

System Development

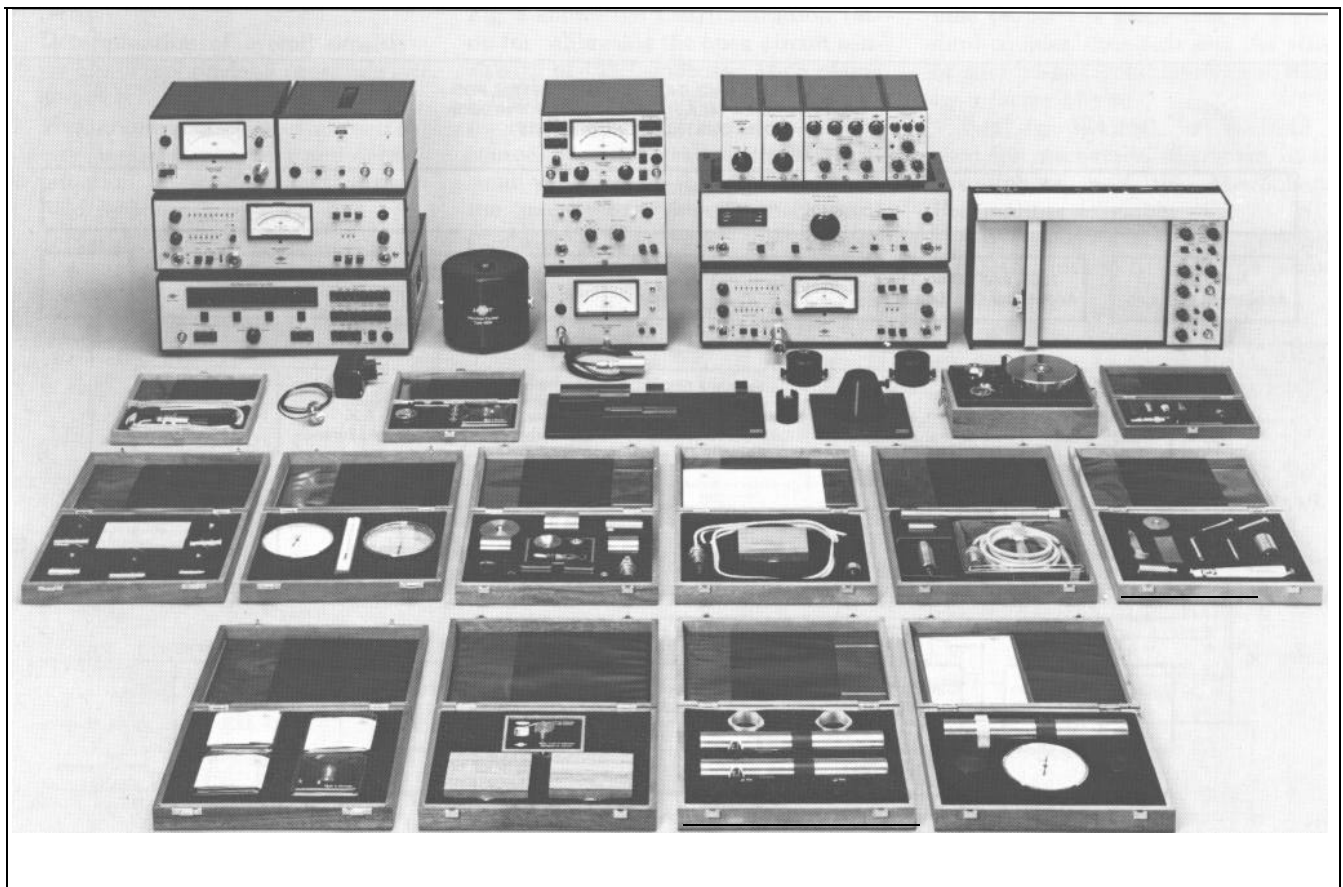
Calibration Systems — Types 9559, 9604 and 9605 for Microphone Cartridges, Accelerometers and Pistonphones

FEATURES:

- 0 Turn-key calibration system with step-by-step operation procedures and preprinted worksheets
 - 0 Calibration by the comparison method, giving high precision and excellent repeatability
 - 0 System verification procedure included
 - 0 Traceability to National Institute of Standards and Technology, Washington DC, USA
 - 0 Design flexibility, allowing a wide range of options to be added
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- Sensitivity with preamplifier
 - 0° incidence free-field response
 - Random incidence response
- 0 Accelerometer Calibration:
 - Measurement of mounted resonance
 - Charge and voltage sensitivities
 - Capacitance
 - 0 Pistonphone Calibration:
 - Output Sound Pressure Level
 - Frequency
 - Distortion
 - 0 Acoustical Calibrator Performance Check:
 - Output sound pressure level
 - Frequency
 - Distortion

USES:

- 0 Microphone Calibration:
 - Open-circuit sensitivity



The calibration procedures and calibration intervals for measurement microphones, vibration transducers and acoustical calibrators which are used for statutory purposes are normally governed by international or national standards. This is not the case for devices which are used for research and production testing, but good measurement practice requires that regular calibration intervals and the degree of calibration accuracy should also be established for these transducers and calibrators.

Basically a calibration procedure can be divided into three groups or levels according to the accuracy with which the calibration is performed:

1. Calibration of **Primary Standard** transducers
2. Calibration of **Secondary Standard** transducers
3. Calibration of **Measurement** transducers

Primary standard transducers are calibrated with the highest possible accuracy. They are used for the calibration of secondary standards and are seldom used for continuous calibration purposes.

It is recommended that the calibration of secondary standards and mea-

surement transducers is checked at intervals no greater than one year. This assures the stability of a system and ensures that measurement requirements are fulfilled.

To facilitate regular and accurate calibration of measurement transducers and calibrators, Brüel & Kjær has developed the Calibration System Type 9559. The System is designed to fulfil the requirements for calibration of 1", 1/2", 1/4" and 1/8" Brüel & Kjær Condenser Microphone Cartridges, Accelerometers, and Brüel & Kjær Pistonphone Type 4220. Furthermore Type 9559 can be used for sensitivity determination of combined microphone cartridge and preamplifier assemblies and performance checks of Brüel & Kjær Sound Level Calibrator Type 4230.

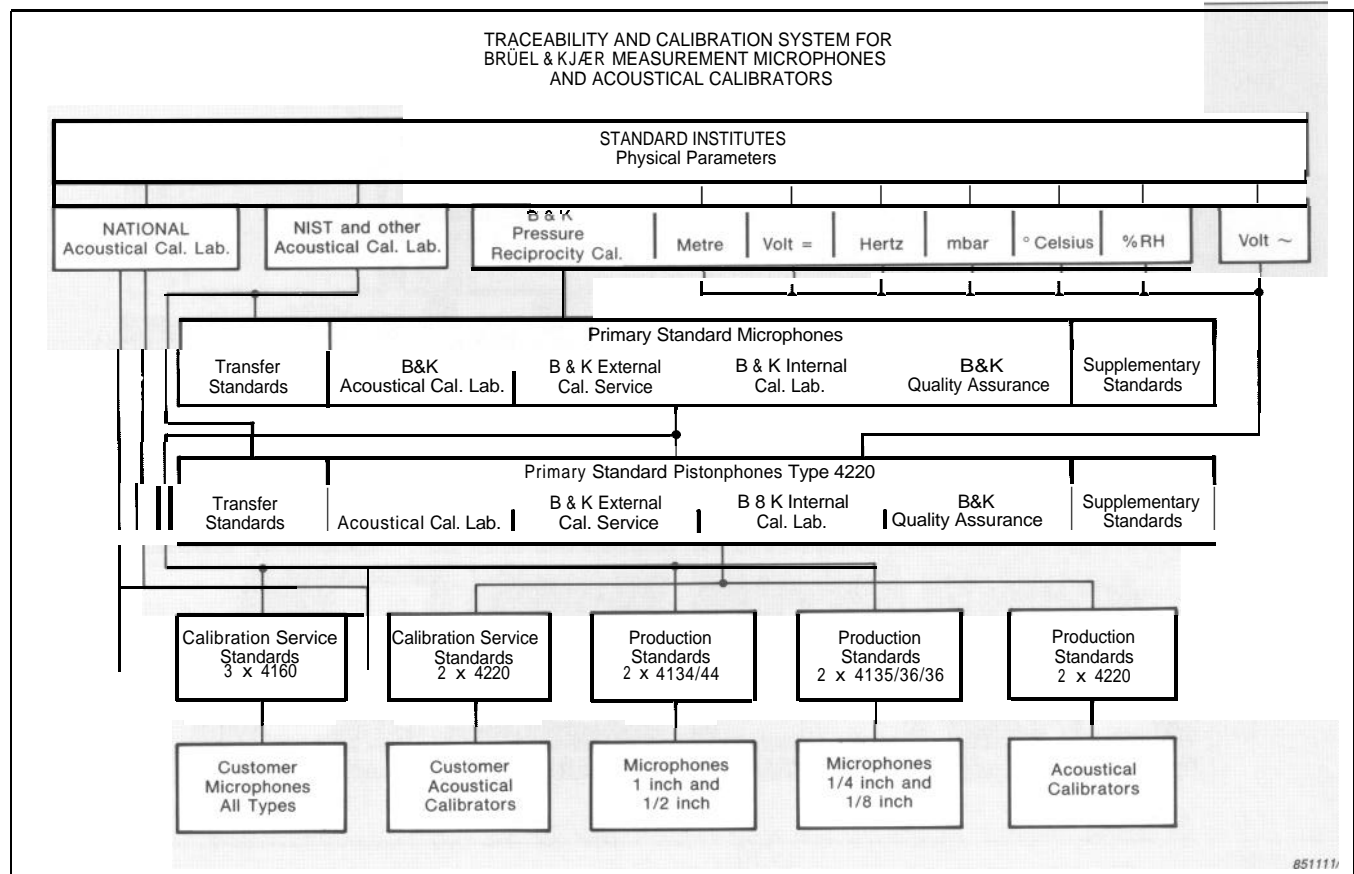
System Description

Calibration System Type 9559 is a turn-key system which is commissioned for the user by trained Brüel & Kjær personnel. Step-by-step procedures ensure the repeatability of the calibration and the system is supplied with detailed worksheets, calibration certificates and documenta-

tion giving the accuracy of the calibration of the various B & K transducers and calibrators. Calibration with Type 9559 is traceable to the National Institute of Standards and Technology, Washington DC or other national calibration laboratories. Design flexibility allows a wide range of options to be selected, customizing the configuration of the System to the user's requirements.

Type 9559 consists of a number of standard B&K instruments and a number of Test Jigs and Calibration Aids which have been developed by the B&K Systems Engineering Group and are termed System Development instruments. Figs. 3, 4, 6 and 7 (described in succeeding sections) show some typical instrument configurations used for calibration with the Type 9559. Precision Attenuator WB0566 and Expanded Meter Type 5908 are the key instruments governing the accuracy of the measurements.

Operation of the Calibration System is straightforward using the set-up and calibration procedures which are included. A verification procedure which is performed prior to calibration is given for each instrument set-up, thus giving high confidence in the accuracy of the measurement.



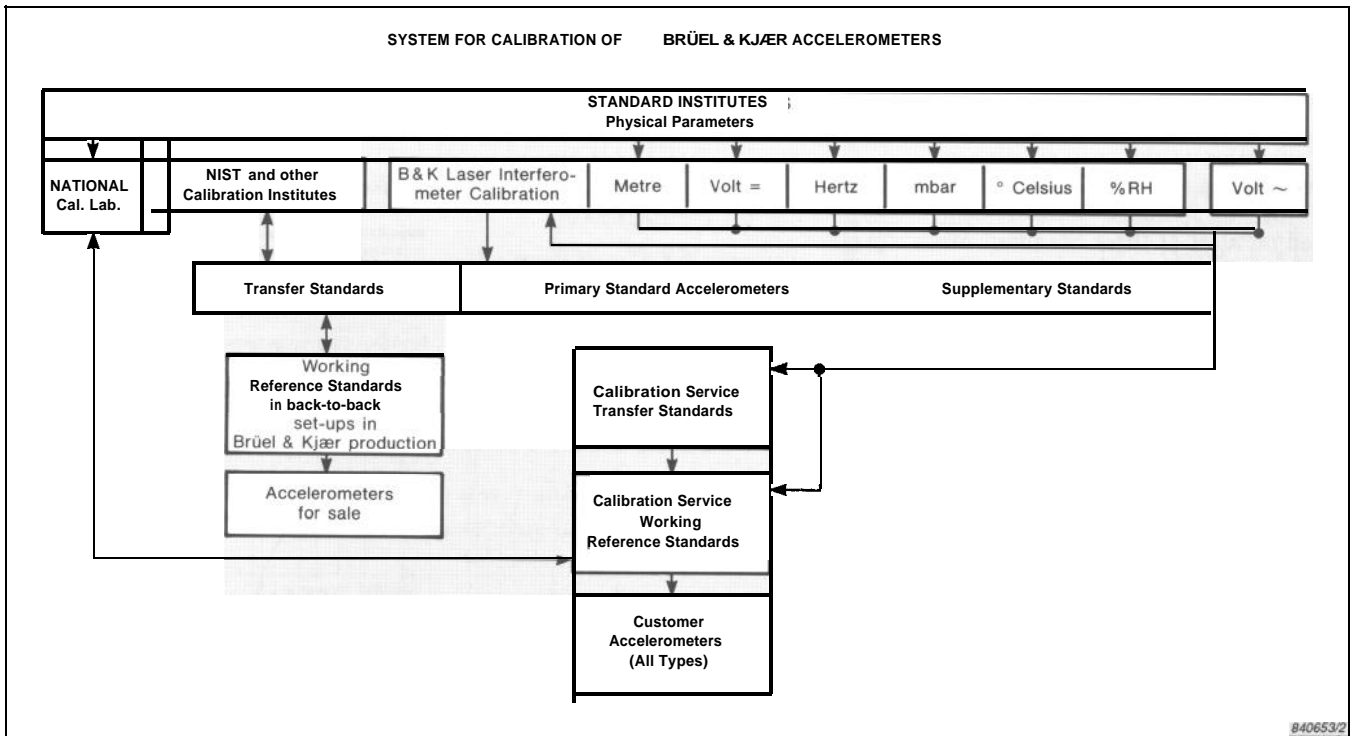


Fig. 2. Principle of the system for calibration of Brüel & Kjær Accelerometers

Calibration of Condenser Microphone Cartridges

- 0 Calibration of open-circuit sensitivity
- 0 Determination of overall sensitivity of microphone and preamplifier assembly
- 0 Measurement of electrostatic actuator frequency response and determination of free-field and diffuse field responses

Open-Circuit Sensitivity

Fig. 3 shows the instrumentation set-up for calibrating the open-circuit sensitivity of 1/2" Condenser Microphone Cartridges. A Brüel & Kjær Pistonphone Type 4220 is used as the sound source. In order to reduce the effect of small variations in the front volume of the microphone due to mechanical production tolerances, this Pistonphone is supplied with a special 1"

Coupler WA0242. The Coupler volume (40 cm³) is twice that of a standard coupler, thus reducing the effect of microphone front volume variations by a factor of two.

Test Jig WA0241 or WA0249 is used for mechanical alignment of the Pistonphone and the Microphone-Preamplifier assembly.

A special half-inch Adaptor WA0245 which is fitted to the piston-

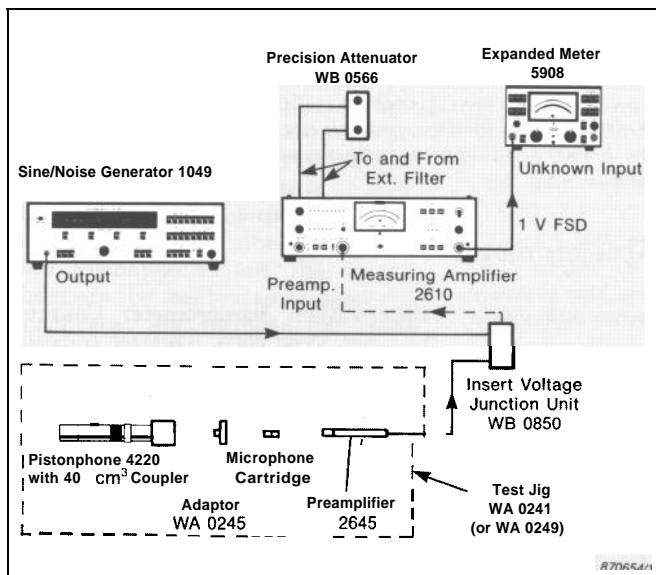


Fig. 3. Calibration of the open-circuit sensitivity of 1/2" condenser microphone cartridges

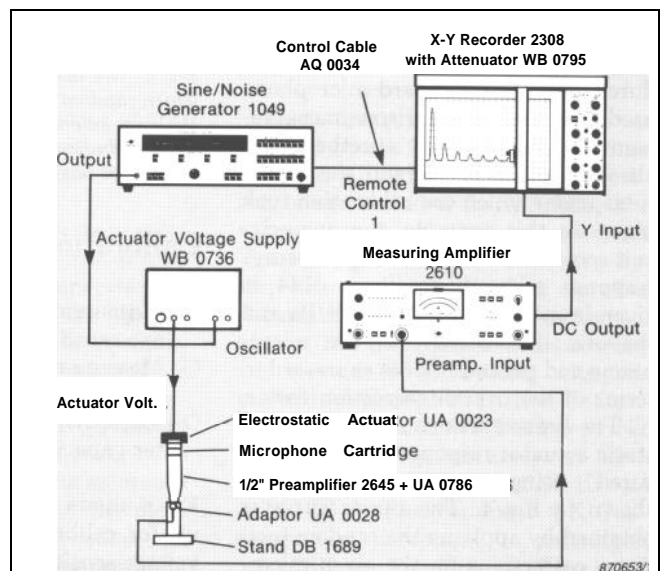


Fig. 4. Instrument configuration for recording the electrostatic actuator response of 1" condenser microphone cartridges

phone coupler has been designed for calibration of 1/2" cartridges. This adaptor is individually checked to ensure the correct loading volume of the pistonphone is obtained.

Calibration of the open-circuit sensitivity of the test cartridge is carried out by comparison measurement, based on a set of three Standard Microphone Cartridges Type 4160. This set of microphones is specially calibrated using Brüel & Kjær Primary Standard Microphones as reference and the open-circuit sensitivities are specified with a resolution of 0,0dB.

The overall sensitivity, S_{MP} , of the microphone cartridge and preamplifier assembly can also be determined using the basic instrumentation set-up shown in Fig. 3. This sensitivity can be expressed in dB re 1V/Pa or as an overall correction factor, K , defined in terms of the calibrated value, S_{MP} :

$$K = -26,00 - S_{MP} \quad [\text{dB}]$$

Electrostatic Actuator Response (Frequency Response)

Fig. 4 shows the instrumentation set-up for recording the electrostatic actuator frequency response of 1" Microphones. The Actuator Voltage Supply WB0736 is designed specifically to produce the voltages necessary to generate the required electrostatic force on the diaphragm of the microphones. Free-field and diffuse field responses can be determined by applying the free-field or diffuse field corrections contained in the Calibration Manual to the obtained actuator response.

Calibration Certificate

An example of a microphone Calibration Certificate is shown in Fig. 5. All essential features of the calibration are fully described, giving contractual evidence of the reliability of the procedures used. The standard microphone used for the comparison measurements is documented together with absolute uncertainties and the conditions under which the calibration took place. In this example, the open-circuit sensitivity of a B & K 1" pressure-response microphone Type 4144 is given in mV/Pa and dB re 1V/Pa and the overall sensitivity of the microphone and preamplifier is expressed in terms of the overall correction factor, K . The lower curve shows the electrostatic actuator response which is measured using the instrumentation shown in Fig. 4. The upper curve is obtained by applying the random incidence corrections for the given microphone type to the actuator response.

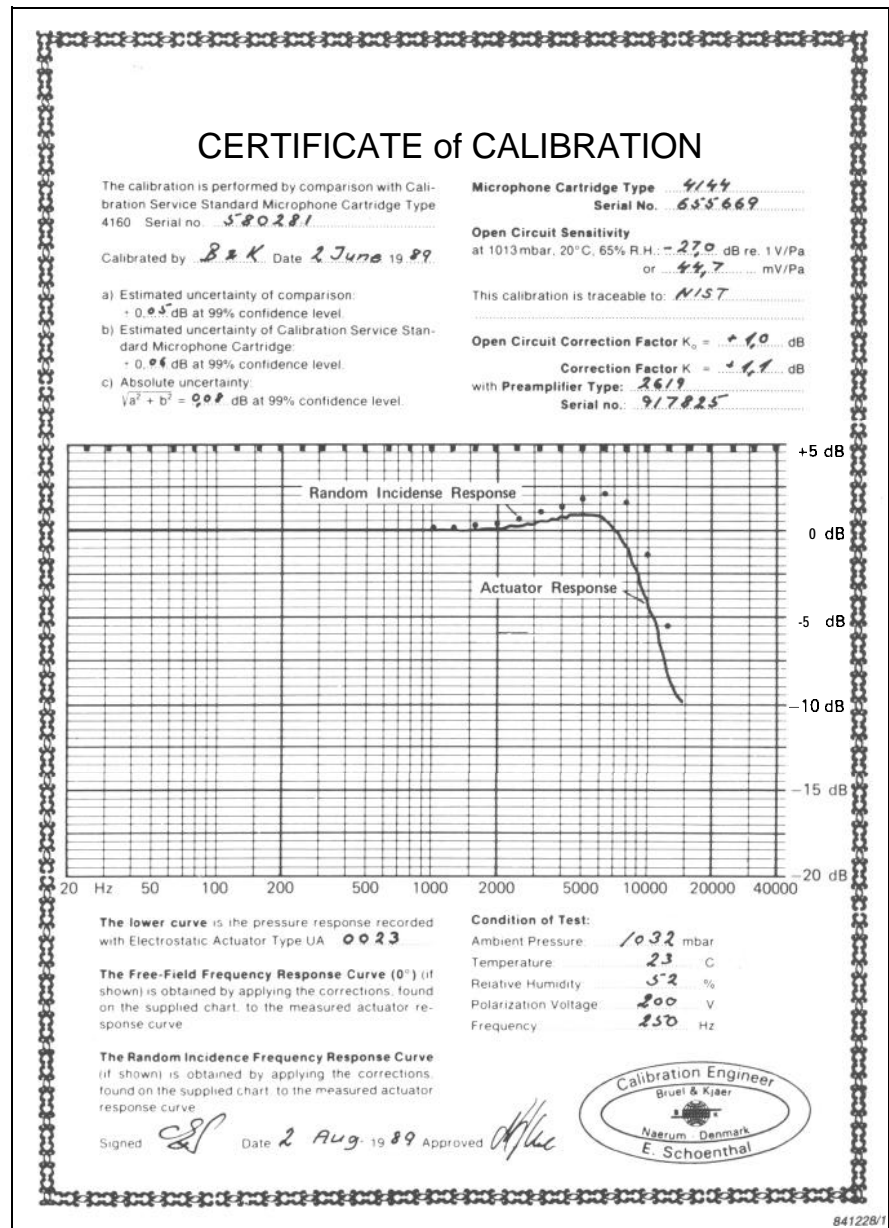


Fig. 5. Example of microphone Certificate of Calibration for a 1" B&K Condenser Microphone Type 4144. The open-circuit sensitivity of the cartridge and the overall sensitivity of microphone and preamplifier assembly are determined using the instrumentation shown in Fig. 3. The instruments shown in Fig. 4 are used for measuring the actuator response, to which random incidence corrections have been applied to obtain the diffuse field response of the microphone. The Calibration Certificate documents all essential details of the calibration, including data on the Primary Standard microphone, absolute uncertainties of the measurements and conditions of test

Calibration of Accelerometers

- 0 Measurement of charge and voltage sensitivities
- 0 Measurement of mounted resonance frequency
- 0 Measurement of total accelerometer capacitance, including cable

Fig. 6 shows the instrumentation set-up for calibration of the charge and voltage sensitivities of Accelerometers. The sensitivities are determined by a comparison measurement based on

Brüel & Kjær Accelerometer Calibration Set Type 3506. This set consists of Standard Accelerometer Type 8305 and Conditioning Amplifier Type 2626 which are calibrated as an integral pair using the laser interferometry method.

The Accelerometer Calibration Set Type 3506 is used as reference. Precision Attenuator WB0566 and Expanded Meter Type 5908 are the key instruments governing the accuracy of

the measurement. The comparison measurement is carried out by mounting the unknown accelerometer onto the standard reference accelerometer on a controlled vibration exciter. Normally a back-to-back configuration is used for the two accelerometers. Both charge and voltage sensitivities are determined at 160Hz.

Measurement of the mounted frequency response through the point of primary resonance is carried-out using Calibration Exciter Type 4290 which is included with Type 9559. Determination of the total accelerometer capacitance including cable is obtained from the measurements of the charge and voltage sensitivities. The total accelerometer capacitance, C_{ac} , is given by the relationship:

$$C_{ac} = S_{qa} / S_{va} \quad [\text{pF}]$$

where S_{qa} and S_{va} are the charge and voltage sensitivities in pC/ms^{-2} and mV/ms^{-2} respectively.

Calibration Certificates, similar to that shown in Fig. 5 for microphones, are also included for accelerometer calibration. These include text fields for recording all essential data concerning the calibration.

Calibration of Pistonphones

- 0 Measurement of output sound pressure level
- 0 Measurement of calibration frequency
- 0 Measurement of distortion

Fig. 7 shows the instrumentation set-up for calibration of the Output Sound Pressure Level produced by a Pistonphone Type 4220. A special Transducer Assembly Type 9545 has been designed for the Calibration System ensuring the correct effective loading volume of the Pistonphone. The output sound pressure level is determined by a comparison measurement between two Standard Reference Pistonphones and the Pistonphone to be calibrated. Calibration Certificates are included for documenting the calibration.

Calibration Accuracy

The purpose of establishing a Service Centre built-up around B&K Calibration System Type 9559 is to enable highly accurate, traceable calibration of Condenser Microphone Cartridges,

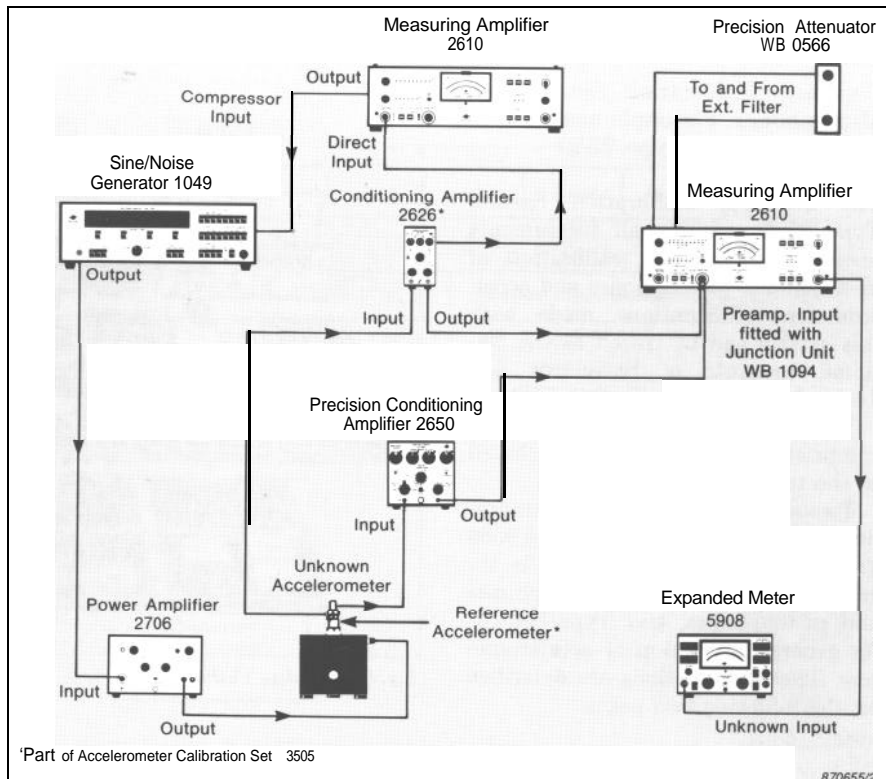


Fig. 6. Calibration of the charge and voltage sensitivities of accelerometers

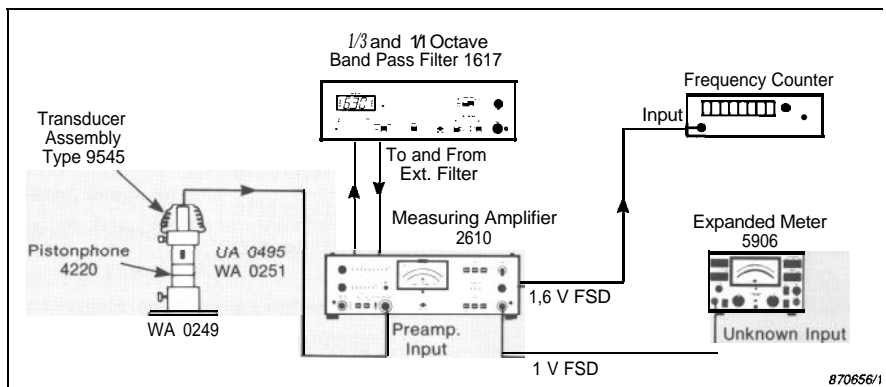


Fig. 7. Calibration of the output sound pressure level of Brüel & Kjær Pistonphone Type 4220

Accelerometer and Acoustical Calibrators to be made, and to issue contractual documentation in the form of Calibration Certificates.

Such a Calibration Laboratory must be equipped for measurements of high accuracy and adequately supervised to maintain the standard of the calibration procedures. Type 9559 is established predominantly in accordance with MIL 45662 A and must be periodically reviewed by a Brüel & Kjær Calibration Engineer to ensure its standard. Calibration of the reference and working standards and the measurement instrumentation must be checked at yearly intervals, normally under the terms of a service contract, by a B&K Calibration Engineer.

Each instrumentation set-up is checked by the verification procedure included with the System, and worksheets are included for recording the various stages of the measurement. The System is delivered with step-by-step instructions, including detailed documentation of the calibration accuracy. The components of inaccuracy are treated in accordance with the methods described in British Calibration Service Guidance Document No. 3003. Calibration accuracy at 99% confidence level is $\pm 0,09\text{dB}$ to $\pm 0,18\text{dB}$ for the various B&K Condenser Microphone cartridges, $\pm 0,10\text{dB}$ for Pistonphone Type 4220 and within 1,2% for the various B&K Accelerometers.

Calibration System Type 9559

Complete Calibration System for Microphones, Pistonphones and accelerometers — Type 9559

The complete Calibration System Type 9559 contains all instruments necessary to perform calibration of microphones, pistonphones and accelerometers. Calibrations made with this system can be traced to the National Institute of Standards and Technology, Washington DC, USA.

The instruments and accessories comprising the 9559 system are listed in the table below.

Two special versions of the comprehensive Calibration System Type 9559 are also available. Type 9604 is for general calibration of microphones and pistonphones, and Type 9605 is for general calibration of accelerometers. These two options are described on the following two pages.

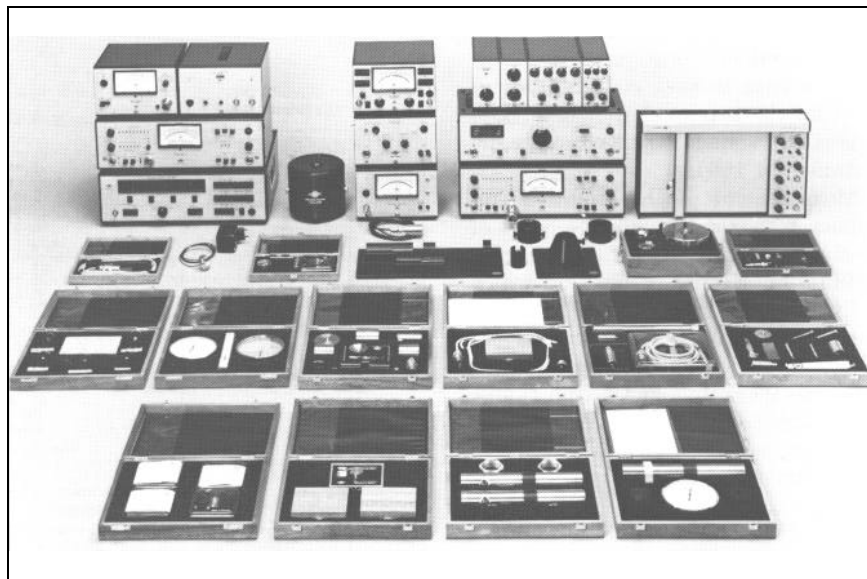


Fig. 8. Complete Calibration System Type 9559

Calibration System Type 9559 consists of both standard production and specially developed Brüel & Kjær instruments as listed below. Instruments marked with an asterisk (*) are supplied with "History-cards".

*Sine/Noise Generator Type 1049	Accessory Kit for calibration of 1/4" and 1/8" MicrophonesType 9582
*1/3- and %-Octave Band Pass FilterType 1617	Accessory KitType 9543
*X-Y RecorderType 2308	"Calibration Service Standard Microphones Type 9544
*Measuring AmplifierType 2610	*Transducer Assembly for 4220 and 4230Type 9545
*Measuring AmplifierType 2610	*Calibration Service Standard Accelerometer Type 9546
*Preamplifier (1/4") Type 2633	Accessory KitType 9554
*Preamplifier (1/2" insert voltage) with 1/2" to 1" Adaptor UA0786Type 2645 S	1 Power Supply for Type 4220WB 0771 or WB 0820
*Precision Conditioning Amplifier 2650/WH 1373	Calibration StampsType 9553
*Power Amplifier Type 2706	Set of Calibration CertificatesType 9557
*Accelerometer Calibration SetType 3506	Set of Calibration WorksheetsType 9558
*Pistonphone4220/WH 1395	Complete set of calibration procedures for 9559, installation on location and one week training course ... WW 4180
*Calibration ExciterType 4290	Cables and adaptors:
"Vibration ExciterType 4809	1 Test Jig WA 0241
*Gigaohm Meter Type 5909	1 Test Jig WA 0249
Attenuator for Type 2308WB 0795	1 Adaptor for 4220 WA 1030
*Precision Attenuator (5 kΩ)WB0566	1 Adaptor for WA0249WA0331
Junction UnitWB 1094	1 Adaptor for 4220 (20 cm ³)WA 0251
*Actuator Voltage Supply WB0736/WH 2211	1 Adaptor for 4220 (40 cm ³)WA 0252
*Polarization Voltage MeterWB0781	2 BNC to BNC Coaxial Cables (3 m)A0 0142
Junction BoxWB 0981	10 BNC to BNC Coaxial Cables (1,2 m) A0 0087
Exciter FixtureWA 0438	3 Accelerometer Cables (1.2 m)A0 0038
*Expanded MeterType 5908	2 Cables with 4 mm "banana" PlugsWL 0878
*Insert Voltage Junction UnitType 9585	5 B & K Input Adaptors for BNC PlugsJP 0144
Weather Station Type 9541	2 BNC Input Adaptors for Miniature Plugs JP 0145
*Calibration Service Standard PistonphonesType 9542	2 BNC "T" Connectors JJ 0152

Calibration System Type 9604

Calibration System for Microphones and Pistonphones – Type 9604

Type 9604 is a system exclusively for general calibration of microphones and pistonphones, and consists of the instruments and accessories listed in the table below.

The 9604 System can be upgraded to a Type 9559 System by adding the extra instruments. As standard the 9604 System is delivered with a Sine/Noise Generator Type 1049 for easy upgrading to a Type 9559 System. However, if it is desired to use the system as a Type 9604 for acoustical measurements only, a Sine Generator Type **1051** may be ordered instead of the Sine/Noise Generator Type 1049.

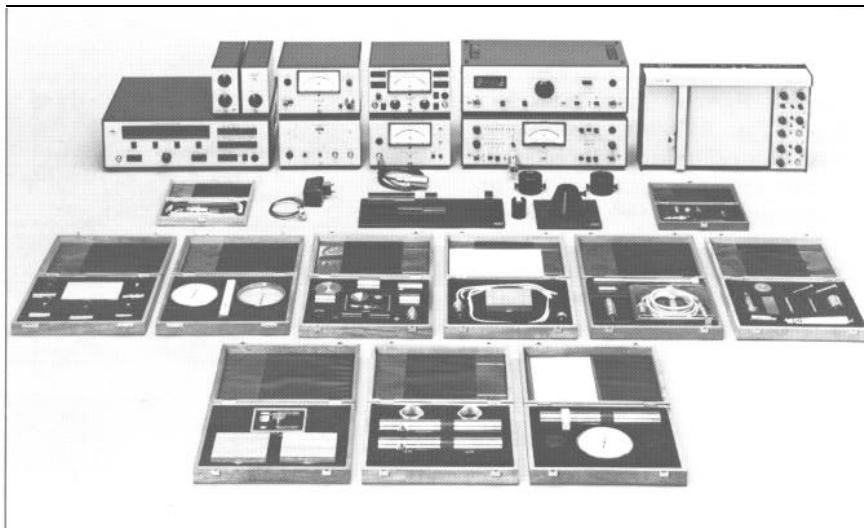


Fig. 9. Calibration System Type 9604 for calibration of microphones and pistonphones

Calibration System Type 9604 with instruments **especially** for calibration of microphones and pistonphones. Instruments marked with an asterisk (*) are supplied with "History-cards".

*Sine/Noise GeneratorType 1049	Junction BoxWB 0981
● % and %-Octave Band Pass FilterType 1617	1 Test JigWA 0241
*X-Y RecorderType 230%	1 Test JigWA0249
*Measuring AmplifierType 2610	1 Power Supply for Type 4220WB 0771 or WB 0820
*Microphone Preamplifier (1/4") Type 2633	1 Calibration Worksheet for microphonesWA0281
*Preamplifier (1/2" insert voltage) with 1/2" to 1" Adaptor UA0786Type 2645 S	1 Calibration Worksheet for pistonphonesWA 0283
*PistonphoneType 4220/WH 1395	Calibration Certificates for microphonesWA 0439
*Expanded MeterType 5908	Calibration Certificates for pistonphonesWA0440
*Gigaohm MeterType 5909	Complete set of calibration procedures for 9604, installation on location and one week training course ... WW4180
Weather StationType 9541	Cables and adaptors:
'Calibration Service Standard PistonphonesType 9542	2 BNC to BNC Coaxial Cables (3 m)A0 0142
Accessory KitType 9543	10 BNC to BNC Coaxial Cables (1.2 m) A0 0087
*Calibration Service Standard MicrophonesType 9544	3 Accelerometer Cables (1,2m)A0 0038
'Transducer Assembly for Types 4220 and 4230 Type 9545	2 Cables with 4mm "banana" PlugsWL0878
Calibration StampsType 9553	5 B & K Input Adaptors for BNC PlugsJP0144
Accessory KitType 9554	2 BNC Input Adaptors for Miniature Plugs JP 0145
Accessory Kit, for calibration of 1/4" and 1/8" MicrophonesType 9582	2 BNC "T" ConnectorsJJ 0152
'Insert Voltage Junction UnitType 9585	1 Adaptor for Type 4220WA 1030
Attenuator for Type 2308WB0795	1 Adaptor for WA 0249WA 0331
*Precision Attenuator (5 kΩ)WB 0566	1 Adaptor for 4220 (20 cm ³)WA 0251
'Actuator Voltage Supply WB0736/WH 2211	1 Adaptor for 4220 (40 cm ³)WA 0252
'Polarization Voltage MeterWB0781	

Calibration System Type 9605

Calibration System for Accelerometers – Type 9605

Calibration System Type 9605 is a version of Type 9559 with instruments especially for calibration of accelerometers. The system consists of the instruments and accessories listed in the table below.

The 9605 System can be upgraded to a Type 9559 System by adding the extra instruments.

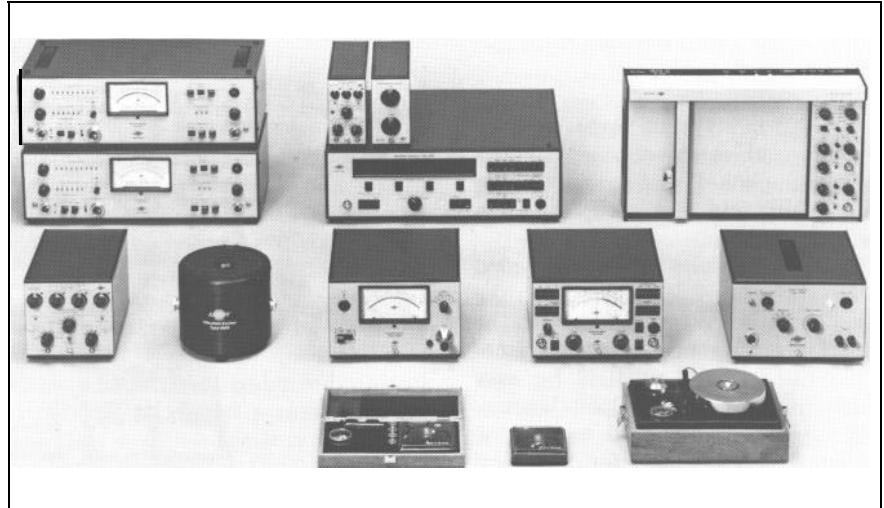


Fig. 10. Calibration System Type 9605 for calibration of accelerometers

Calibration System Type 9605 with instruments especially for calibration of accelerometers. Instruments marked with an asterisk (*) are supplied with "History-cards."

*Sine/Noise GeneratorType 1049	Junction UnitWB1094
*X-Y RecorderType 2308	Exciter FixtureWA0438
*Measuring AmplifierType 2610	Calibration Worksheets for accelerometers WA0282
*Measuring AmplifierType 2610	Calibration Certificates for accelerometersWA 0277
*Precision Conditioning Amplifier Type 2650/WH 1373	Complete set of calibration procedures for 9605, installation on location and one week training course ... WW4180
*Power AmplifierType 2706	Cables and adaptors:
*Accelerometer Calibration SetType 3506	2 BNC to BNC Coaxial Cables (3 m)A00142
*Calibration ExciterType 4290	10 BNC to BNC Coaxial Cables (1 ,2 m) A0 0087
*Vibration ExciterType 4809	3 Accelerometer Cables (1.2 m)A00038
*Expanded MeterType 5908	2 Cables with 4 mm "banana" PlugsWL0878
*Standard Reference AccelerometerType 8305	5 B&K Input Adaptors for BNC Plugs JP0144
*Gigaohm MeterType 5909	2 BNC Input Adaptors for Miniature Plugs JP0145
Syringe with High-vacuum GreaseWA041 7	2 BNC "T" ConnectorsJJ 0152
Attenuator for Type 2308WB0795	
*Precision Attenuator 5 k ΩWB 0566	

These systems are developments of the Brüel & Kjær Systems Engineering Group and are not standard production instruments. Specifications can be modified, on a contract basis, to meet individual requirements. For prices and delivery time, please contact your local representative.

Brüel & Kjær 

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