on the estimation points.

The noise load caused by the constant noise sources being active during the steady state operation of the power-plant exceeded the background noise only by maximum 3 dB at any of the estimation points. In this mode of operation the environmental limits were fulfilled also in the dwelling area beyond the chemical research institute to the south of the power-plant, not considered during the planning. Both from the estimation points 1-10 and the new estimation points in the southern areas the chimney and significant part of the block of the new building are directly visible, including the environment of the exhauster of the feed storage tank.

The impact time of the noise level change higher by 5 dB than the background noise was 70 minutes during the operation of the most significant noise source, the gas turbine starting valve. The noise level varied between 44 – 69,5 dBA both on the earlier examined and on the newly defined estimation points. We registered significantly different environmental noise during the individual examinations despite the nearly identical meteorological conditions (-2 °C, 90 % relative humidity, 1,0 m/s SW „wind"): on one occasion the excess over the limit reached 26 dB on the northern area while on the southern area it didn't exceed 18 dB, on another occasion just the opposite happened – the excess over the limit reached 29.6 dB on the southern area while on the northern area it didn't exceed "only" 18 dB. The phenomenon can be explained by the enormous quantity very high temperature steam emitted into the

environment, which changes the conditions of the sound propagation on an extended area and causes the phenomenon of interference. The short measurement spectrum measured on different estimation points in a distance of 370-520 m from the noise source is represented. While only distance-dependent 3-5 dB level differences were registered in the 50-630 Hz frequency range, the level differences in the 630-5000 Hz frequency range reached 15-20 dB.

Table 2 — Noise limits excesses

Estim. point	A-sound pressure level L_A, (dB)		Noise limit excess ΔL_p, (dB)	
	1st occasion	2nd occasion	1st occasion	2nd occasion
M4	50,2	68,1	10,2	28,1
	49,3	69,0	6,3	29,0
M13	-	69,6	-	29,6
	-	71,2	-	31,2
M15	47,3	64,5	-	24,5
	46,6	64,5	-	24,5
M18	66,0	45,1	26,0	-
	65,1	46,4	25,1	-
M19	43,8	56,0	-	16,0
	43,8	58,1	-	18,1

During the revision of the technology and environment plans of the starting valve we stated that the cause for the apparently high noise emission is the ineffective silencer. We could check on the plans of the starting valve silencer (design data sheet) the (nominal) A-weighted sound power incident to the blowing duct and from that to the silencer and finally radiated (as planned) by the valve.

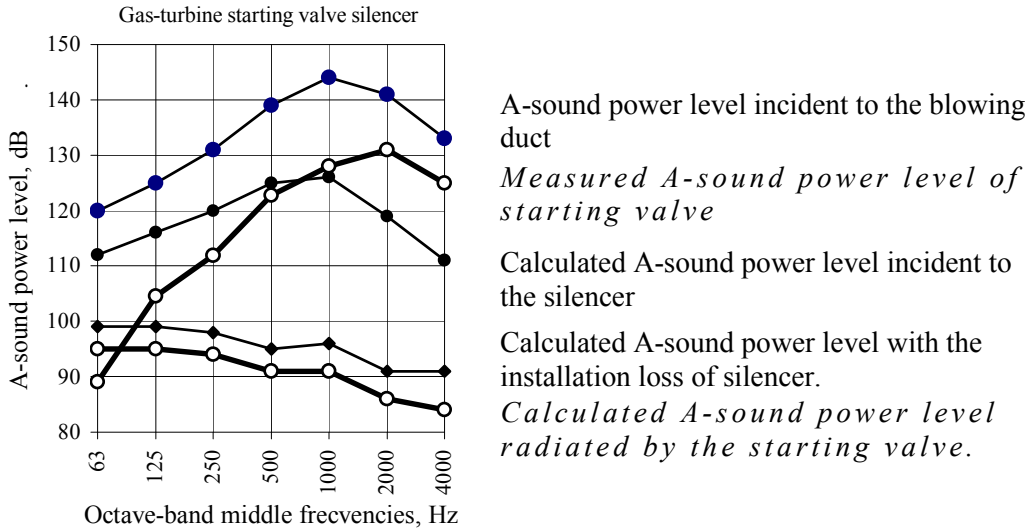

Figure 3 — Calculated and radiated A-sound power level of the starting valve

By the comparison with the approximatively measured data of the effectively radiated noise by the valve it could be stated: the silencer was practically ineffective. During the summer outage of the installations when the noise absorbing fillings of the silencer were broken up it came to light that the fillings were damaged by the erroneous connection of a rainwater line.

SUMMARY

The standard noise emission of the plant having a complex mode of operation and containing many noise sources occurs not necessarily at maximum load of the installations. In the present case the mode of operation of the equipments (the power-plant serves as a peak-load power-plant) being significantly different from the planned one classes up a noise source having practically no relevance in a constant mode of operation. The impact time of the temporary noise source was longer than originally planned when doing the environmental planning and fully filled the nightly estimation time. The high quantity steam emitted into the air during the operation of the installations resulted in such changes of the condition and physical characteristics of the atmosphere that disadvantageously influenced the subjective judgement of the noise phenomenon.