

# RADIOHuset, Studio 1

## COPENHAGEN, DENMARK

### RENOVATION COMPLETED 1989

Acoustics Consultant:	Jens Holger Rindel, Anders Christian Gade, DTU. Niels V. Jordan, Denmark
Architect:	Vilhelm Lauritsen AS, Denmark
Owner:	Ministry of Cultural Affairs, Denmark
Structural Engineers and Stage Technique:	Birch & Krogboe A/S, Denmark
Construction Cost:	8 Mio. DKK (approx. 1.1 Mio. USD)

The "Studio 1" is a concert hall in the Danish Broadcasting Building in Copenhagen and home of the Danish Radio Symphony Orchestra. Soon after the inauguration in September 1945 members of the orchestra began to criticize the acoustic conditions for not allowing them to hear each other sufficiently. The hall has a wide fan shape and a high vaulted ceiling. During the early fifties, a number of experiments were carried out in attempts to improve the ensemble conditions, and as a result an array of hexagonal reflectors was suspended under the high ceiling and covering the orchestra area. The 31 reflector plates were 1.8 m wide. The effect of this reflector array was noticeable but still limited, and the complaints from the orchestra members prevailed.

In 1985 Lamberto Gardelli was appointed new chief conductor for the orchestra and he convinced the management that the acoustic problems would have to be solved. A renovation project was started and the Department of Acoustics at the Technical University of Denmark was asked to advise on and conduct the necessary experiments. The task was to improve the acoustic conditions for the musicians, while the benefit for the audience was supposed to be better performances rather than better acoustics. The investigations started with experiments in a 1:20 scale model and the following changes were found to be effective: (1) Installation of zigzag shaped reflectors on the side walls in the platform area, (2) Lowering the ceiling reflectors and (3) Moving the orchestra two meters further back on the platform.

In August 1987 a full-scale experiment was conducted in the hall. In twelve combinations of the above-mentioned measures the orchestra played a short program of selected classical works and on two scales in a questionnaire the orchestra members evaluated the ease of hearing the others and themselves. The average of these subjective evaluations showed a high correlation with the measured Support ST-early parameter. (ST-early is measured 1.00 m from a sound source and it is the level of energy in the impulse response between 20 and 100 ms relative to the energy of the direct sound, in dB).

The new design for the hall was made in accordance with the best results from the experiments. Niels Jordan joined the team as an acoustic consultant and during the summer of 1989 the renovation was made. The changes included:

- A new floor of wood over airspace with a flexible, hydraulic riser system
- Installation of large reflectors on the side walls, the upper parts tilted inwards
- New suspended reflector array designed to be more effective than the old one
- A new rear wall with the possibility of variable sound absorption

The reflector array was designed from theoretical work, which has shown that the useful frequency range is determined by the upper limiting frequency, and this is inversely proportional to the area of the plates in the reflector array. The new reflectors are 1800 × 800 mm and the upper limiting frequency is approximately 1200 Hz, compared to 600 Hz for the old design. The plates are bowed about 80 mm in the longitudinal direction in order to let the reflections from each row overlap those from the next row. Since the reopening in September 1989 all reports from the orchestra about the acoustics have been very positive.

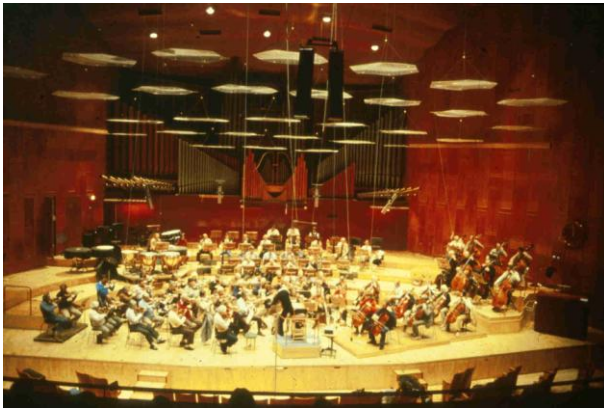
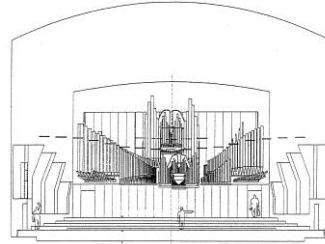
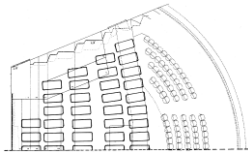
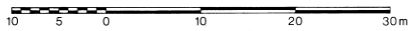
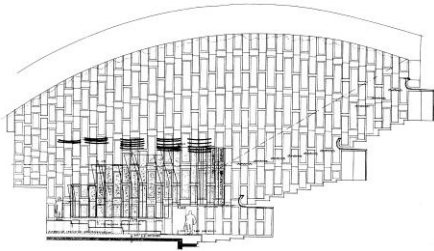
On the orchestra area the measured average value of Support, ST-early (250 – 2000 Hz), is –12.6 dB, while the value before the renovation was –14.3 dB with the old reflector array, and –16.1 dB without. (For comparison, ST-early is –13 dB in Musikvereinssaal, Vienna).

#### References:

- A.C. Gade & J.H. Rindel. Proceedings, Institute of Acoustics 1988, Vol. 10: Part 2, p. 207-214.  
N.V. Jordan, J.H. Rindel & A.C. Gade. NAM-90, Luleå 1990. Proceedings p.117-122.  
J.H. Rindel. Applied Acoustics 1991, Vol. 34, p.7-17.

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*View from the hall before 1989*



*View from the hall after the renovation*

## Building details and acoustic data

Volume:	11,700 m <sup>3</sup>
Seating capacity:	1081
Stalls, balcony, 2 <sup>nd</sup> balcony:	368, 375, 338
Orchestra area:	288 m <sup>2</sup>

Measuring results, unoccupied, 500 – 1000 Hz:

Reverberation time, T <sub>30</sub>	1.93 s
Early Decay Time, EDT:	1.96 s
Clarity, C <sub>80</sub> :	-0.3 dB

