Ten years of acoustic documentation of pipe organs in the Czech Republic

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Abstract
The method for acoustic documentation of pipe organs was developed in the early nineties'. This method includes recording of steady state sounds of all organ stops and plena, room acoustic measurement and diagnostic methods. During past ten years about twenty organs in the Czech Republic were documented using this method. Examples of the results of the diagnostic of various instruments measured before and after the reconstruction are given.

Introduction

There are thousands of pipe organs in all regions of the Czech Republic. The Czech organ builders indisputably reach the zenith of organ sound richness and beauty in the Baroque period. An entire range of instruments was preserved from this period, modified to a greater or lesser extent in the past but also many newly styled instruments were built in all next periods. In recent years greater attention has been paid to organs, above all to rare historical ones. These instruments are at present gradually reconstructed or restored, preserving or resetting original specification and use of original pipes. Part of the effort to preserve rare instruments is acoustic documentation of their sound.

The organ as a musical instrument has many specific acoustic and technical properties. Its sound richness is determined by the complexity of its technical construction. Both the organ's general sound design and diversity in creating individual sounds, together with its construction, have undergone long historical development in diverse European countries and regions. Several organ types emerged, differing in specification of stops, instrument range, and absence of specific tones. Moreover, every instrument is firmly connected with the space in which it is found, thus becoming an acoustically original musical instrument.

All these facts were taken into account in the preparation of acoustic documentation method using contemporary technical devices and aimed above all to the documentation of the Czech organs but permitting the documentation of organs from other European regions and countries.

Method

The basis of the acoustic documentation method is digital recording of the sound from all pipes of documented instruments and room acoustic measurement [1]. The quasi-stationary parts of the tones are picked up by three microphones placed in the typical listening position in a church and a mean amplitude spectrum is recorded. Three neighbouring semitones (triads) are played simultaneously (older version) or each individual tone (more memory consuming new version). In addition to all stops of pipes, a plenum sound of every organ machine is documented. Two microphones measure the starting transients of C-tones of all stops, one in the position of triad measurement and one placed close to the organist. The impulse responses measured by the MLSSA measurement system are used to calculate frequency dependence of reverberation time of the room.

The developed diagnostic methods enabled a detailed view and comparison of the properties of the sound spectra both among different stops and in different measurements of the same instrument (for example before and after the reconstruction) or between different instruments. The same

diagnostic procedures are possible to use in plena in which the sound character of the instrument is most expressive. It is possible to follow the behaviour and changes in levels of individual harmonics or levels of the sound as a whole. The repetitions (repeated sequence of pitches along the keyboard) in mixtures (stops originated of more than one row of pipes) is also possible to identify in the documented instrument or even to follow their change through the reconstruction. The reverberation times are strictly dependent on the room or church in which the instrument was built and can fairly change through the reconstruction of the interior.

Results and discussion

The first documented instrument was Rieger-Kloss organ in Dvořák hall of the Prague Rudolfinum, documented on May 1992. From this time seventeen instruments were measured on the whole, the list of documented instruments is in Tab.1.

Previous publications were focused either on the more detailed description of one instrument [2 – 4] or on the statistical evaluation of behaviour of the group of instruments [5, 6]. Examples of various methods of diagnostic analyses made from the results of measurement of different instruments are presented here in the following paragraphs.

a) Overall levels of individual tones

Plenum of H. H. Mundt organ in the church P. Marie před Týnem in Prague.

Tab. 2 Plenum 8' composition.

Principal 8'	Quint minor 1 1/2' [1 1/3']
Octava 4'	Sedecima 1'
Quint major 3' [2 2/3']	Mixtur 6 fach 1'
Superoctava 2'	Cembalo 4 fach 2/3'

Overall levels in individual tones before and after the reconstruction are in Fig. 1. The lowest tones were strengthened; the decrease in levels in higher tones (starting from c^1) is more consecutive after the reconstruction.

b) Levels of individual harmonics

Principal 8', H. H. Mundt organ in the church P. Marie před Týnem in Prague. Levels of the first and second harmonic in individual tones before and after the reconstruction are in Fig. 2.

Even if the flow of overall levels remains almost unchanged, the envelopes of levels (especially in second harmonic) are smoother, the dominance of the first harmonic has moved from the note dis to gis.

Tab. 1 The list of documented organs; instruments are ordered according to the year of the construction.

No.		place	church / room	builder	year	documented
1	(*)	Praha	P. Marie před Týnem	H. H. Mundt	1673	1992/1998/2000
2		Český Krumlov	U P. Marie	N. Christeindel	1682	1992
3	(*)	Český Krumlov (small organ)	sv. Vít	unknown	169?	1995/1996
4		Praha	sv. František	A. Starck	1702	1992
5		Polná	Nanebevzetí P. Marie	J. D. Sieber	1702	1992
6		Žďár n. Sázavou	Nanebevzetí P. Marie	J. D. Sieber	1723	1992
7		Most (small organ)	Gothic transferred	V. Starck	1741	1992
8		Most (main organ)	Gothic transferred	V. Starck	1741	1992
9		Praha (main organ)	sv. Mikuláš	T. Schwarz	1746	1994
10	(*)	Praha (small organ)	sv. Mikuláš	T. Schwarz	1746	1992/1995
11		Dub nad Moravou	proboštský chrám	J. Výmola	1769	1992
12		Žlutice	sv. Petr a Pavel	F. P. Noli	1775	1992
13		Děčín	Povýšení sv. Kříže	Rieger	1891	2002
14		Český Krumlov (main organ)	sv. Vít	H. Schiffner	1908	2001
15	(*)	Praha	Smetana hall	J. Tuček, H. Voit	1912	1994/1998
16		Praha	Dvořák hall	Rieger-Kloss	1974	1992
17	(*)	Praha	Martinů hall	Rieger-Kloss	1993	2002/2002

(*) documented before and after the reconstruction

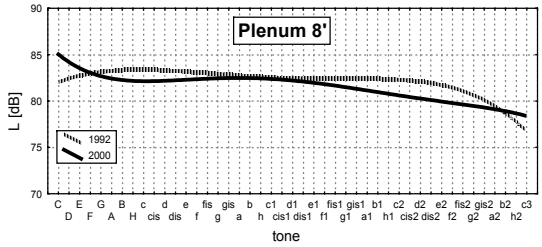

Fig. 1 Overall levels of individual tones: change due to organ reconstruction (plenum of H. H. Mundt organ in the church P. Marie před Týnem, Prague).

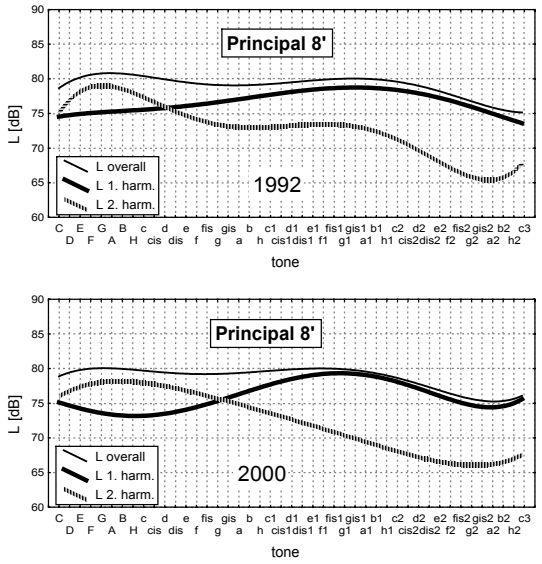

Fig. 2 The levels of the first and second harmonic in individual tones, 1992 – before, 2000 – after the reconstruction (Principal 8' of H. H. Mundt organ in the church P. Marie před Týnem, Prague).

c) Mean levels averaged over the octave

Plenum of J. Tuček & H. Voit organ in Smetana hall, Municipal house Prague.

Tab. 3 Plenum 8' composition.

before the reconstruction	after the reconstruction
Principál 8'	Principál 8'
Oktáva 4'	Oktáva 4'
Superoktáva 2'	Superoktáva 2'
Mixtura maior 6-8x 2'	Mixtura 4x 2'
Mixtura minor 5x 1'	Akuta 4x 1'

Mean levels averaged over the octave for Great and Small octaves before and after the reconstruction are in Fig. 3.

The level of the fundamental harmonic was not changed in both octaves. Harmonics up to 1 kHz were amplified (new voicing of plenum stops), above 1 kHz attenuated (reduction of number of rows in mixtures).

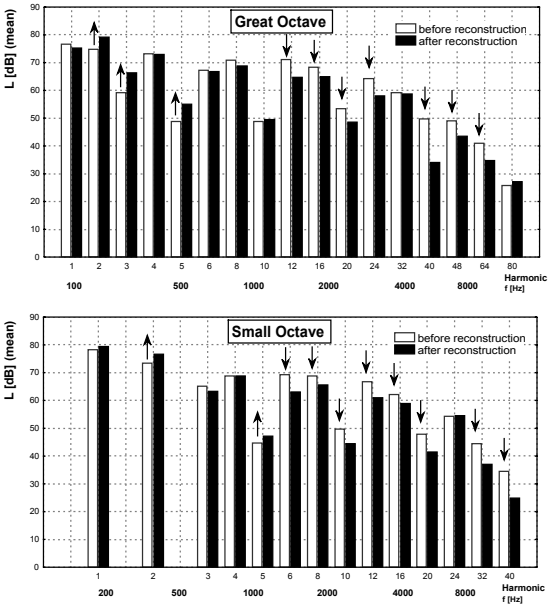

Fig. 3 The levels of individual harmonics (averaged over the octave): change due to organ reconstruction (plenum of J. Tuček & H. Voit organ in Smetana hall, Municipal house Prague). Changes at least 3 dB are marked by arrows.

d) New voicing of individual tone

Tone e^2 in Trompeta 8', the stop of reed pipes, Rieger-Kloss organ in Martinů hall, Lichtenstein palace, Prague.

Trompeta, as a stop of reed pipes, usually possess very rich spectrum of harmonic components. New voicing has amplified all harmonics; broad audible formant has developed in the band about 8 kHz (Fig. 4).

e) Pipe rows in mixture stop

Mixture stop Cymbál 3x 2/3', Rieger-Kloss organ in Martinů hall, Lichtenstein palace Prague.

Tab. 4 Composition of pipe rows and repetitions (situation after the reconstruction is bold).

repetition tones	stop length of rows		
C	**2/3'**	**1/2'**	1/3'
G	**1'**	**2/3'**	1/2'
g	**1 1/3'**	**1'**	2/3'
g^1	**2'**	**1 1/3'**	1'
g^2	**2 2/3'**	**2'**	**1 1/3'**
f^3	**4'**	**2 2/3'**	**2'**

The third row in lower tones was eliminated. Graphical representation of the composition of pipe rows and repetitions is in Fig. 5.

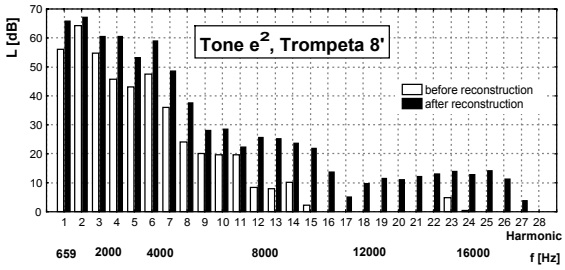

Fig. 4 The changes in the spectrum due to new voicing (tone e^2, Trompeta 8' of Rieger-Kloss organ in Martinů hall, Lichtenstein palace, Prague).

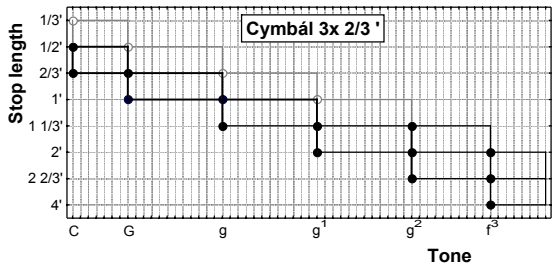

Fig. 5 The composition of pipe rows and repetitions; in the reconstruction eliminated rows are grey (Cymbál 3x 2/3' of Rieger-Kloss organ in Martinů hall, Lichtenstein palace, Prague).

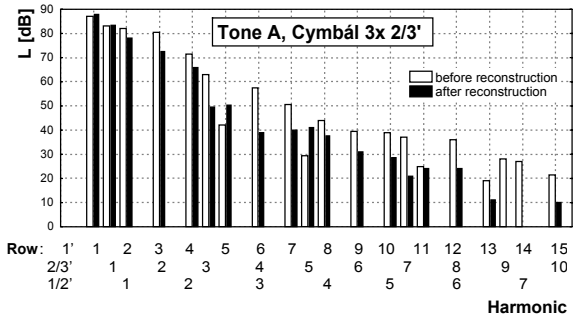

Fig. 6 The tone A in (Cymbál 3x 2/3'; sounding a^2, e^3 and in the reconstruction eliminated a^3, Rieger-Kloss organ in Martinů hall, Lichtenstein palace, Prague).

Higher harmonics of lower tones were attenuated due to the elimination of the third row of pipes; example of the spectrum changes is in Fig. 6.

f) Reverberation time

The reverberation time in Smetana hall, Municipal house Prague was measured before and after the hall (and organ) reconstruction.

Fig. 7 gives frequency dependence of the reverberation time in thirds of octaves.

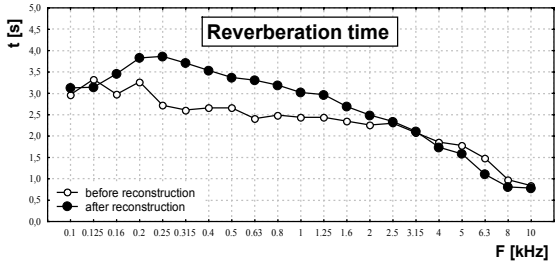

Fig. 7 Frequency dependent reverberation time (Smetana hall, Municipal house Prague).

Longer reverberation times in frequency band from 160 Hz to 2 kHz after the hall reconstruction raised from the covering of vents around doors and filling holes in cupola by heavy glass slices.

Conclusion

During the past ten years the acoustic documentation of pipe organs became a substantial tool for the study of organ sounds and acoustic of churches and concert halls.

Acknowledgements

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References

[1] ***Štěpánek, J., Otčenášek, Z., Syrový, V****.: Acoustic documentation of church organs, Proc. of SMAC 93, Stockholm, Sweden, 516-519, 1994.*

[2] ***Štěpánek, J., Otčenášek, Z., Syrový, V.****: Dokumentace a diagnostika zvuku varhan, Akustické listy 17, 12-21, 1999.*

[3] ***Syrový, V., Otčenášek, Z., Štěpánek, J.****: Acoustic Evaluation of the Reconstruction of Heinrich Mundt Pipe Organs in Prague, 17. ICA, Rome, CD IV (Music), 2001.*

[4] ***Syrový, V., Otčenášek, Z., Štěpánek, J.****: Akustické hodnocení rekonstrukce varhan H. Mundta v chrámu P. Marie před Týnem v Praze, Proceedings of the 6th International Colloquium ACOUSTICS '01, Zvolen – Banská Štiavnica, 49-52, 2001.*

[5] ***Syrový, V., Otčenášek, Z., Štěpánek, J.****: Spectral Characteristics of Czech Baroque Pipe Organs, Proceedings of ISMA 2001, Perugia, 477-480, 2001.*

[6] ***Štěpánek, J., Syrový, V., Otčenášek, Z.****: Spektrální charakterizace plén českých barokních varhan, Proceedings of the 6th International Colloquium ACOUSTICS '01, Zvolen – Banská Štiavnica, 53-56, 2001.*