B&K - Web Course

‘Calibration of Microphones’

Presenters:

Erling Frederiksen
- microphone and calibration specialist

Henrik Carlsen
- system and software specialist

Contents

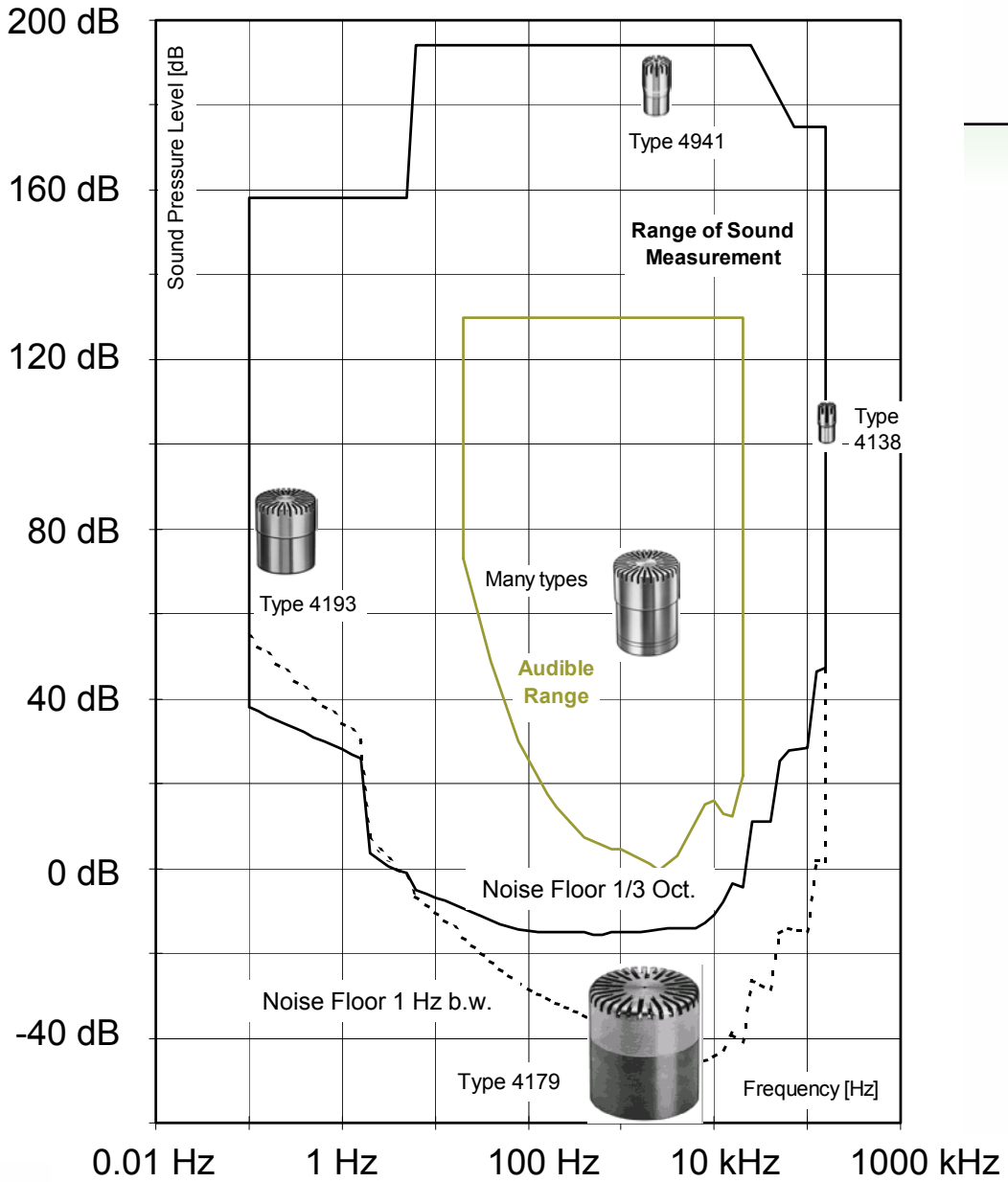
- Types of microphone and sound field
- Types of calibration (primary/secondary)
- International Calibration Standards (IEC)
- B&K Calibration Systems
- Type 9721 – *a system for calibration service centres*
- Methods of Type 9721
- Demonstration of Type 9721
- Questions

Measurement Range

The Acoustic
Measurement Range

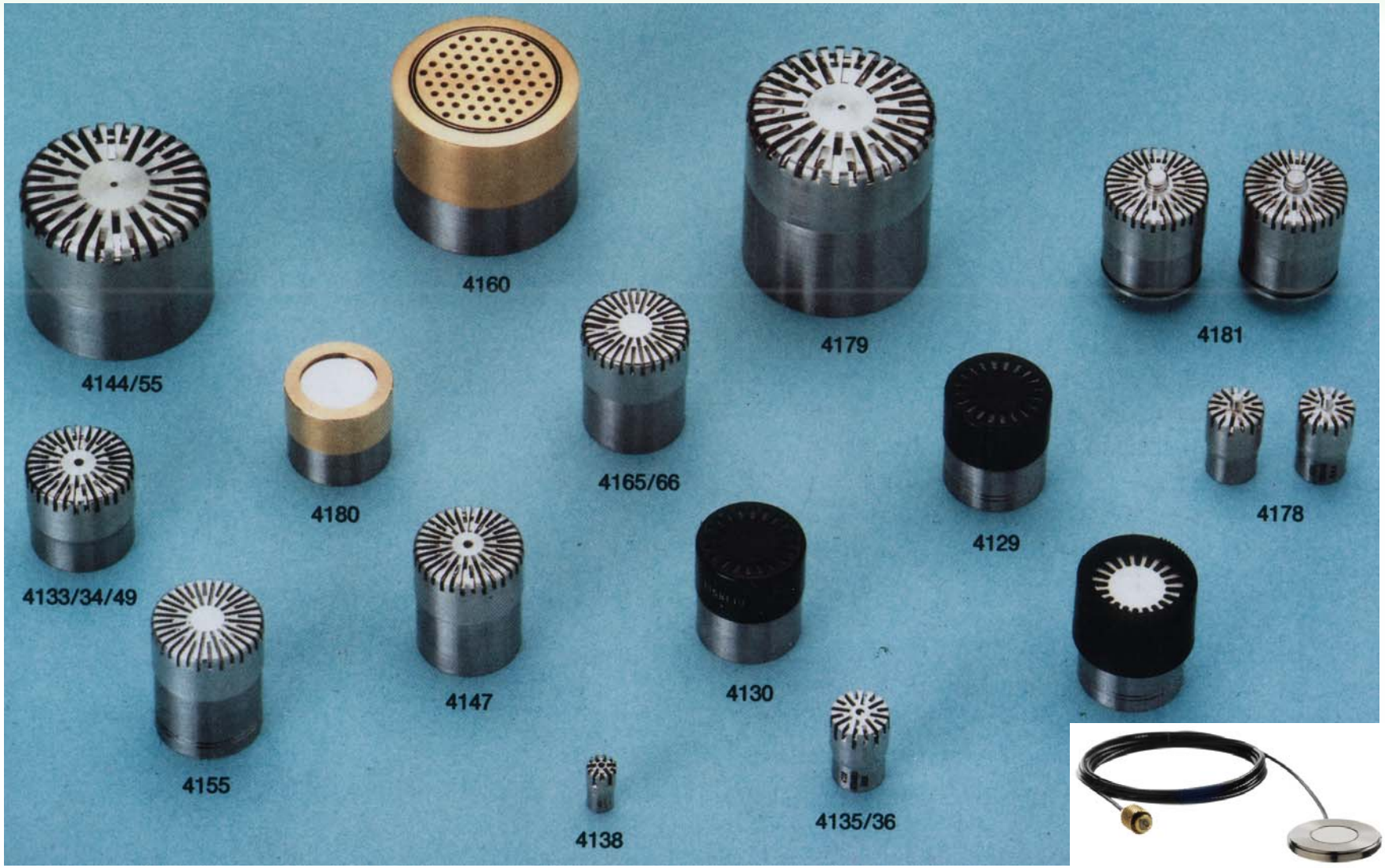
is large
and
much larger
than

the Audible Range



Brüel & Kjær

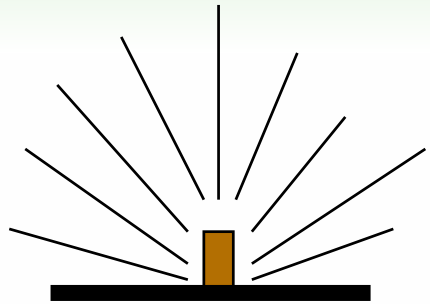
The B&K Microphone Program consists of about 35 types



Brüel & Kjær

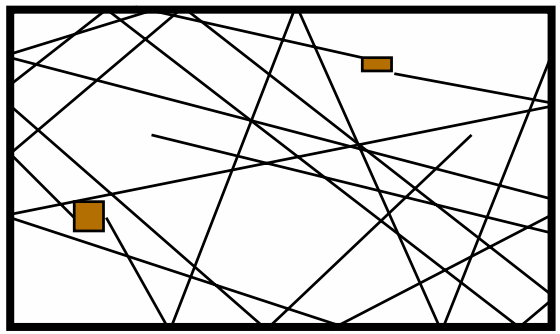
Principal Types of Sound Field

- **Free-field**
  - open space
  - no reflecting surfaces



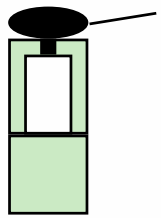
Lawn Mover

- **Diffuse-field**
  - rooms with hard surfaces
  - rooms with many sources



Workshop with two noise sources

- **Pressure-field**
  - small enclosures



Hearing Aid and Test Coupler

Types of Microphone Sensitivity

Pressure-field Sensitivity

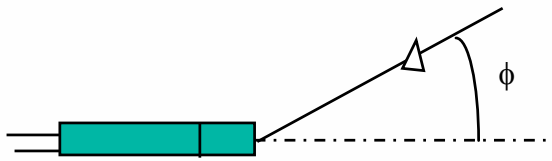
Refers to:

Uniform pressure on microphone diaphragm

Free-field Sensitivity

Refers to:

Pressure of non-disturbed free-field



The Sensitivity is a Function of the Angle of Sound Incidence

Diffuse-field Sensitivity

Refers to:

Pressure of non-disturbed diffuse-field

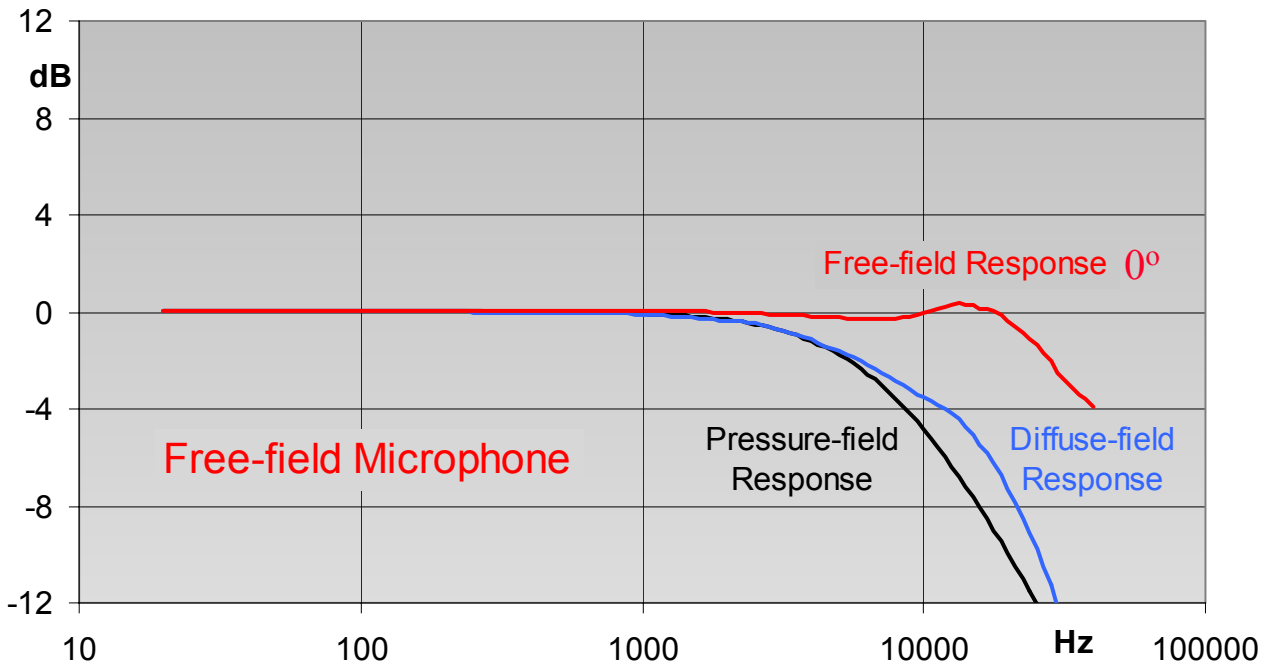
The above sensitivities are different at lower and at higher frequencies, but they are essentially equal in the range 20 Hz to 1000 Hz that includes the frequencies of the most common acoustic calibrators

Microphone Frequency Responses

0° Sound Incidence

Microphone optimised for

Free-field



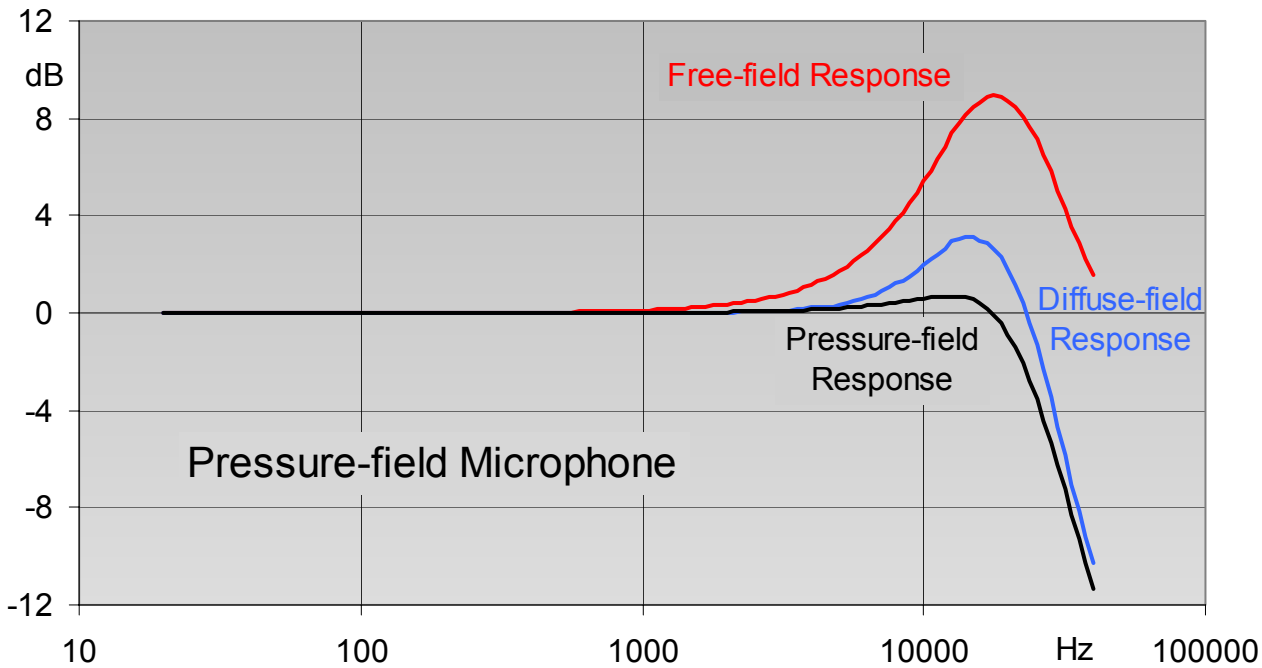
Brüel & Kjær

Microphone Frequency Responses

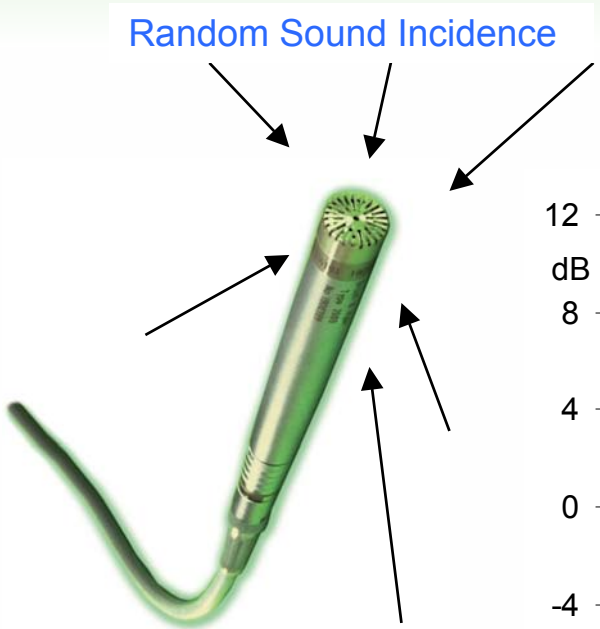
Uniform Pressure on Diaphragm

Microphone optimised for

Pressure-field

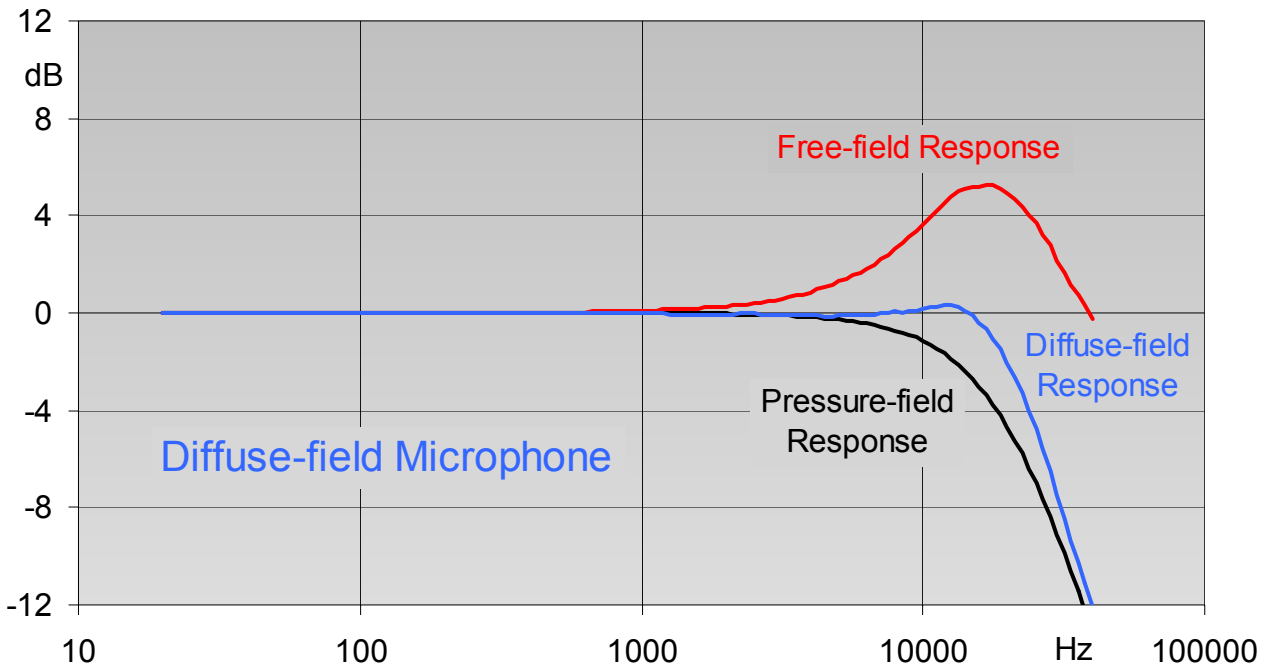


Microphone Frequency Responses

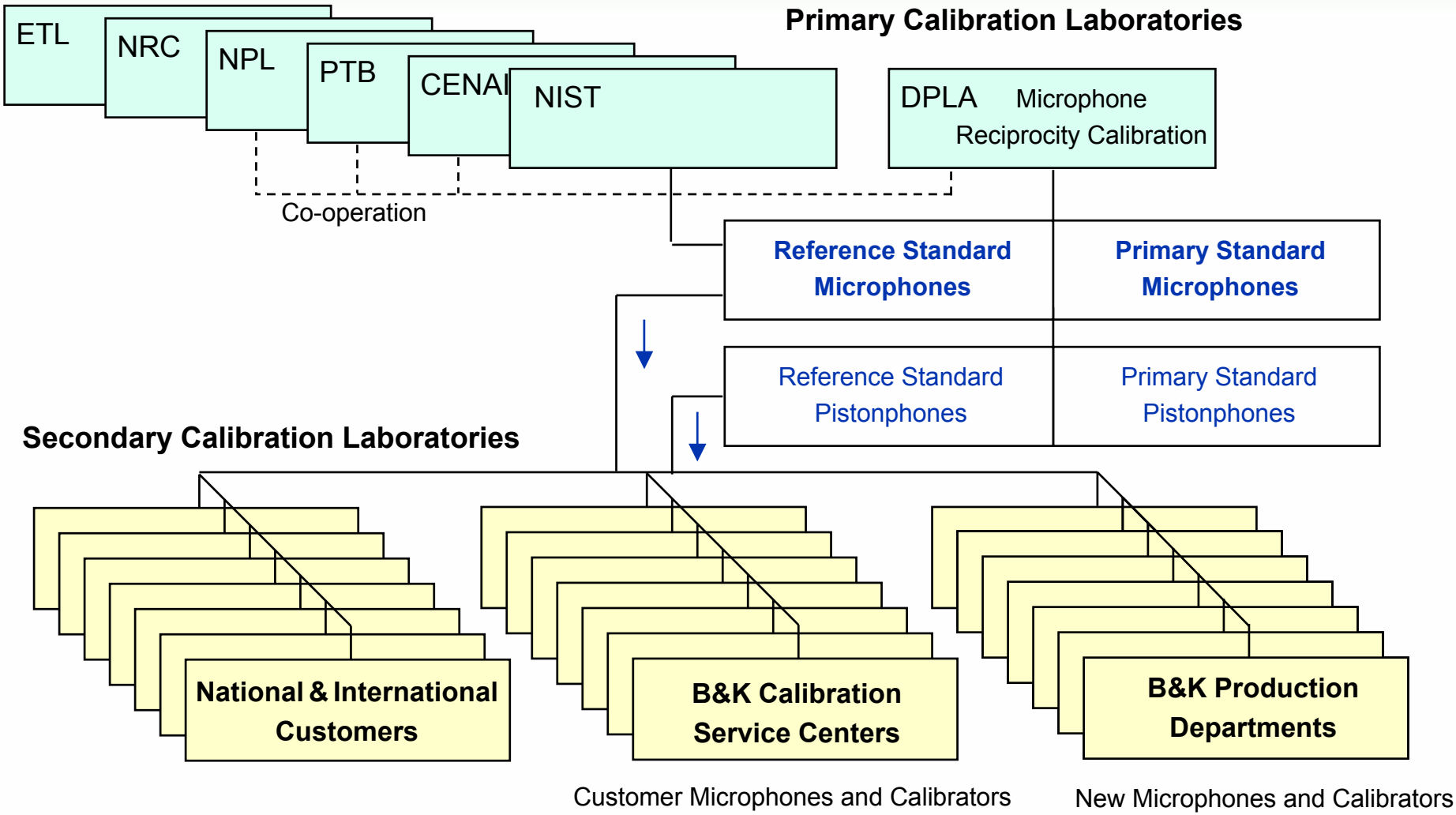


Microphone optimised for

Diffuse-field



Calibration Hierarchy of DPLA and B&K



Brüel & Kjær

IEC Microphone and Calibration Standards

1) IEC 61094-1 Laboratory standard microphones
2) IEC 61094-2 Primary method for pressure calibration
3) IEC 61094-3 Primary method for free-field calibration

4) IEC 61094-4 Working standard microphones
5) IEC 61094-5 Pressure-field comparison calibration
6) IEC 61094-6 Electrostatic actuator calibration
7) IEC 61094-7 Free-field corrections of lab. std. Microphones

8) IEC 61094-8 Free-field comparison calibration (draft)

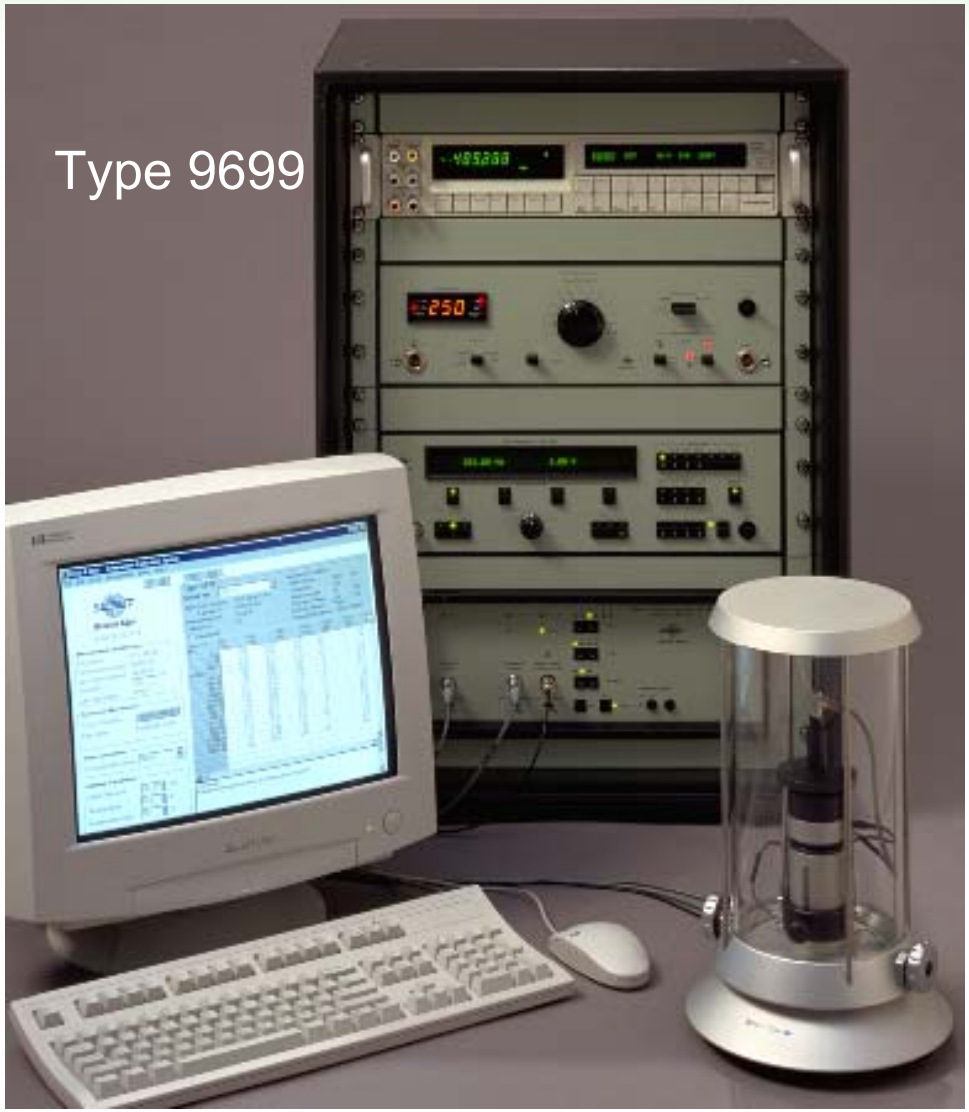
9) IEC 61043 Sound intensity instruments and their calibration
10) IEC 61183 Diffuse-field calibration of sound level meters

Reciprocity Calibration

A primary calibration principle

IEC 61094-2 and 61094-3

B&K Pressure Reciprocity Calibration System



Type 9699

Reciprocity Calibration is a primary method – mainly applied by National Metrology Institutes

- Highly Accurate
- Frequency Range up to 25 kHz

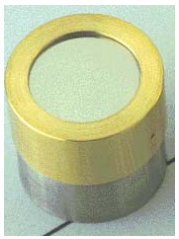
Brüel & Kjær

New Type 9699 with B&K PULSE Analyzer

Brüel & Kjær

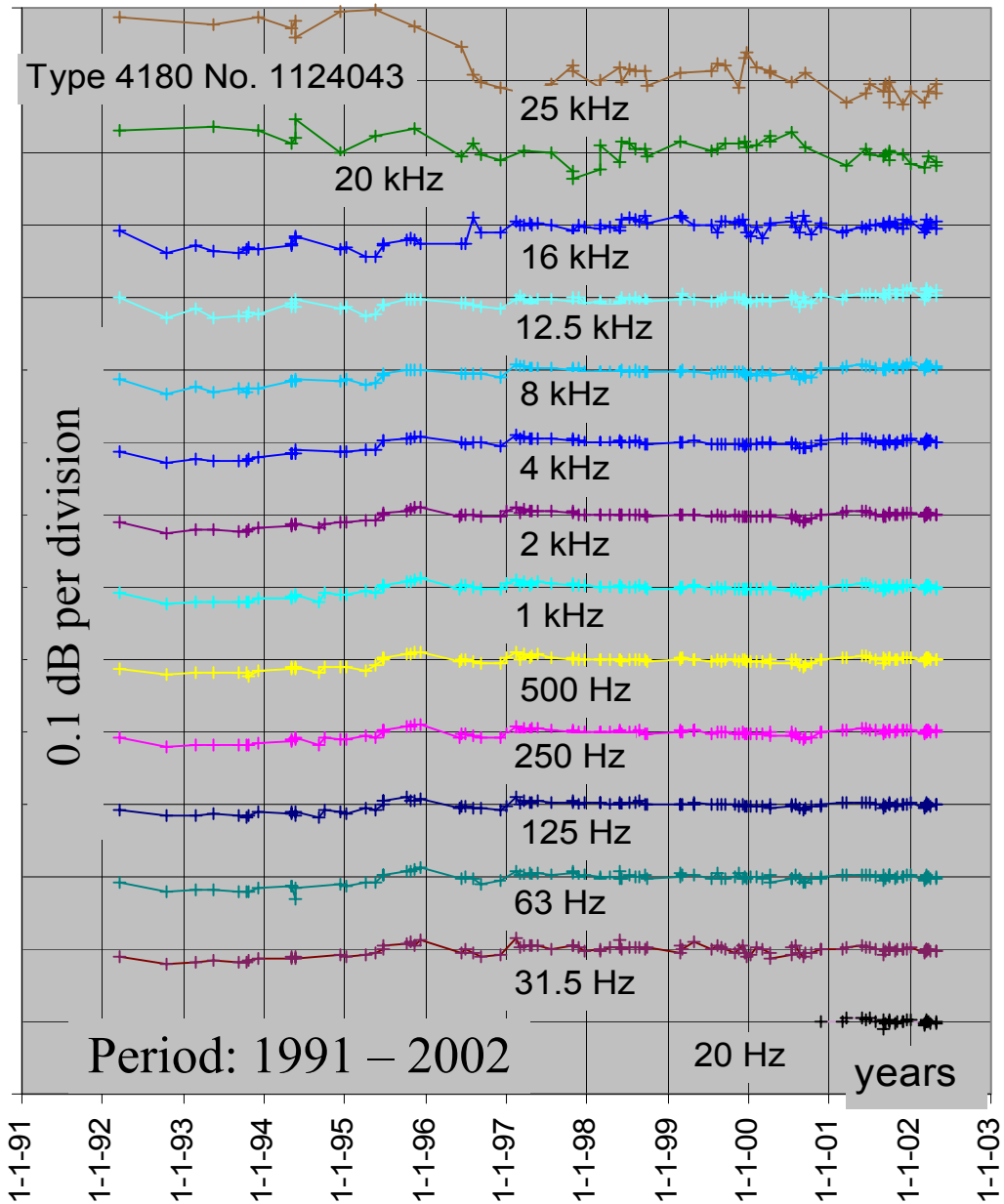
Calibration History

DPLA Standard Microphone
Type 4180 No.1124043



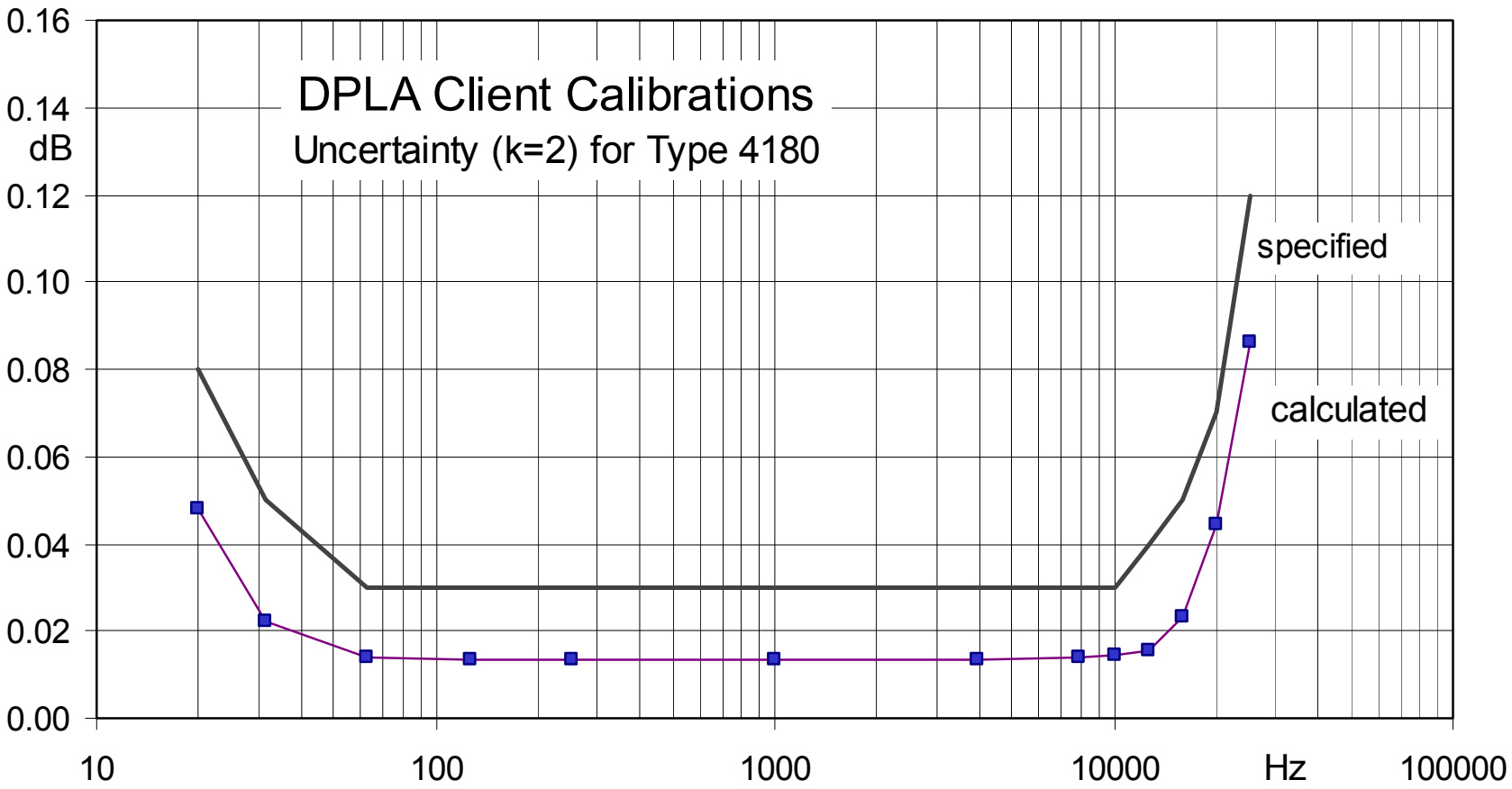
half-inch

Pressure Reciprocity Calibration
Results normalised with Average
Sensitivity of last 5 years



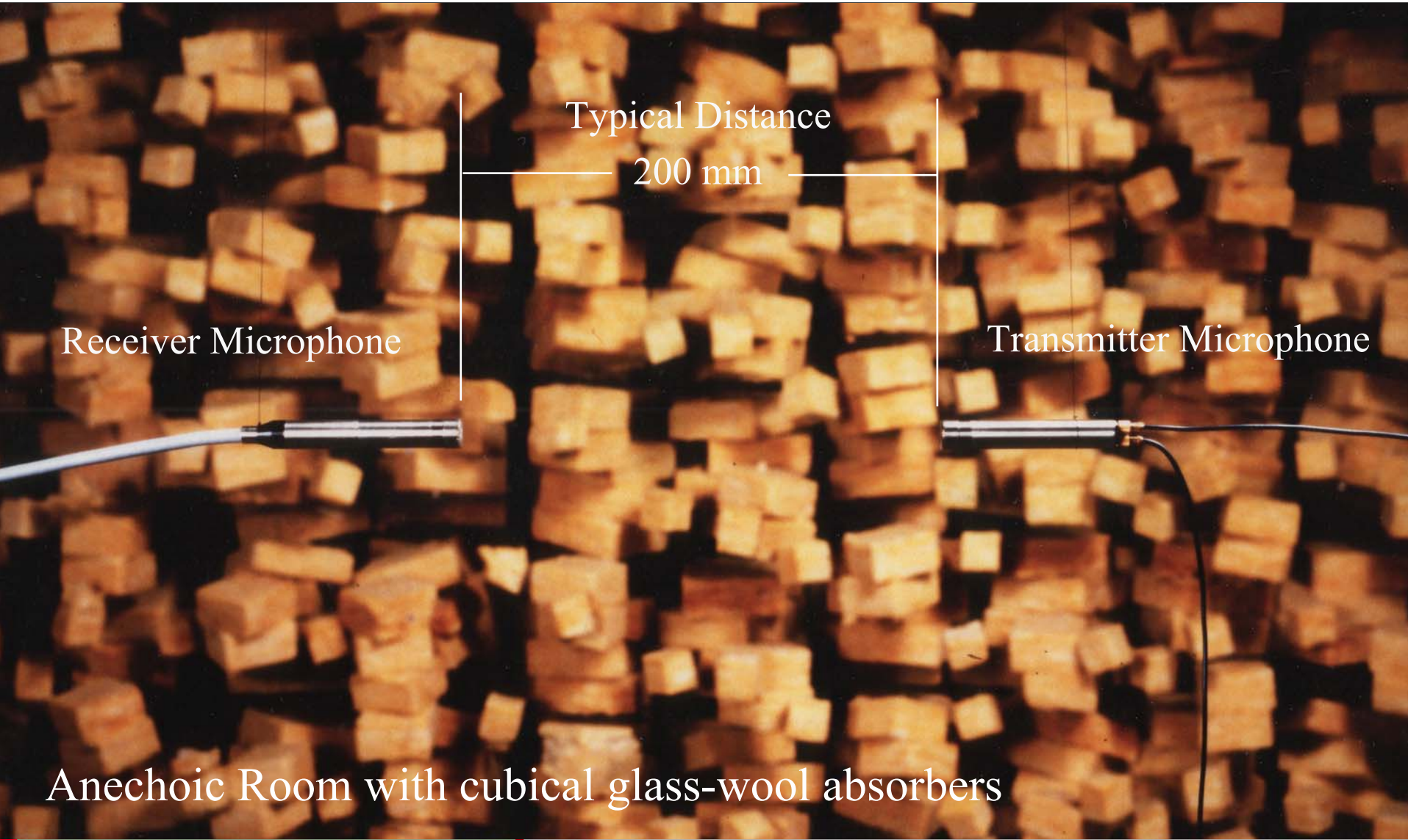
Brüel & Kjær

DPLA Uncertainty of Type 4180 Calibrations



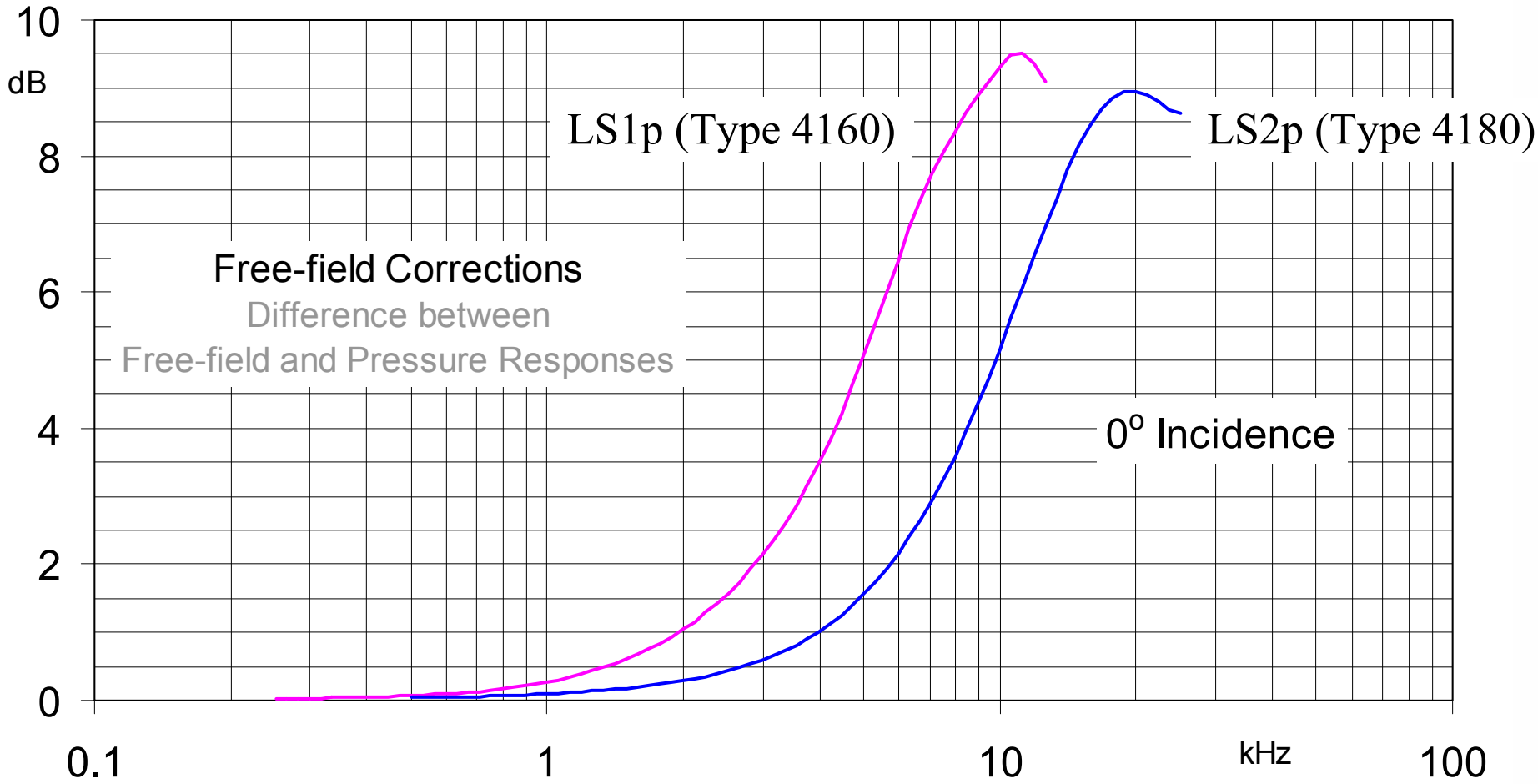
Brüel & Kjær

Free-field Reciprocity Calibration, Half-inch

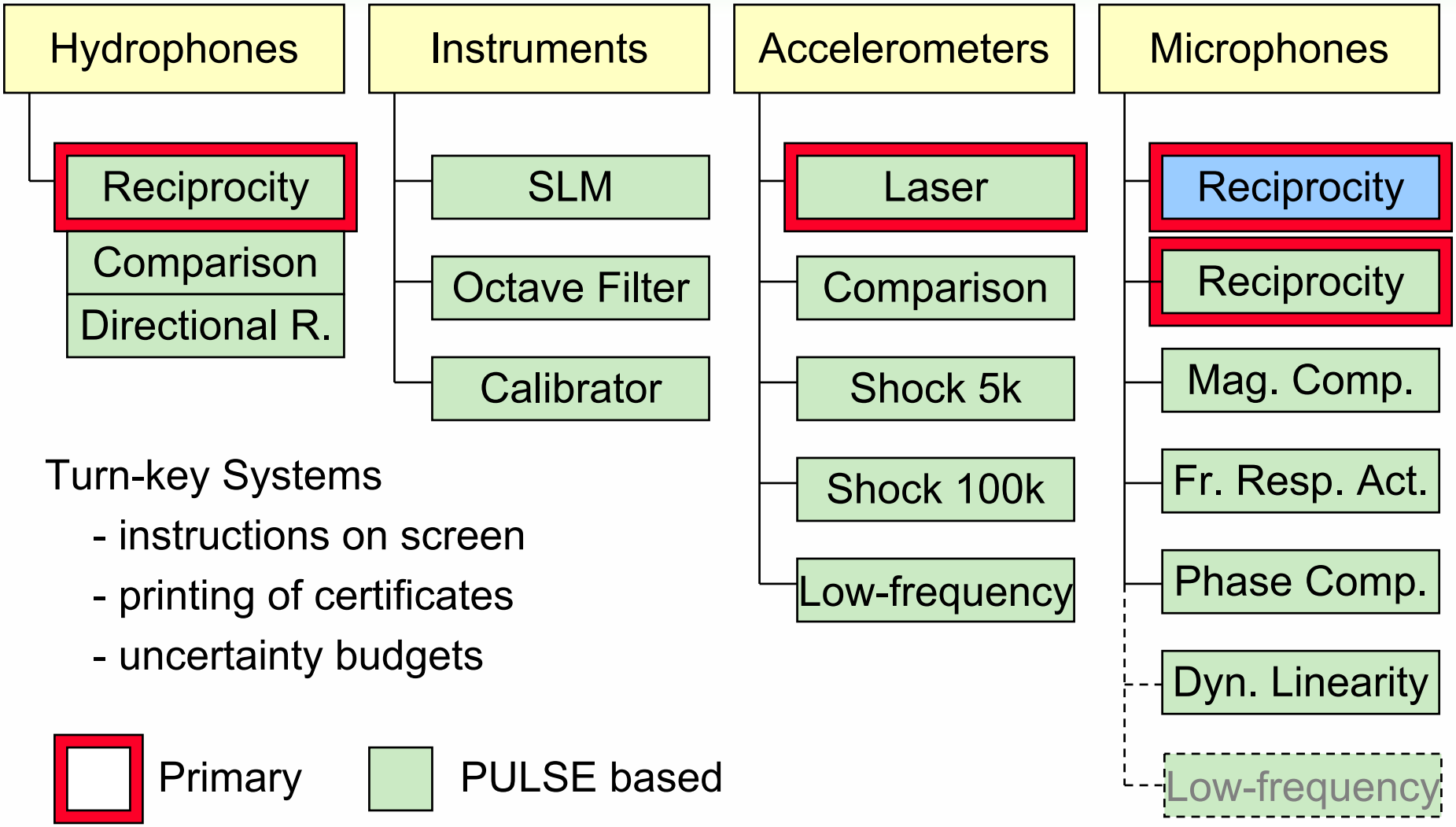


Brüel & Kjær

IEC 61094-7 Free-field Corrections



B&K Calibration Systems



Turn-key Systems

- instructions on screen
- printing of certificates
- uncertainty budgets

Primary

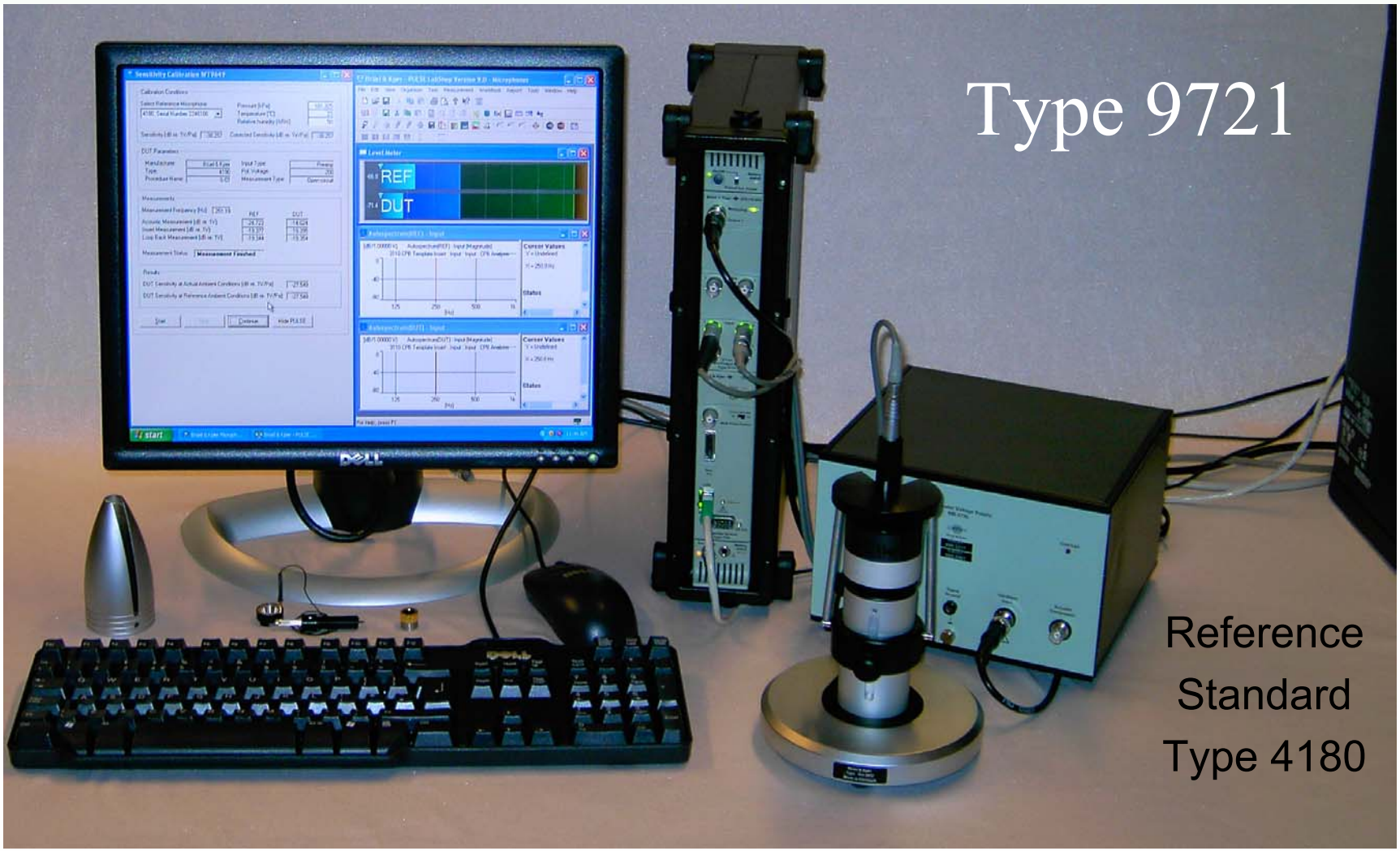
PULSE based

Brüel & Kjaer

Type 9721

Microphone Calibration System

Calibration of B&K and other brands of microphone - 1/8” to 1/1”



Brüel & Kjær

Types of Microphone

- LS1 and LS2 of IEC61094-1 (1/1” and 1/2”)

- WS1, WS2 and WS3 of IEC61094-4 (1/1”, 1/2” and 1/4”)

- 1/8” microphones 

- surface microphones 

- non-B&K microphones

(some types may require specific types of actuator and adapter)

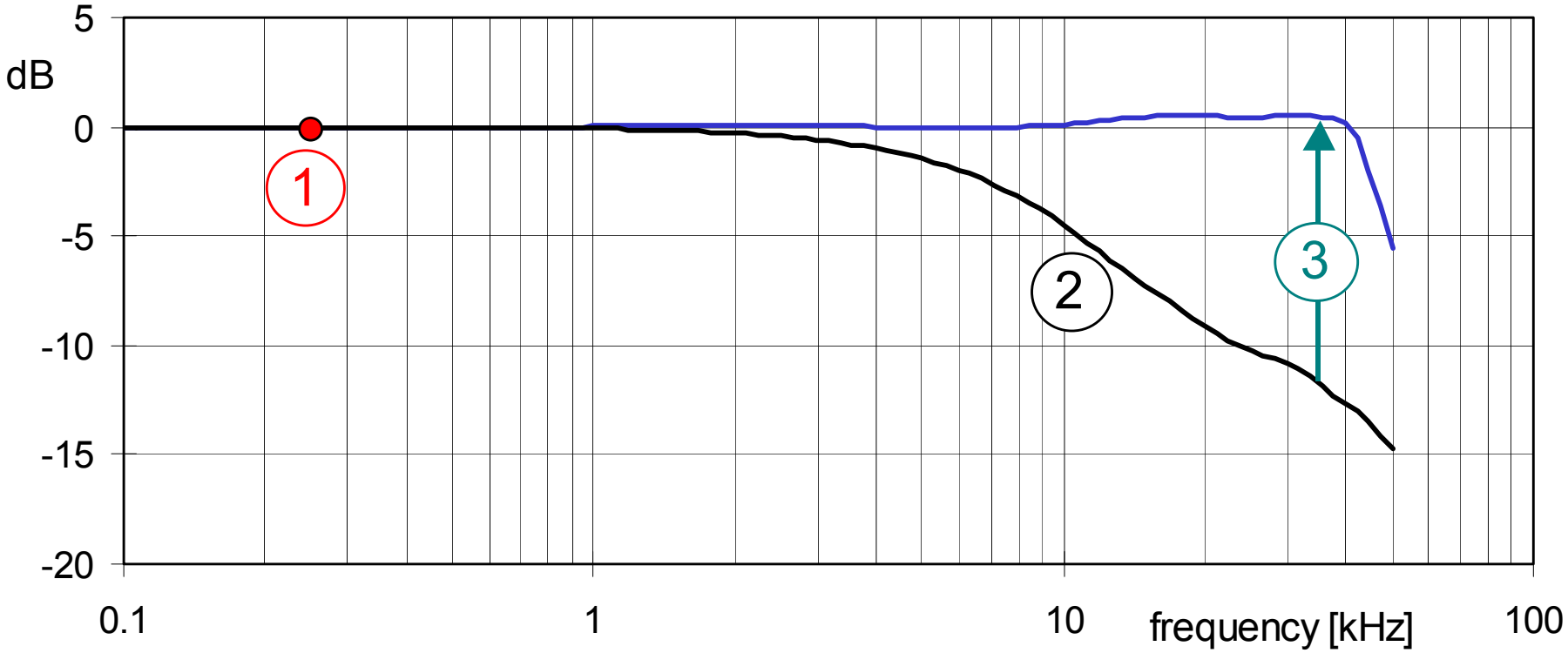
Microphone Calibration System Type 9721

- Sensitivity at 250 Hz or 1000 Hz — by comparison
  - Open Circuit
  - Loaded with preamplifier

- Frequency Responses — by adding corrections to measured Electrostatic Actuator Response
  - Free-field
  - Diffuse-field
  - Pressure-field

- Tolerance Checking of Frequency Response

Type 9721 Microphone Calibration

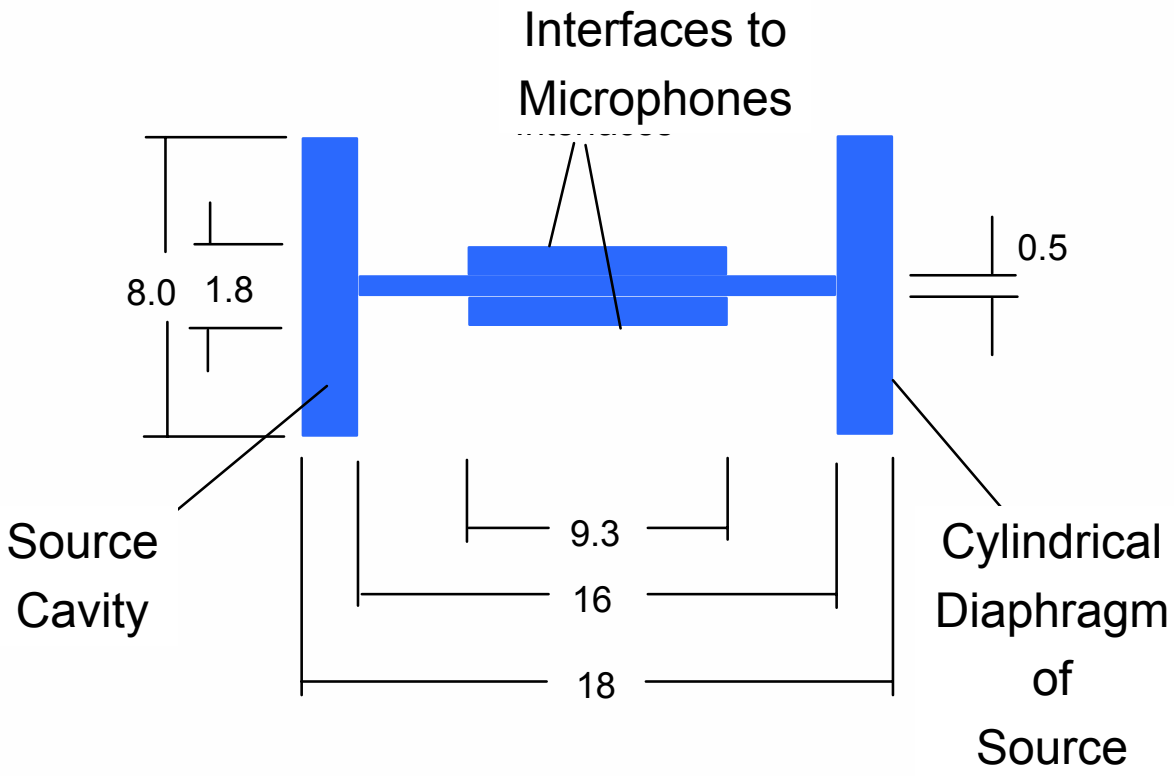


1. Sensitivity at 250 Hz
2. Electrostatic Actuator Response
3. Sound-field Correction

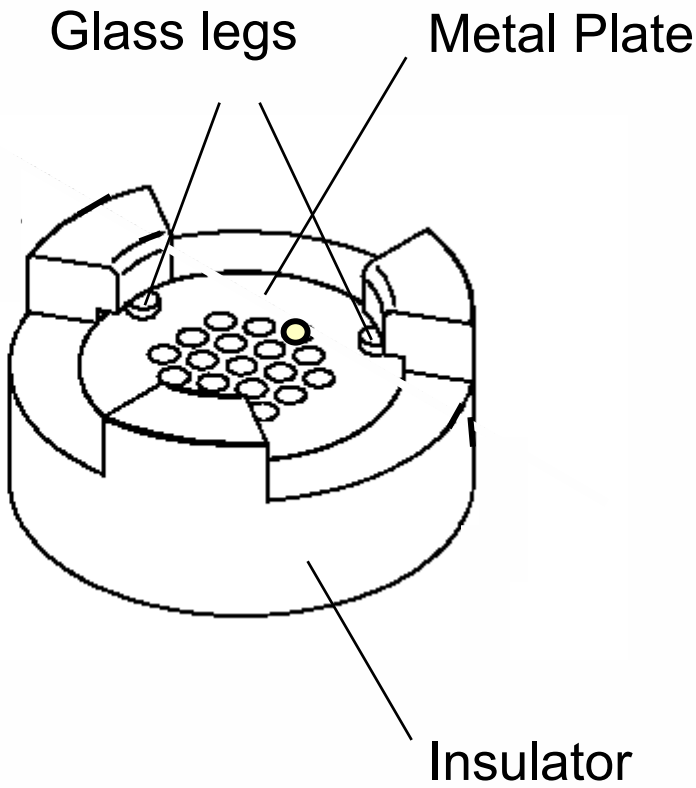
Comparison Calibration Method – IEC61094-5

Comparison Coupler
with built-in Sound Source

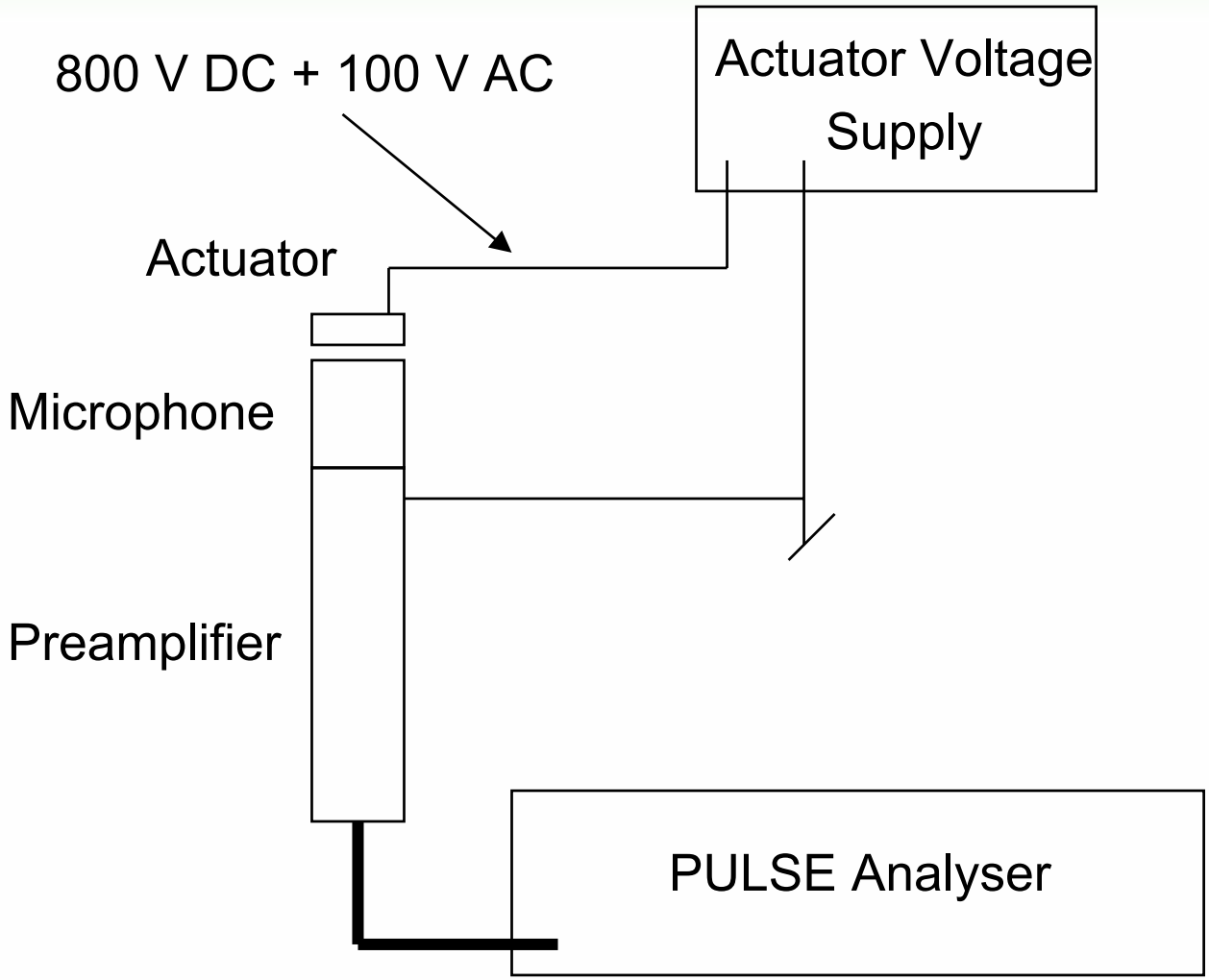
20 Hz – 16 kHz



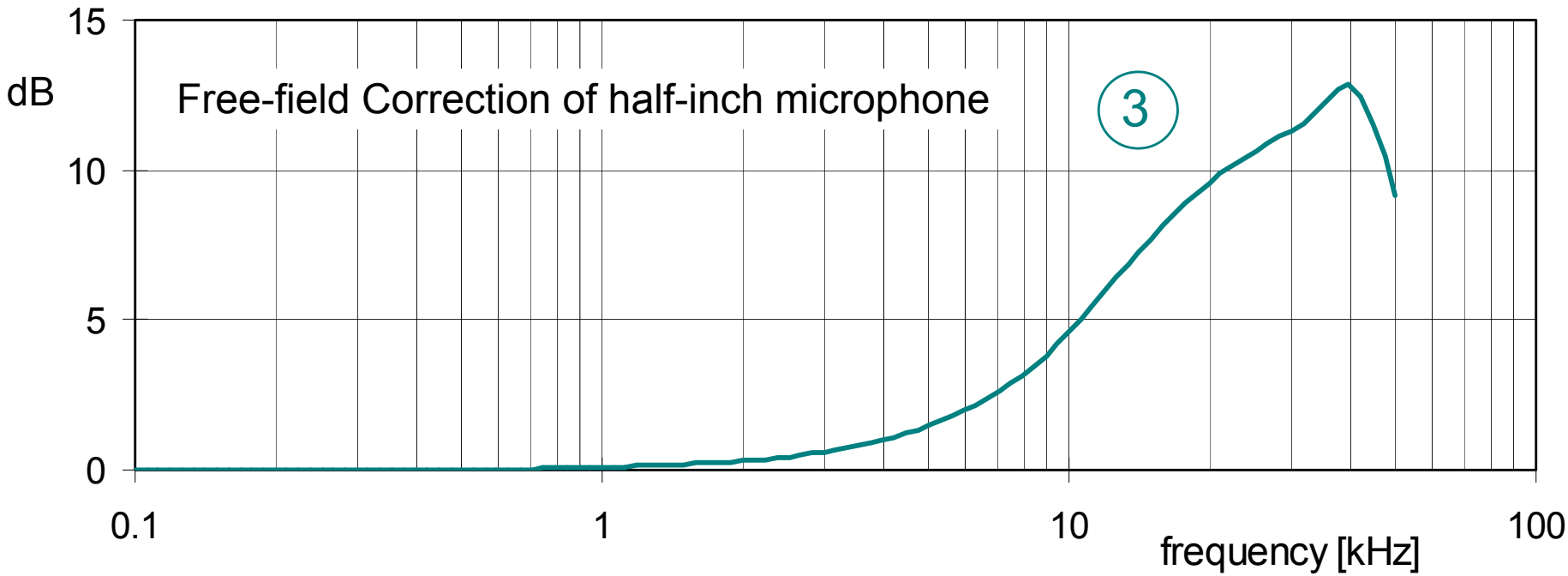
Electrostatic Actuator



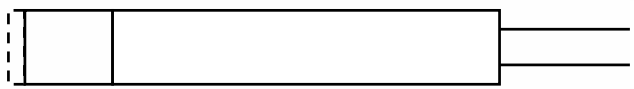
Setup for Electrostatic Actuator Calibration



Example of Sound-field Correction

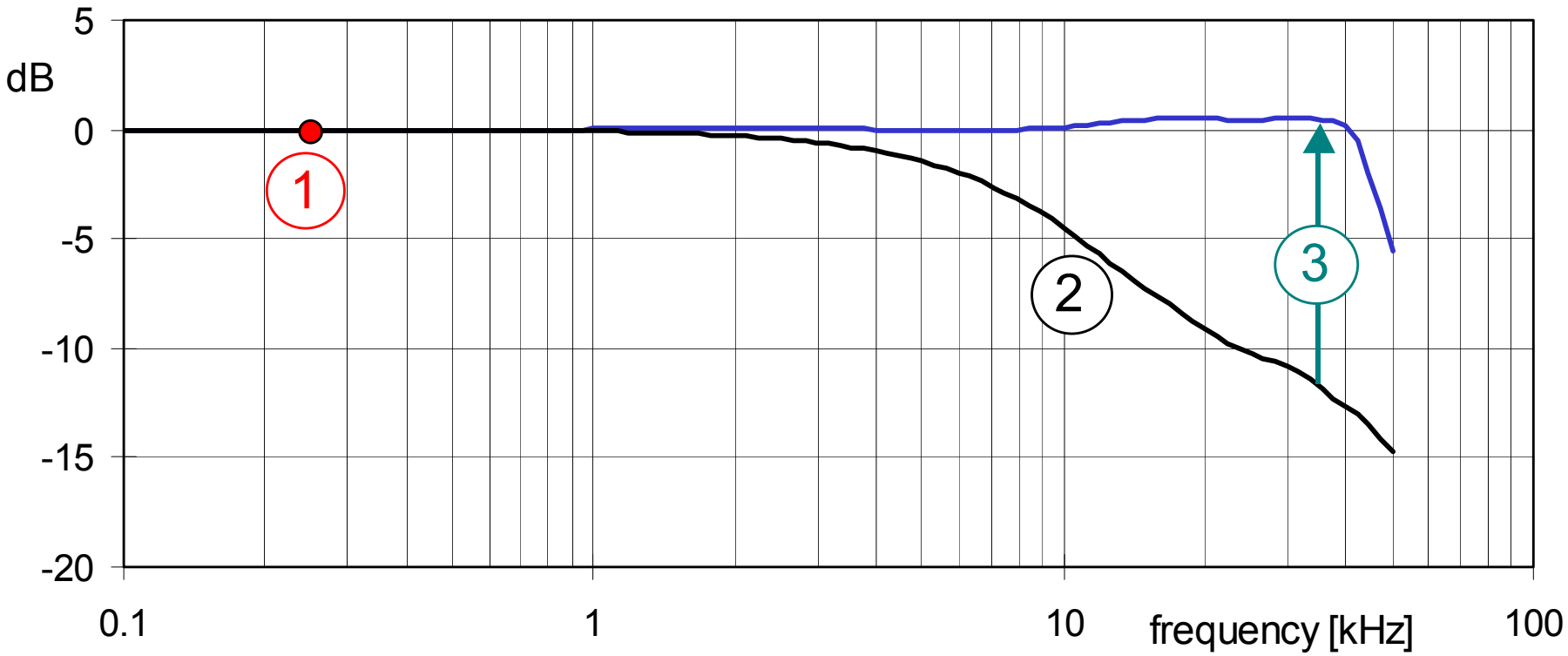


Direction of Sound Incidence (0°)



Microphone with Diaphragm Protection Grid

Microphone Calibration made with Type 9721

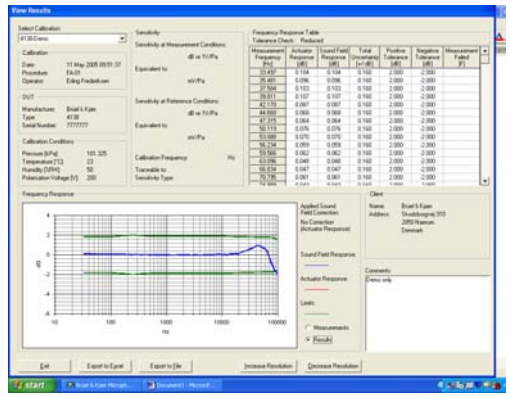


1. Sensitivity at 250 Hz
2. Electrostatic Actuator Response
3. Sound-field Correction

Output of results

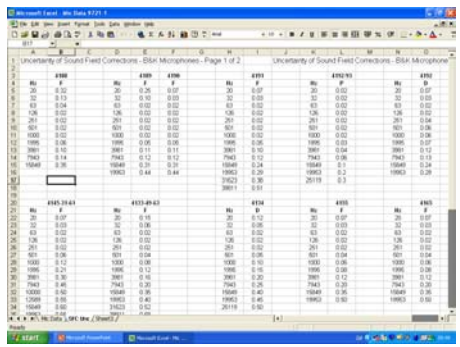
- printing of certificate

Certificate



- recalling from database

- exporting to Excel



- exporting to text file

CD

Microphone Fixture and Active Coupler WA0817

Monitor
Microphone
Type 4192

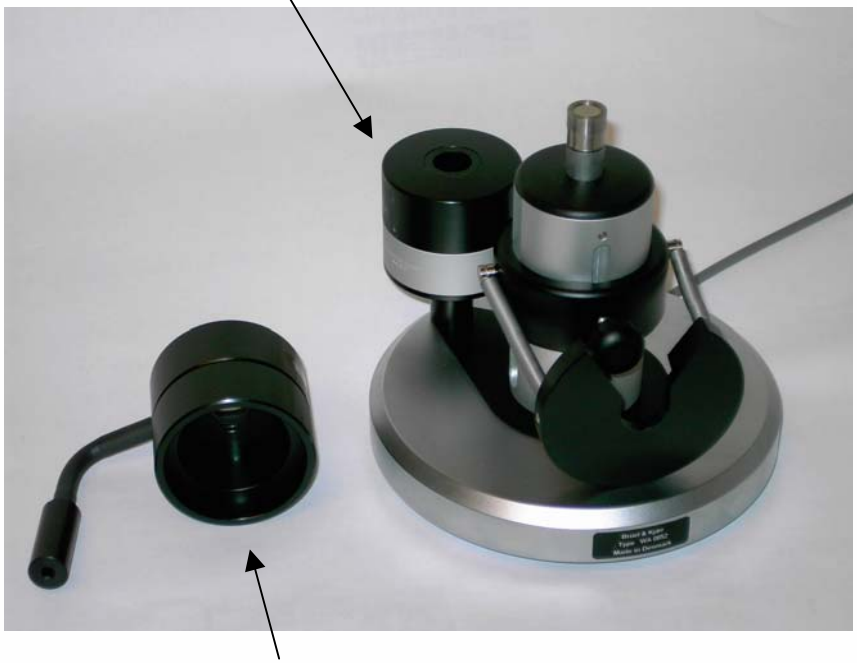
Calibration Fixture
WA0852

Active Comparison
Coupler WA0817
(90 dB SPL for 1V)

Coupler and fixture mounted
for calibration of half-inch
and smaller microphones

Couplers and fixture for calibration of one-inch microphones

Active Coupler
WA0817



One-inch Coupler
UA1609

The active coupler WA0817 supplies the sound for the ppassive one-inch coupler

Microphone Calibration Module Type 5001

Driver unit for Active Coupler and Electrostatic Actuator

Brüel & Kjær

Chart for calculation of sensitivity uncertainty

System Owners Specification of Ambient Conditions in his Calibration Laboratory	Unit	Lower Limit	Upper Limit	Reference Conditions	Max. Dev. from Ref.
Static Pressure	kPa	*92.325*	*104.325*	101.325	9
Temperature	°C	*20*	*28*	23	5
Relative Humidity	% RH	*10*	*85*	50	40

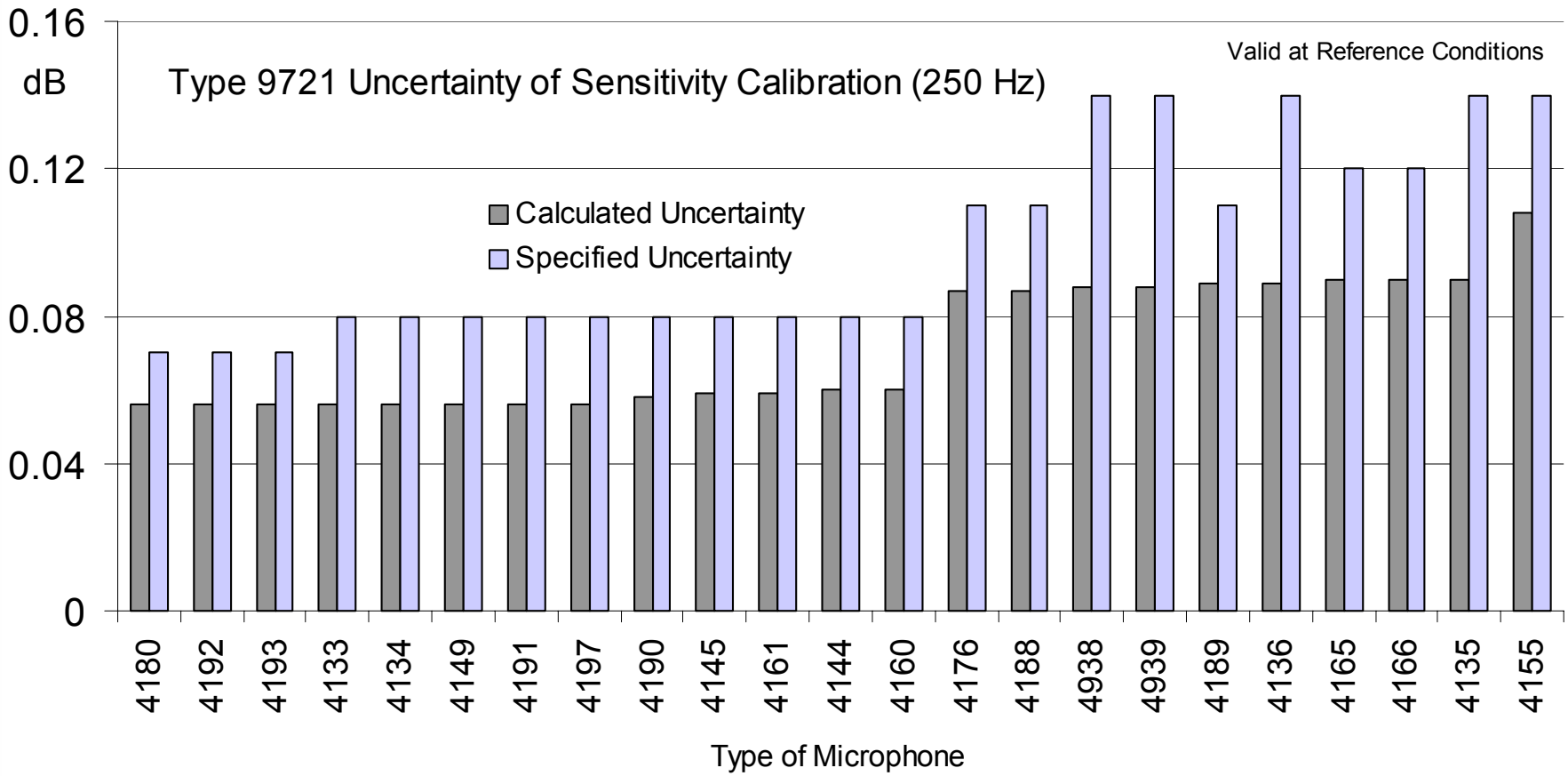
System Owners Specification of his Ambient Condition Measurements	Unit	Meas. Unc.	Unc. Type	Distrib.	Contribution to Sensitivity Uncertainty dB
Static Pressure	kPa	*0.2*	max.	Rect.	
Temperature	oC	*1.5*	max.	Rect.	
Relative Humidity	% RH	*10*	max.	Rect.	

B&K Specification of Reference - Type 4180	Unit	Value	Unc.	Unc. Type	Distrib.	k=2
Sensitivity Calibration	dB re.1 V/Pa	individual	0.030	k=2	Norm.	0.030
Sensitivity Instability (1 year)	dB/year	0.020	0.020	max.	Rect.	0.023
Static Pressure Coefficient	dB/kPa	-0.0055	0.00066	max.	Rect.	0.004
Temperature Coefficient	dB/°C	-0.002	0.001	max.	Rect.	0.004
Relative Humidity Coefficient	dB/%RH	0	0	max.	Rect.	0.000
						0.038

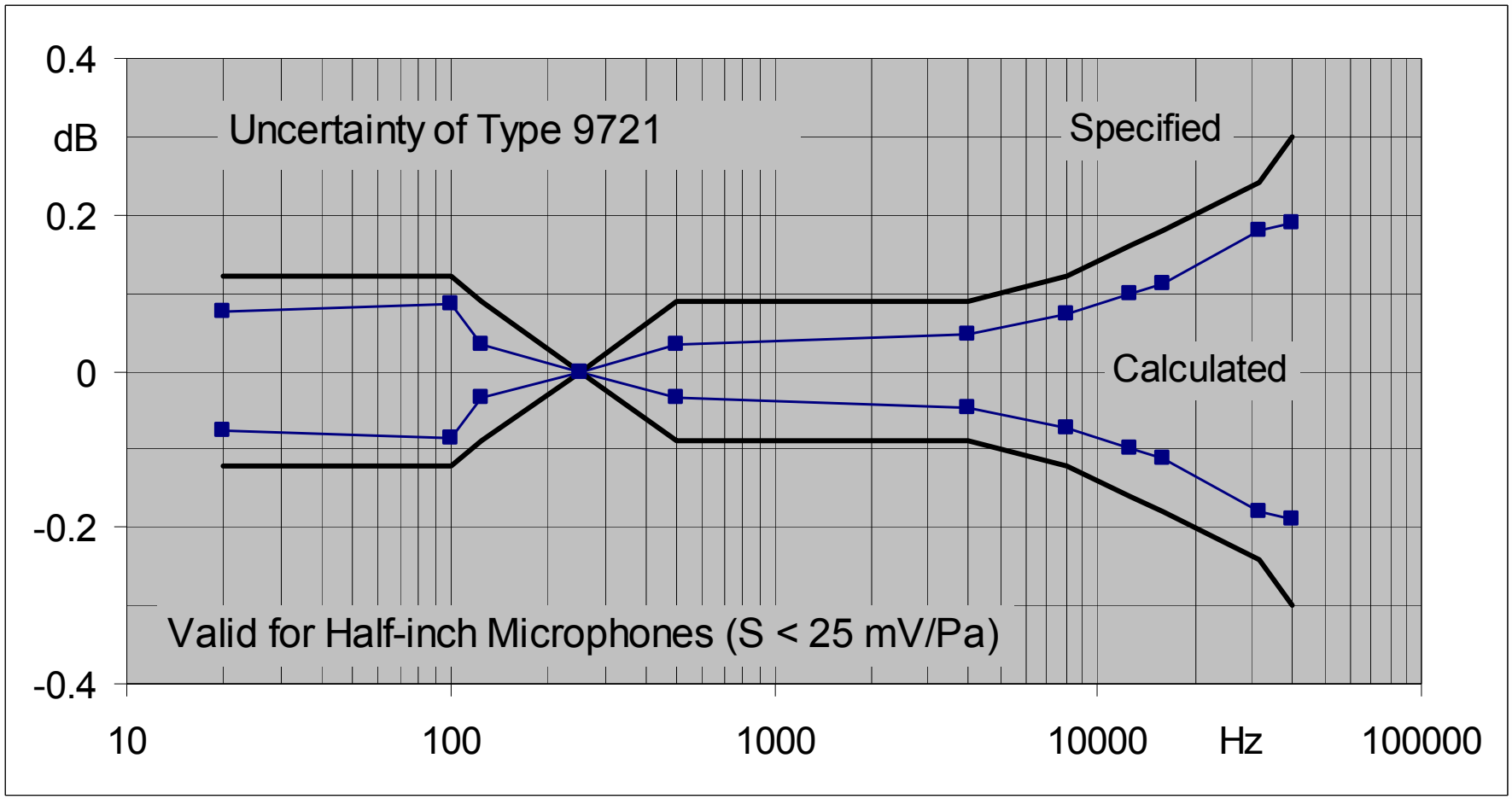
B&K Specification of Comparison Measurem.	Unit	Value	Unc.	Unc. Type	Distrib.	k=2
Voltage Ratio - Sound Excitation	dB	-20 to +14	0.025	max.	Rect.	0.029
Voltage Ratio - Insert Voltage	dB	-2 to +2	0.01	max.	Rect.	0.012
Voltage Ratio - Loop-back	dB	-0.1 to +0.1	0.005	max.	Rect.	0.006
Gainratio	dB	-0.1 to +0.1	0.005	max.	Rect.	0.006
Reproducibility of Calibration Results*	dB	-	0.007	k=2	Norm.	0.007
Polarization Voltage of PULSE	V	200	1	max.	Rect.	0.010
Preamplifier Terminals (dev. from IEC Standard)	dB	0	0.015	max.	Rect.	0.017
						0.039

DUT Specification	Unit	Value	Unc.	Unc. Type	Distrib.	k=2
Static Pressure Coefficient	dB/kPa	*-0.007*	*0.001*	max.	Rect.	0.010
Temperature Coefficient	dB/°C	*-0.002*	*0.001*	max.	Rect.	0.006
Relative Humidity Coefficient	dB/%RH	*0*	*0*	max.	Rect.	0.000
Nominal Polarization Voltage (0 V or 200 V)	V	*200*	-	-	-	-
Diameter	inch	*0.5*	-	-	-	-
Type of Microphone	-	*4191*	-	-	-	-
						0.012

Proposed and Calculated Uncertainty	**Recommended Specification**			**Calculated Uncertainty**		
- at Measurement Conditions	**k=2**	**dB**	**0.07**	**k=2**	**dB**	**0.055**
- at Reference Conditions	**k=2**	**dB**	**0.08**	**k=2**	**dB**	**0.056**


Type 9721 Uncertainty of Sensitivity Calibration (250 Hz)
Valid at Reference Conditions
0.16
dB
0.12
0.08
0.04
0
Calculated Uncertainty
Specified Uncertainty
4180
4192
4193
4133
4134
4149
4191
4197
4190
4145
4161
4144
4160
4176
4188
4938
4939
4189
4136
4165
4166
4135
4155
Type of Microphone

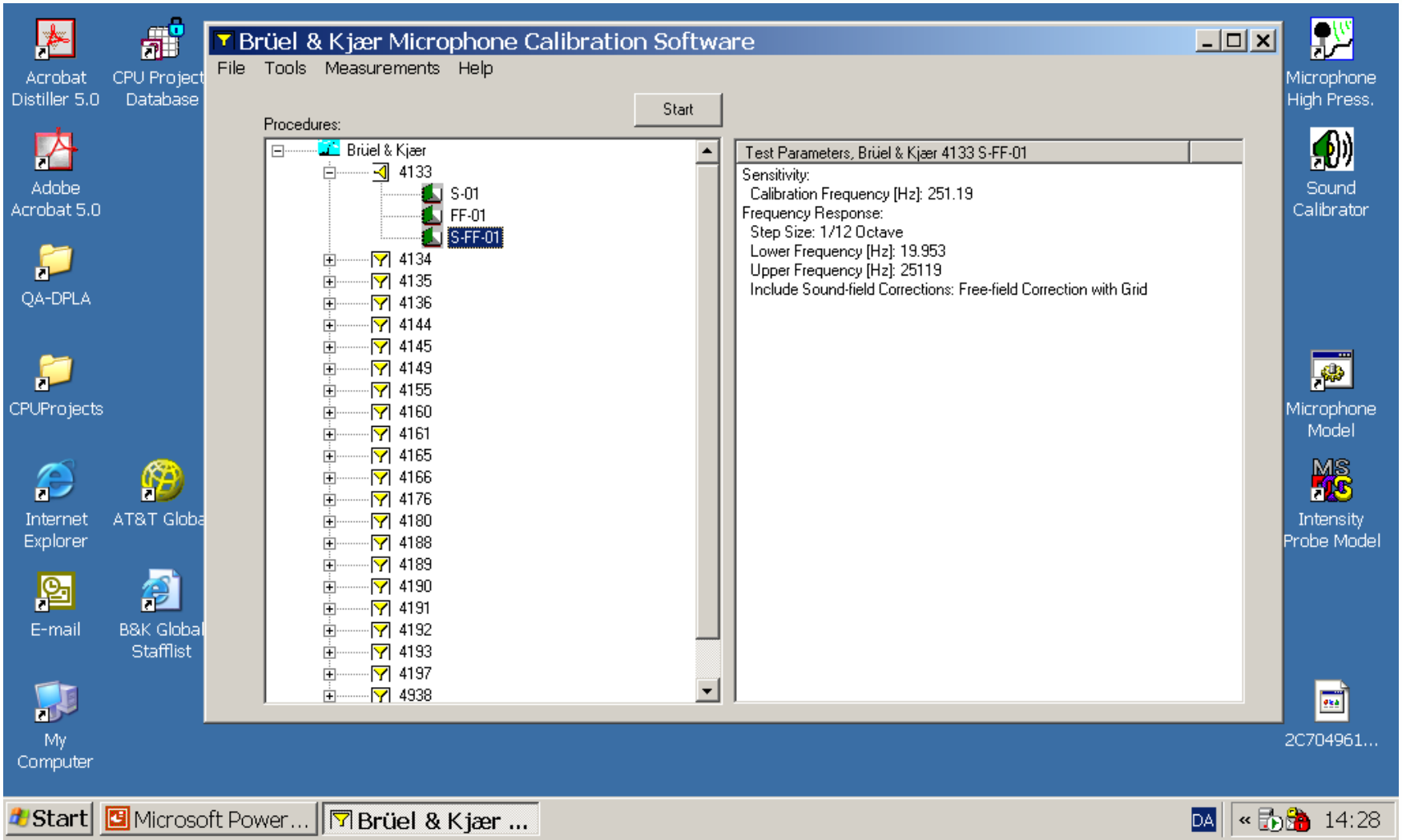
Brüel & Kjær



Actuator Frequency Response

Brüel & Kjær

Start Window of Type 9721 Software



Brüel & Kjær

Demo of

Secondary Microphone Calibration System

Type 9721

Now the lecture and the demo are finished

Thanks for your attention!

For a little while we shall keep the line open for possible questions

(write to us in the chat window)