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A New Chamber Hall in M. Karlowicz Philhamonic Orchestra in Szczecin, Poland

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Abstract

This paper describes a new Chamber Hall inside of: "M.Karlowicz Philharmonic, in Szczecin". The acoustic design of the project was finished in 2009. It was built later and finally opened on 6nd September 2014. The acoustics of the two halls of new Philharmonic hall have been very well received by audience public. On this report, we outline several acoustic aspects of design which were developed, obtaining a very result excellent. Furthermore we show the acoustic results. In this design we have played with convex curves that are excellent diffusers of sound. This curves more tensed are seen also in the walls. "The Chamber hall, also known as **"**acoustical gem**",** may accommodate nearly 192≈200 people. All acoustic parameters of the Chamber hall are excellent. In this report, we outline several acoustic aspects of design which were developed, obtaining a good result.

Keywords: Room acoustics, acoustic design.

1.Introduction

The acoustics of the new Chamber Hall have been very well received by public audience. “The Chamber hall, also known as the Gem Hall, may accommodate nearly 200 people.

The magnificent acoustics of the Gem Hall is originated from its special geometry of the walls and ceiling. All parameters of the Chamber hall (strength, uniformity of sound, delay and lateral energy fractions have been excellent.

2.Geometry of the hall, audience size

This room is rectangular in plan section and convex curved in vertical section. Acoustic Design of the hall obeys to a criteria be getting most sound and better by the diffusing properties have the convex surfaces. The beauty of all surfaces curved in great dimensions was a good solution.

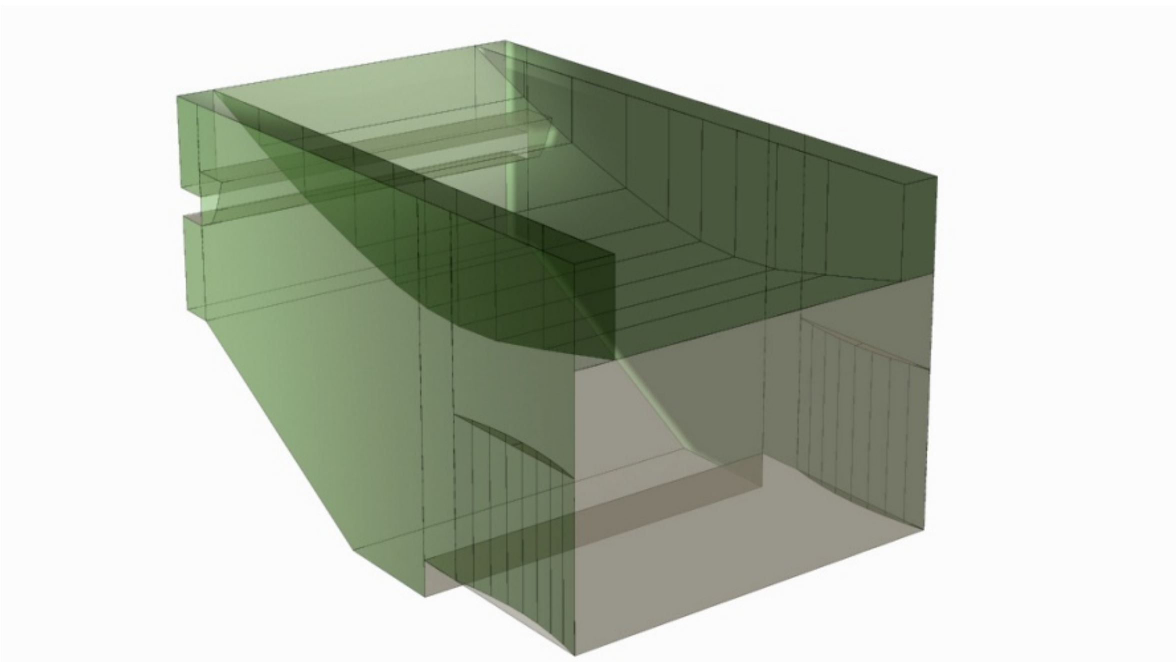

Figure 1. Several Pictures and photos of the Szczecin Chamber Hall.

3. Preliminary: Chamber Hall configuration

The capacity audience of this hall is: N= 192 ≈ 200 seats.

The volume hall for get a T_{mid} = 1.46 s, according the dimensioned law [1], it is

V= 1448.8 m^3. In this case we assume that only absorption is due to the audience

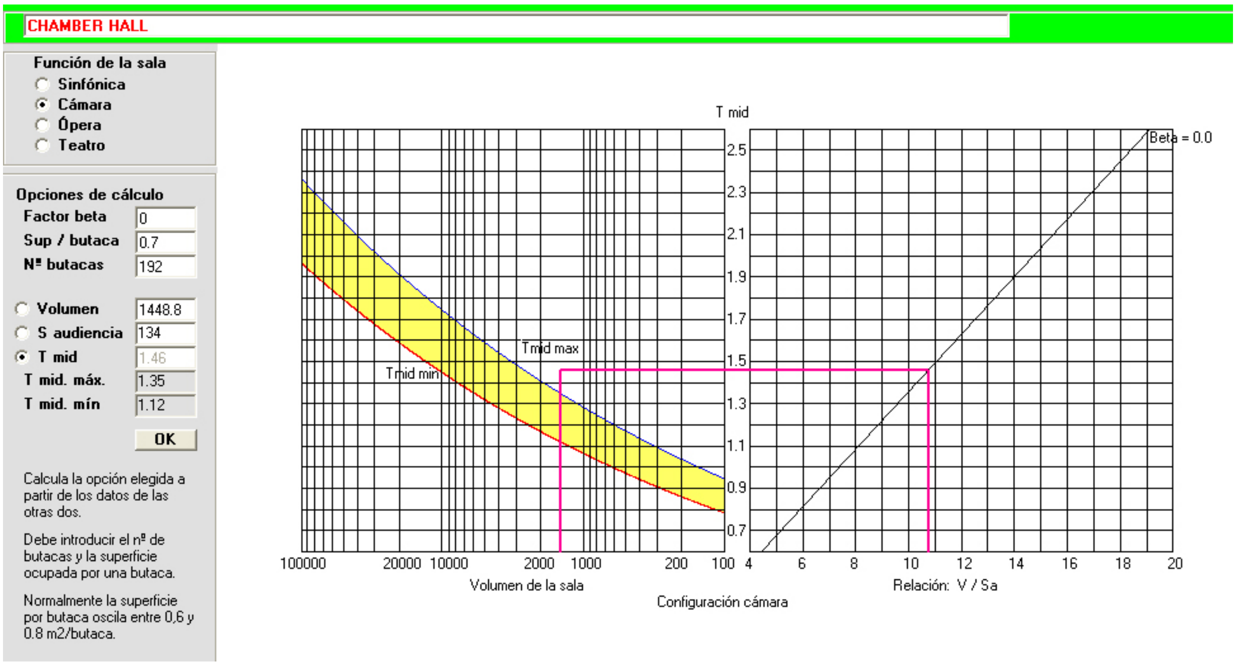

Figure 2. Calculation of dimensioned hall

4. Acoustic goal parameters for occupied hall

The goal parameters for occupied room must be approximately:

ACOUSTIC GOAL PARAMETRES (OCCUPIED HALL)		
Parameter	**Denomination**	**Range Advised**
T_{MID} (500 Hz - 1 kHz)	Reverberation Time in middle frequencies	1,11 s ≤ T_{MID} ≤ 1.50 s
T_{MID} design	Reverberation Time of design: Chamber	1.50 s
EDT_{MID} (500 Hz - 1 kHz)	"Early Decay Time"	EDT_{MID} ≈ 0.9 T_{MID}
BR	Bass Ratio: Warmth	1,1 ≤ BR ≤ 1,3
Br	Brilliance	Br ≥ 0,85
C_{80} (500 Hz - 1 kHz)	Clarity music	-2 dB ≤ C80 ≤ 4 dB
G_{MID} (500 Hz-1kHz)	Strength dB	0 dB ≤ G_{MID} dB
ST1 (250 Hz - 2 kHz)	Objective Suport on Stage	ST1 ≥ -12 dB dB
LF (125 Hz - 1 kHz)	Lateral Efficiency	LF ≥ 20%
ITDG	"Initial Time Delay Gap"	ITDG ≤ 20 ms

5. RT of Chamber hall with occupied seats analyzed by Odeon and others software.

FREQUENCY (Hz)	125	250	500	1000	2000	4000	T_{MID}	T_{LOW}	T_{HIGH}
RT-Sabine	1.25	1.30	1.33	1.35	1.39	1.31	**1.34**	1.27	1.35
RT-Vian (Epidaure)	1.18	1.21	1.22	1.22	1.27	1.21	**1.22**	1.19	1.24
RT-Arau-P.	1.17	1.26	1.43	1.56	1.65	1.39	**1.50**	1.21	1.52
(o)RT-Odeon T-average	1.38	1.46	1.60	1.75	1.81	1.56	**1.68**	1.42	1.71

(+) RT-Odeon T_{30}	1.42	1.52	1.68	1.86	1.92	1.60	**1.77**	1.47	1.76
(+)RT-Odeon T_{20}	1.35	1.41	1.53	1.65	1.71	1.53	**1.59**	1.38	1.66
(o)RT- Odeon T- av	1.38	1.46	1.60	1.75	1.81	1.56	**1.68**	1.42	1.71

(+) Global estimation RT; (o+) Average of RT_Odeon T_{20} and T_{30}

EDT *of chamber hall with occupied seats*

FREQUENCY (Hz)	125	250	500	1000	2000	4000	EDT_{MID}
EDT_Arau-P. (*)	1.02	1.09	1.21	1.29	1.34	1.14	**1.25**

RT *of chamber hall with occupied seats + curtain in rear stage wall*

FREQUENCY (Hz)	125	250	500	1000	2000	4000	T_{MID}	T_{LOW}	T_{HIGH}
RT-Sabine	1.20	1.08	1.08	1.11	1.13	1.03	**1.10**	1.14	1.08
RT-Arau –P.	1.13	1.06	1.15	1.20	1.25	1.07	**1.175**	1.095	1.16
(o+)RT-Odeon T-av	1.35	1.33	1.30	1.42	1.45	1.29	**1.36**	1.34	1.41

(-) No computed

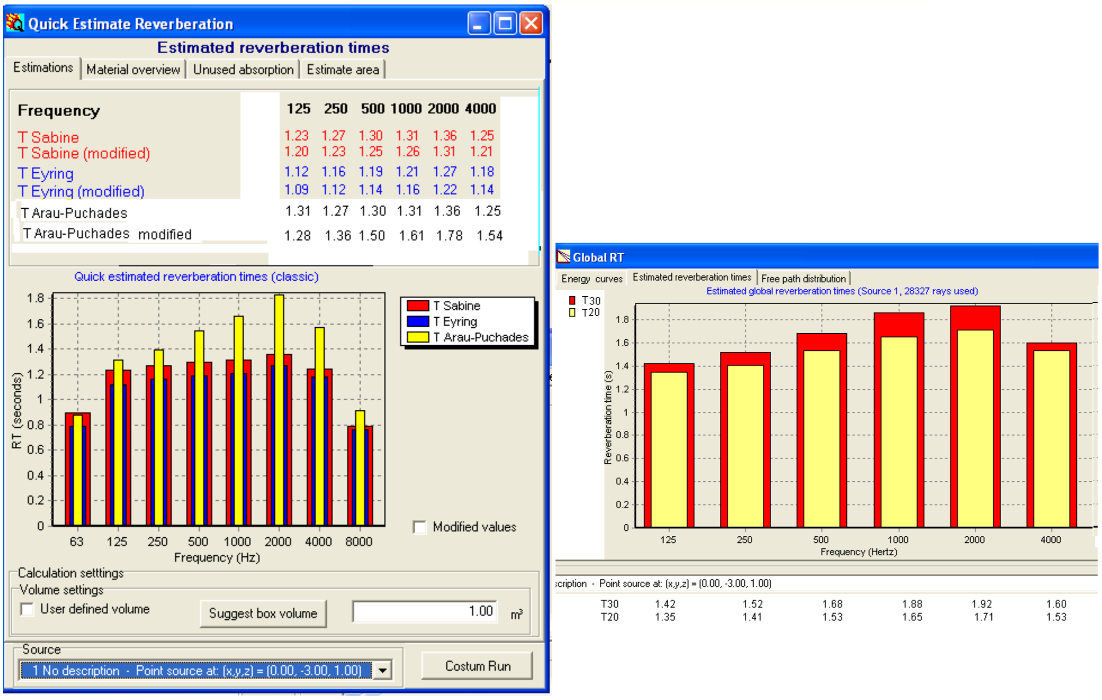

Figure 3. Drawings Odeon of Calculations realised.

6. RT of chamber hall with occupied seats analyzed by statistical methods.

RT, calculated by Statistical Methods, W.C.Sabine, C.F:Eyring, H. Arau-P. with hall seats occupied by audience.

Case 1: Hall with Audience

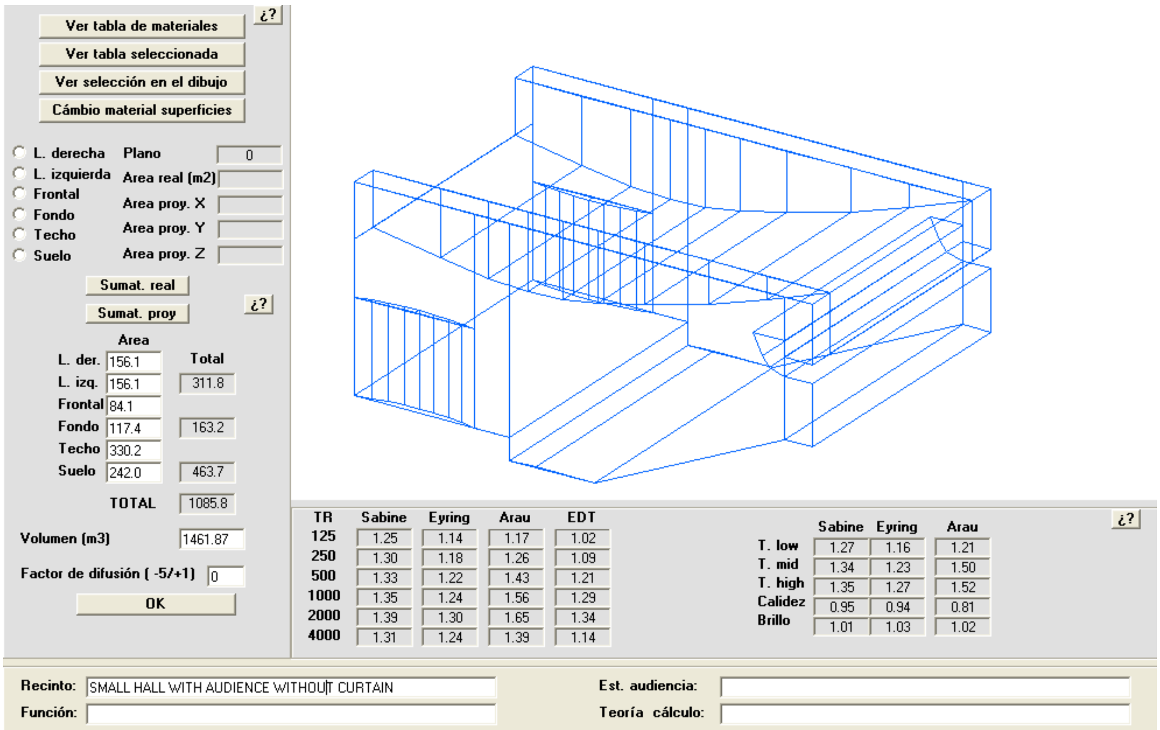

Figure 4. Figure of calculations realised by Statistical Arau Software.

Case 2: Hall with Audience + Curtains in bottom stage

Figure 5. Photo hall with curtains

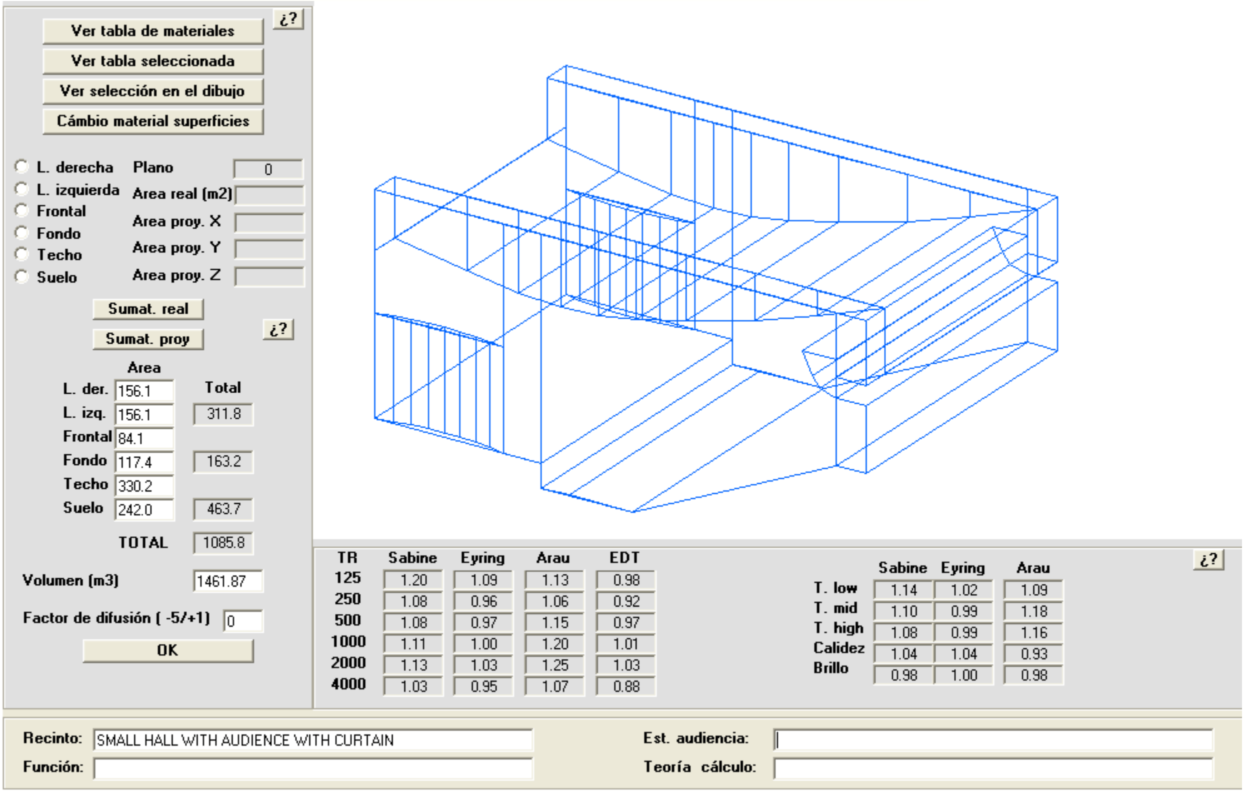

Figure 6. Figure of calculations realised by Statistical Arau Software.

7. Final measurements

Here we are exposing the results of average values measured by "os laboratory Katedra Politechnika Wroclawska Akustyki i Multimediów Laboratorium Badawcze Akustyki", are:

CHAMBER HALL		125	250	500	1000	2000	4000	MID
RT or T30 (s)	Unocc. seat	1.52	1.48	1.58	1.68	1.64	1.52	**1.63**
	Occ. Seat	1.34	1.35	1.47	1.53	1.5	1.39	**1.50**
EDT (s)	Unocc. seat	1.32	1.19	1.35	1.5	1.42	1.32	**1.42**
	Occ. Seat	1.03	0.94	1.17	1.41	1.32	1.24	**1.29**
G (dB)	Unocc. seat	15.7	13	12.2	13.3	13.8	12.1	**12.75**
	Occ. Seat	16.1	12	12.3	12.9	13.9	12.6	**12.6**
C_{80} (dB)	Unocc. seat	2.4	2.3	1.5	1	1.2	1.9	**1.25**
	Occ. Seat	3.5	3.8	2.2	1.1	1.4	1.8	**1.65**
LE_F	Unocc. seat	0.16	0.29	0.36	0.65	0.3	0.35	**0.505**
	Occ. Seat	--	--	--	--	--	--	**--**
ST_{early} (dB)	Unocc. seat	-8.2	-6.4	-6.175	-5.3	-3.35	-3.55	**-5.3**
	Occ. Seat	--	--	--	--	--	--	**--**

ST_{late} (dB)	Unocc. seat	-8.65	-8.075	-7.3	-6.7	-5.45	-5.8	**-6.9**
	Occ. Seat	--	--	--	--	--	--	**--**
Distribución L_p (dB)	Unocc. seat							**92.1 - 90.9**
	Occ. Seat							**72.2 - 70.2**
ITDG[-5dB] (ms) (*)	Unocc. seat							**9**
	Occ. Seat							**11**
ITDG[-10dB] (ms) (*)	Unocc. seat							**9**
	Occ. Seat							**10**
Background Noise L_p (dB) (max.)	Ventilación OFF – Iluminación escenario OFF							**8.2**
	Ventilación ON – Iluminación escenario OFF							**19.4**
	Ventilación OFF – Iluminación escenario ON Config1(**)							**18.5**
	Ventilación ON – Iluminación escenario ON Config1(**)							**23.8**
	Ventilación OFF – Iluminación escenario ON Config2(**)							**28.4**
	Ventilación ON – Iluminación escenario ON Config2(**)							**28.6**

Notes:

1. Seats are upholstered.
2. ITDG measurements: (*).
3. The Mean Noise levels values of Ventilation on Hall with Stage lighting ON or OFF.
   (**)Lighting configuration: Config1: 10 focos, Quiet Mode 0%, Intensidad 70%
   and Config2: 10 focos, Quiet Mode 100%, Intensidad 70%

8. Conclusions

The Owner explains that this chamber hall – designed for 192 people – the reverberation time is compliant with the project to the hundredth of a second. This is why this hall is known as the **"acoustical gem"**.

References

[1] H. Arau (1997) Variation of the Reverberation Time of places of public assembly with audience size. Building Acoustics, Volume 4 nº 2.

[2] J.P.Vian-J.Martin-Van Maercke EPIDAURE (1993). Binaural simulation of concert halls: New approach for the binaural reverberation process. JASA 94(6).

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[4] W.C. Sabine (1900) Collected Papers on acoustics. Dover Publications (1922)

[5] H. Arau-P (1988). An improved Reverberation Formula. Acustica (Hirzel Verlag).Vol 65 nº4, p:163-180.

[6] H.Arau (1999). ABC de la Acústica Arquitectónica. Editorial CEAC .

[7] Software simulation Rooms ODEON - Danmark University

Hello, my name is Julián Álvarez , I am a collaborator of Dr. Higini Arau, and I'm today substituting him. Dr.Arau presented this paper but unfortunately was unable to come to the ISMRA. This presentation is about the chamber music hall that is part of the MIECZISLAW KARLOWICZ Filharmonia in Szczecin, in Poland, built in 2015 by Barcelona-based Barozzi-Veiga Studio. The building received recently the Mies Van der Rohe Prize, and the Chamber Hall has been praised for its acoustics and for the precision of the expected value of the reverberation time.

The purpose of this conference is to describe this hall, starting with the acoustical criteria that guided the design, following with the relation between the important magnitudes of the hall, and ending with the comparison of different methodologies in order to give the values of relevant parameters, especially T30, T20 and EDT, before and after the construction. An analysis with Odeon and the Statistical Methods of the own software of Arau Acustica will be shown. Finally, the Badadwcze Akustiky Laboratorium, an institution dependant from the Polytechnical of Wroclaw, will provide the on-site measurements of the hall.

Outline

1) Geometry and Configuration of the Hall
2) Setting the objective acoustical parameters
3) RT calculations with Odeon
4) RT calculations with own Statistical Methods
5) Final measurements on-site

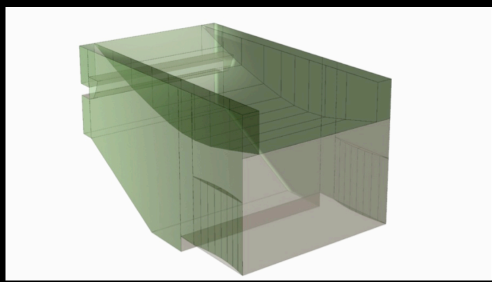
First of all, we are going to explain the geometry of the hall, defining the parameters that will shape it. A definition of the acoustical parameters goals will be necessary in order to know what are the values that we are willing to achieve. This values are mostly common sense and apply to chamber halls that have been regarded as a reference by consensus. After this, the Reverberation Time calculations with Odeon will show the different values in terms of the physical theory for the reverberation, whether it is by the Eyring , Sabine or Arau-Puchades formula, or by the Odeon ray tracing method, using Quick Estimation in the firsts cases, and Global Estimation in the last one.

Then, the results obtained by means of the statistical methods of Arau Acustica will be delivered, which are the ones that are generally used by the studio in order to work out the design. All results will be divided into the cases of the occupied hall with and without an added curtain in the rear wall. At last, the data from Badadwcze Akustiky Laboratorium will demonstrate the precision of the predictions and verify that the resulting acoustics are excellent according to the acoustic goals.

Geometry & Configuration (I)

Goal = maximum difussion with no extra absorption.

Convex vertical section & rectangular plan section

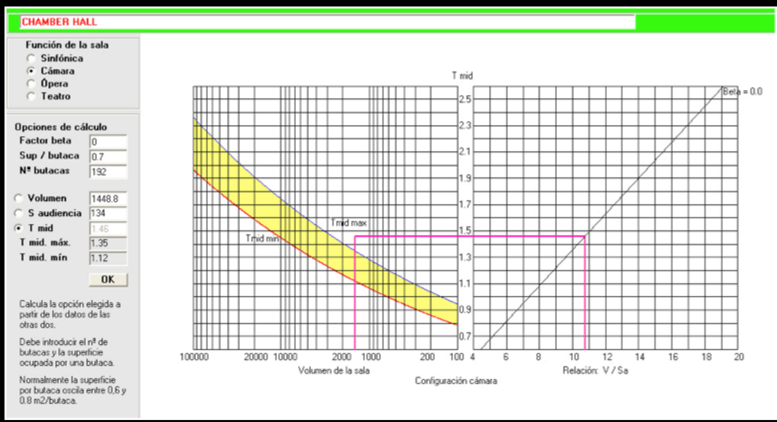


The room was designed with the objective of obtaining the best sound out of the diffusive properties of the convex surfaces, with the only absortion from the audience. Convexly shaped surfaces, as it is known, are the best ones in order tu ensure diffusion in a hall. The room is therefore rectangular in the plan section , but the vertical section is shaped convexly .

Geometry & Configuration (II)

Audience size N=192. Objective: Tmid=1.46s

with Dimensioned Law , V=1448.8 m3



The projected audience was 192 people. In order to get a sound that would ressemble that of a bigger hall, a T mid has been chosen of 1.46 seconds, later adjusted to 1.50, sligthly bigger than recommended for a chamber hall. As we can see in the picture, the suggested values are lower than the chosen ones. The power curves that mark the limits for the suggested reverberation times were developed by Lothar Cremer.

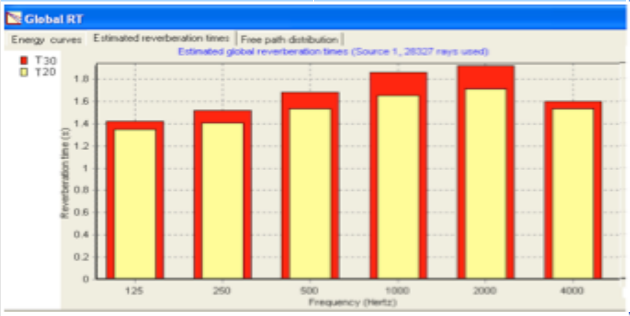
The resulting volume of the hall,once the Tmid is chosen, is of 1448 m3, following the dimensioned law. This law is exposed at the article of Higini Arau himself (Variation of Reverberation Time of Places of Public Assembly with Audience Size) that relates the fraction volume and audience surface with the reverberation time through a proportionality. In this case, the parameter Beta, described in the second graph , has the value 0. It physically means that there are no balconies.

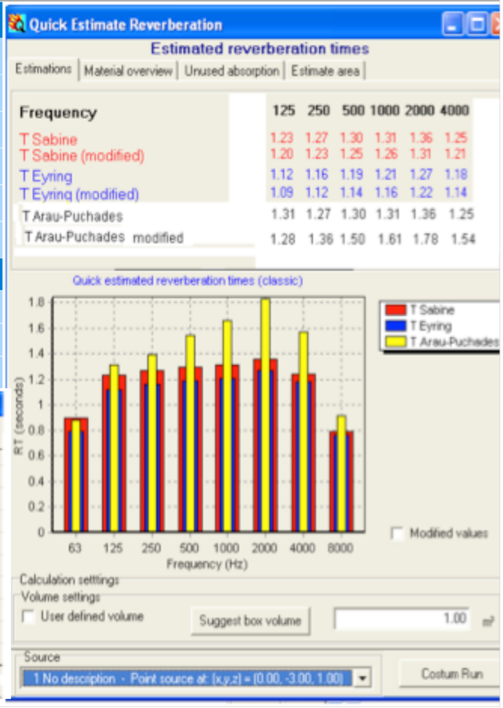
Acoustical Goal Parameters (Occupied Hall)		
Parameter	**Denomination**	**Range Advised**
T_{MID} (500 Hz - 1 kHz)	Reverberation Time in middle frequencies	1,11 s ≤ T_{MID} ≤ 1.50 s
T_{MID} design	Reverberation Time of design: Chamber	1.50 s
EDT_{MID} (500 Hz - 1 kHz)	“early decay time”	EDT_{MID} ≈ 0.9 T_{MID}
BR	Bass Ratio : Warmth	1,1 ≤ BR ≤ 1,3
Br	Briliance	Br ≥ 0,85
C_{80} (500 Hz - 1 kHz)	Clarity music	-2 dB ≤ C80 ≤ 4 dB
G_{MID} (500 Hz-1kHz)	Strenght dB	0 dB ≤ G_{MID} dB
ST1 (250 Hz - 2 kHz)	Objective Support on Stage	ST1 ≥ -12 dB dB
LF (125 Hz - 1 kHz)	Lateral Efficiency	LF ≥ 20%
ITDG	Initial Time Delay Gap	ITDG ≤ 20 ms

In order to define the geometry of the hall, so as to obtain good acoustics, we have chosen acoustical goals that are common in good halls. The TMID was expected between 1,11s and 1,50s, getting the top value. The Early Decay time at the mid frequencies had to be around 0.9 TMID The bass ratio, or Warmth, was expected to be between 1,1 and 1,3 Brilliance, bigger or equal than 0,85. The Clarity, the C80 parameter, had to be between -2dB and 4 dB. Strengh must be bigger than 0dB. The Gade Support paramenter should be bigger than -12 dB. The Lateral efficiency, bigger than the 20%. And finally, the Inital time delay gap, smaller than 20 ms

RT with Odeon

Chamber Hall with Occupied Seats	
Parameter	TMid (s)
RT -Sabine	1.34
RT Arau -P	1.50
RT – Odeon T30	1.77
RT – Odeon T20	1.59
RT – Odeon T-Av	1.68
Chamber Hall with Occupied Seats + Curtain	
RT Sabine	1.10
RT ARau - P	1.18
RT Odeon T-Av	1.36





Now we are going to see the predicted values of the RT for the two cases (occupied hall with and without curtain) with the Software ODEON in two ways. First, with the reverberation formulas of Sabine and Arau-Puchades, we can calculate the Quick Estimation of the reverberation time, obtaining 1,34 and 1,50 for Sabine and Arau-Puchades respectively. Once this is performed, we calculate the Global Estimation with the free path distribution, for the T30 and T20, and an average of both, obtaining 1,77, 1,58 and 1,69 respectively.

We will make similar calculations in the case where we hang a curtain in the back of the stage. The results given for the Quick Estimation will be 1.10 for Sabine, 1.18 for Arau, and the ODEON Average of the Global Estimation will be 1.36.

RT with Statistical Methods

Case 1) Hall With Audience

TR	Sabine	Eyring	Arau	EDT
125	1.25	1.14	1.17	1.02
250	1.30	1.18	1.26	1.09
500	1.33	1.22	1.43	1.21
1000	1.35	1.24	1.56	1.29
2000	1.39	1.30	1.65	1.34
4000	1.31	1.24	1.39	1.14

	Sabine	Eyring	Arau
T. low	1.27	1.16	1.21
T. mid	1.34	1.23	1.50
T. high	1.35	1.27	1.52
Calidez	0.95	0.94	0.81
Brillo	1.01	1.03	1.02

Now we move on to the results obtained with the simualtion of the statistical methods from ArauAcustica. The reverberation theories of Sabine, Eyring and Arau-Puchades are compared, and the EDT is also measured. This magnitude is only measurable with Arau-Puchades theory , as the curve of sound decay has three slopes, and the Early Decay Time would be linked to the first part. That doesn't happen with Sabine or Eyring's , because the physical formulation doesn't consider an asymmetrical absorption (while Arau-Puchades does), and this implies that there is only one slope in the decay. We show results for all bands from 125 to 4000 in this formulations. The obtained T mid, with an occupied audience, is of 1,50 seconds. Also the values of Warmth (here in spanish is named “calidez”) and Brilliance (Brillo) are into the desired values

RT with Statistical Methods

Case 2) Hall with audience + Curtains in the bottom stage

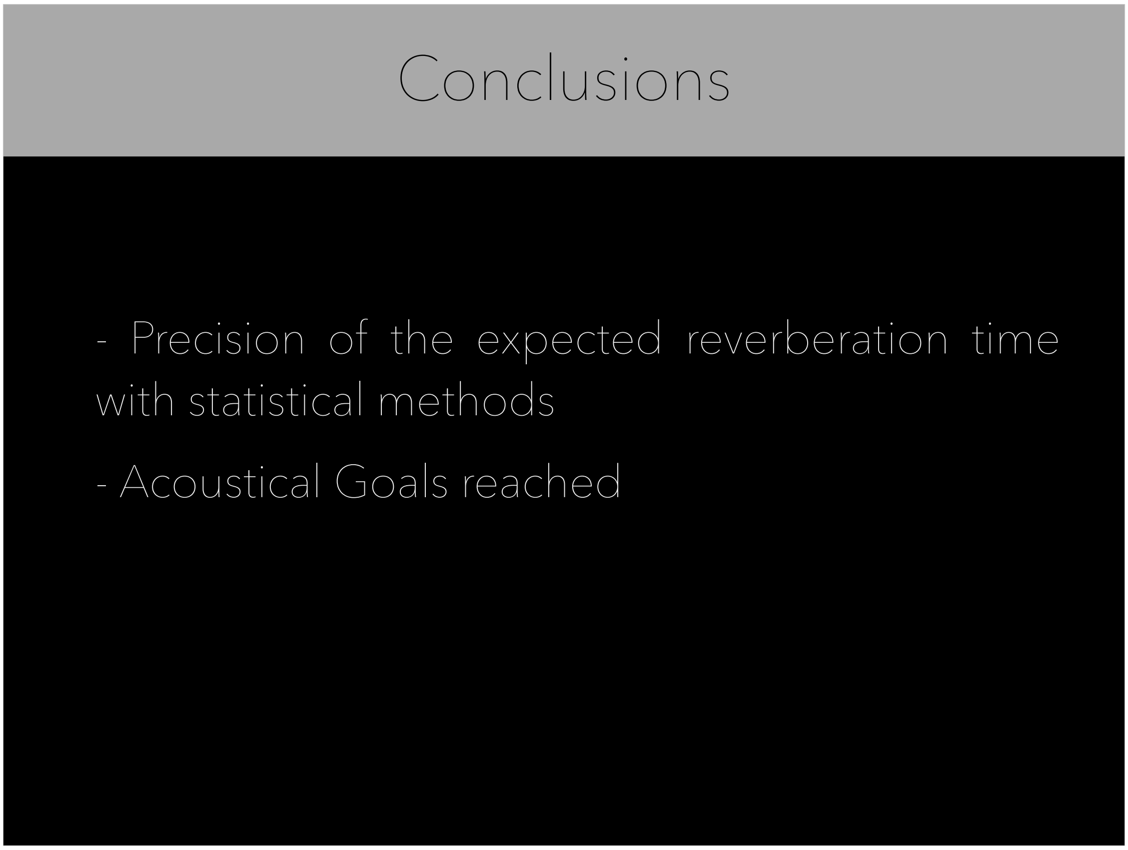
TR	Sabine	Eyring	Arau	EDT
125	1.20	1.09	1.13	0.98
250	1.08	0.96	1.06	0.92
500	1.08	0.97	1.15	0.97
1000	1.11	1.00	1.20	1.01
2000	1.13	1.03	1.25	1.03
4000	1.03	0.95	1.07	0.88

	Sabine	Eyring	Arau
T. low	1.14	1.02	1.09
T. mid	1.10	0.99	1.18
T. high	1.08	0.99	1.16
Calidez	1.04	1.04	0.93
Brillo	0.98	1.00	0.98

In the case where we have curtains hanging in the rear wall, at the stage, we have a value of 1.18 for Arau, 1.10 for Sabine, the same results predicted by Odeon.

On-site measurements OS Laboratory Katedra Politechnika Wroclawska Akustyki Multimediów Laboratorium Badawcze Akustyti					
CHAMBER HALL		MID			MID
RT o T30(s)	Unocc.seat	1.63	Distribución L_p (dB)	Unocc.seat	92.1-90.9
	Occ.seat	1.50		Occ.seat	72.2-70.2
EDT(s)	Unocc.seat	1.42	ITDG[-5dB] (ms)	Unocc.seat	9
	Occ.seat	1.28		Occ.seat	11
G(dB)	Unocc.seat	12.75	ITDG[-10dB] (ms)	Unocc.seat	9
	Occ.seat	12.60		Occ.seat	10
C80(dB)	Unocc.seat	1.25	Bacground NOISE Lp (VentilaciónVT, Iluminación= IL, Configuración de ilumianción 1 = IL1, Configuración de iluminación 2 = IL2)	VT OFF, IL OFF	8.2
	Occ.seat	1.65		VT ON, IL OFF	19.4
LEF	Unocc.seat	0.505		VT OFF, IL1 ON	18.5
	Occ.seat	---		VT ON, IL1 ON	23.8
STearly (dB)	Unocc.seat	-5.3		VT OFF, IL 2 ON	28.4
ST late	Unocc.seat	-6,9		VT ON, IL2 ON	28.6

The Final measurements done by Laboratorium Badawcze Akustyiy associated with the Polytechnical University of Wroclaw, show that the T30 is compliant with what was expected, so the value is 1.50 s for the occupied seats case. All the values that were supposed to meet the expectations are inside the range of values that were desired, such as the EDT (around 0.9RT), the clarity (C80) is also well inside the expected values. Also the ITDG is well below the 20ms limit. The strenght is 12 dB above the minimum value, as it was expected. A calculation of the Background noise when the illumination and the ventilationis active is also given, with a maximum of 28.6 dB in the case of the noisiest illumination.



One of the most remarkable achievements of this chamber Hall inside the M.Karlowicz Philarmonic Hall, designed for an audience of 192, is the compliance of the predicted reverberation time, that is precise to the hundreth of a second as the comparison with the experimental measures and the predicted ones said. Because of this precision and the excellent acoustics of the hall, it has been hailed , by the owners of the building, as an “acoustical gem”.