Application Note

Sound Power Determination according to ISO 9614-2

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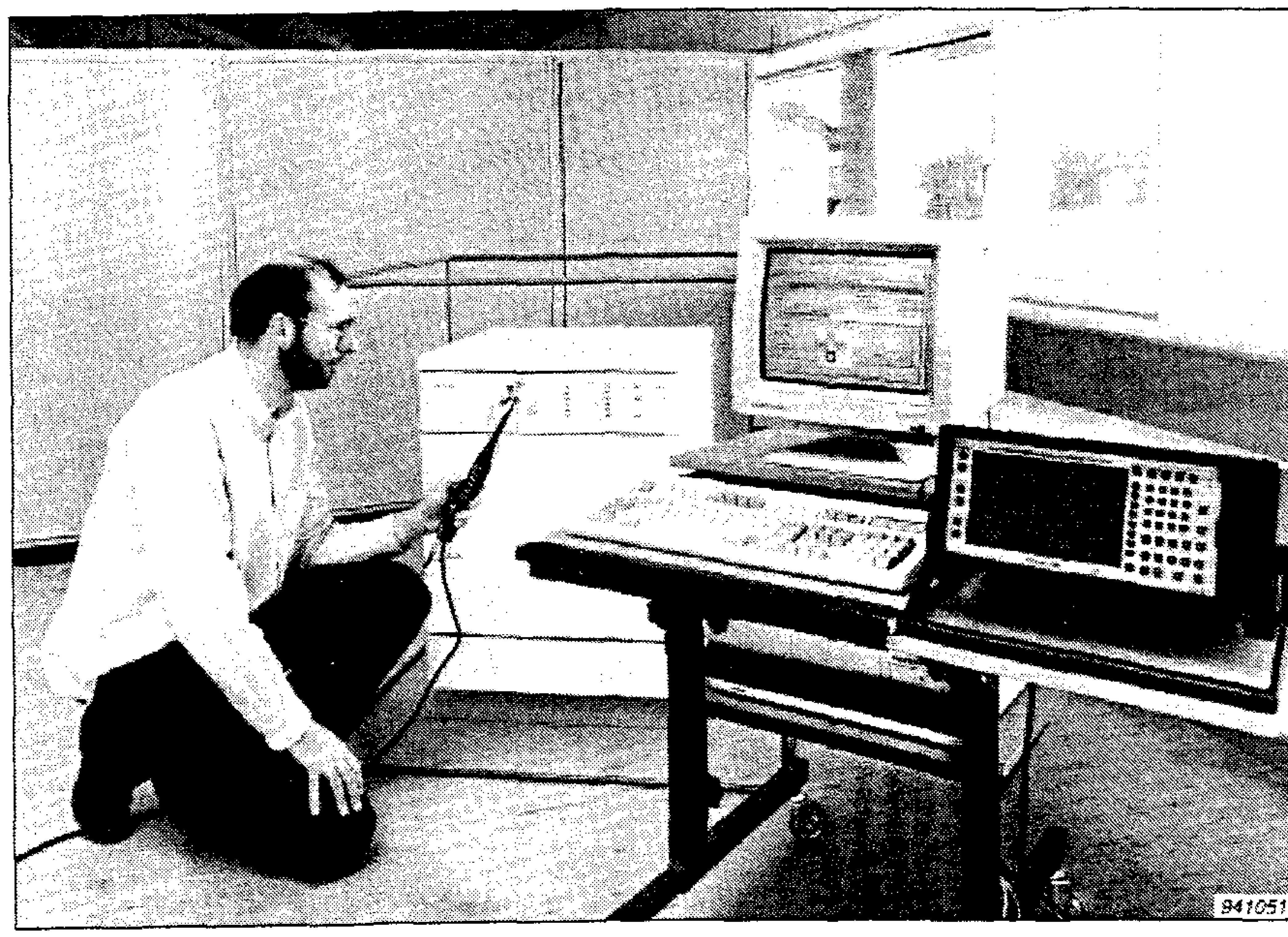
Noise Directives – Machinery
In Europe, a new "Machine Directive" has been written, coming into force from 1/1/95. The purpose of this directive is to ensure the health of people using machines. The directive states, among other things, that all equipment sold in Europe must fulfil specified noise demands. The equipment covered by his directive is everything from toothbrushes, washing machines, office machines and hand-held drills to cars and heavy vehicles.
What should be stated in the instruction manual?
If the A-weighted sound pressure level is below 70 dB(A), this must be indicated (≤ 70 dB(A) re 20μPa). Beyond 70 dB(A), the A-weighted sound pressure level should be stated. If the sound pressure level exceeds 85 dB(A), the A-weighted sound power level should also be stated. If the machine is very big, the sound power level is replaced by the sound pressure level measured at significant positions. If the noise contains peaks exceeding 130 dB(C), this must also be stated.

Note that all sound pressure levels should be measured under "free field" conditions at the typical position of the operators head. If that is not defined, the sound pressure level must be measured at a distance of 1 metre from the surface of the machinery at a hight of 1.6 metres from the floor.



The measurements are done using the Brüel & Kjær Sound Power Program Type 7679, which is dedicated to guide the user through the measurement according to the ISO 9614-2 standard

Introduction

Driven by the new Machine Directive (Council Directive 89/392/EEC), a large number of factories, producers and contractors will begin to make sound power "measurements". For some, these measurements will be their first contact with the acoustic environment.
Sound power is the acoustical energy per time unit, produced by a sound source [Watt].

A sound source radiates power and this results in a sound pressure. Sound power is the cause. Sound pressure is the effect. Consider the following analogy. An electric heater radiates heat into a room and temperature is the effect. The temperature in the room is obviously dependent on the room itself, the insulation, and whether other sources of heat is present. But for the same electrical power input, the heater radiates the same power, no matter what environment it is in. The relationship between sound power and sound pressure is similar. What we hear is sound pressure but it is caused by the sound power emitted from the source.

The sound power can be determined from sound pressure measurements. Unfortunately the influence of the room affects the measurement. A number of international standards (e.g. ISO 3740-46) describes how to perform the measurement and calculate the sound power, as a function of the room.

But the sound power can also be determined from intensity measurements. The method have the advantage, that room and neighbour sound sources does not influence the sound power determination. The disadvantages are the limiting nature of the equipment.

According to the Directive, it is not stated how the measurements should be performed, just that the producer should be kept responsible for the validity of the given specifications.

The purpose of this application note is to show how easily the sound power actually can be determined. For most equipment the ISO 9614-2 standard is suitable to use. It is based on measurements where the sound intensity is continuously measured over a surface. The test object we have chosen is a modern Miele tumbler drier.

The measurements are done using the Brüel & Kjær Sound Power Program Type 7679, which is dedicated to guide the user through the measurement according to the ISO 9614-2 standard.

All measurement results are reproduced with the permission of Miele, Copenhagen.

Running under Windows

To ensure the quality of the sound power determination, the ISO 9614-2 standard prescribes a number of checks (boolean expressions). These checks are calculations, based on the measurements, and they are called Field indicators.

After the introduction of the ISO standard, people have spent a lot of time making advanced spreadsheets or tried to make the calculations by hand. But that is all history now.

Run the Sound Power Program Type 7679 and just let the program guide you through the measurements and mathematically expressions. No need spending hours trying to understand difficult standards. The dedication towards sound power determination makes the program very easy to use, even without reading any manuals.

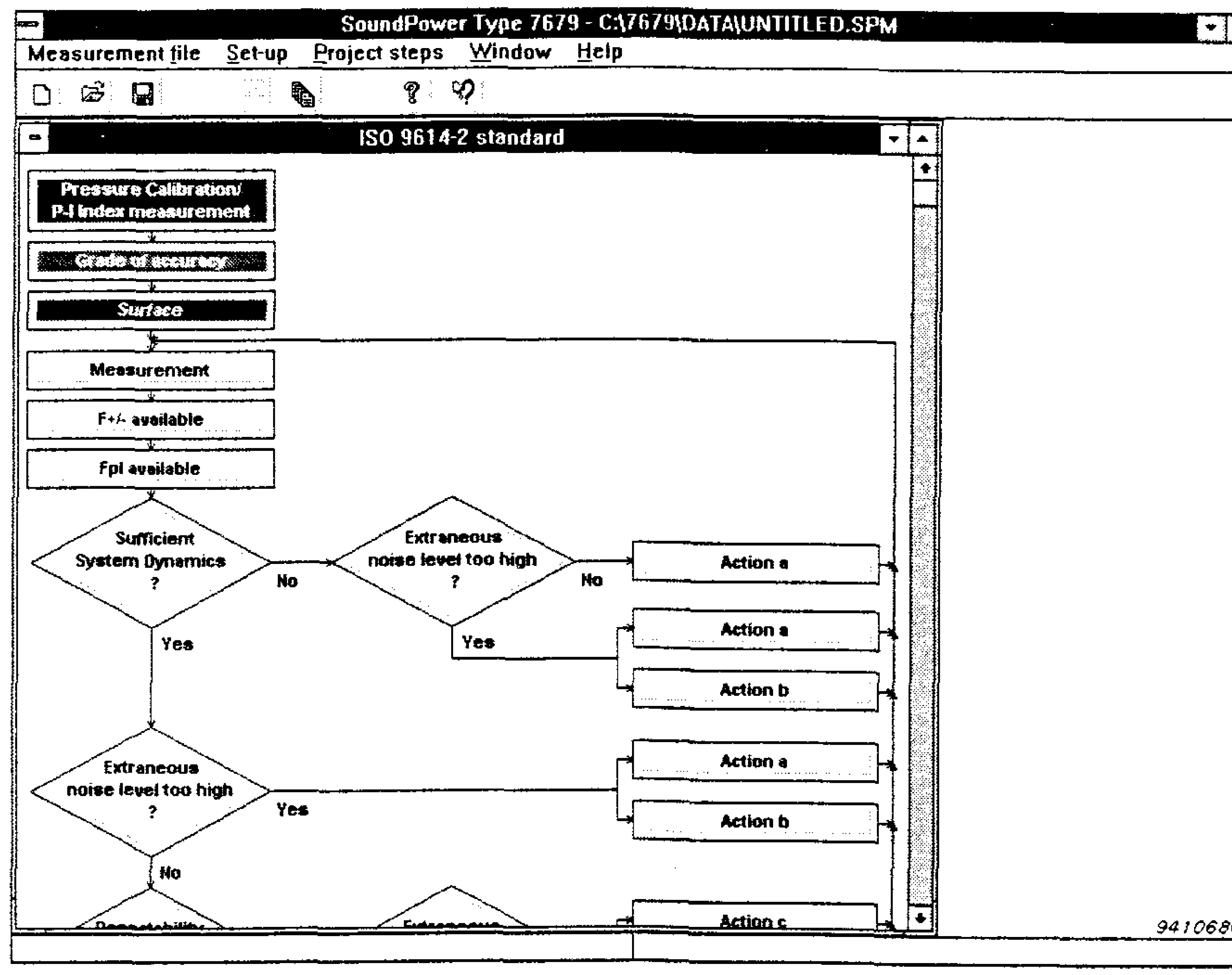


Fig.1. The flow charge makes it easy for the user to perform the measurement according to the ISO 9614-2 Standard

The measurement

Before the measurement can be made, a measurement surface must be defined. This imaginary surface should cover the sound source totally. By measuring over the surface, we make a sort of integration of the sound intensity passing through the surface. The result is the sound power emitted from the sound source. In practice, it is not possible to make a mathematically correct integration of a surface. There exists therefore two major approximations to this problem: The point method (ISO 9614-1) and the scan method (ISO 9614-2). For the scanning, the intensity probe is moved over the surface with a constant speed covering equal areas in equal time.

During the scanning procedure, the intensity probe must all the time be kept perpendicular to the scanned area, and the centre of the microphone spacer should follow the shape of the scanned area.

The scan path should be such that it provides uniform coverage of each segment at a uniform speed, within the range of 0.1 to 0.5 m/s. No partial area should be scanned in less than 20 seconds.

Also note that the ISO 9614-2 standard provides two grades of accuracy:

- Engineering
- Survey

Note that the Survey grade only supports overall A-weighted sound power determination.

For our tumbler drier we choose an arrangement of surfaces that encloses the noise source. This arrangement is here a cubic box of $1 \times 1 \times 1$ m^3.

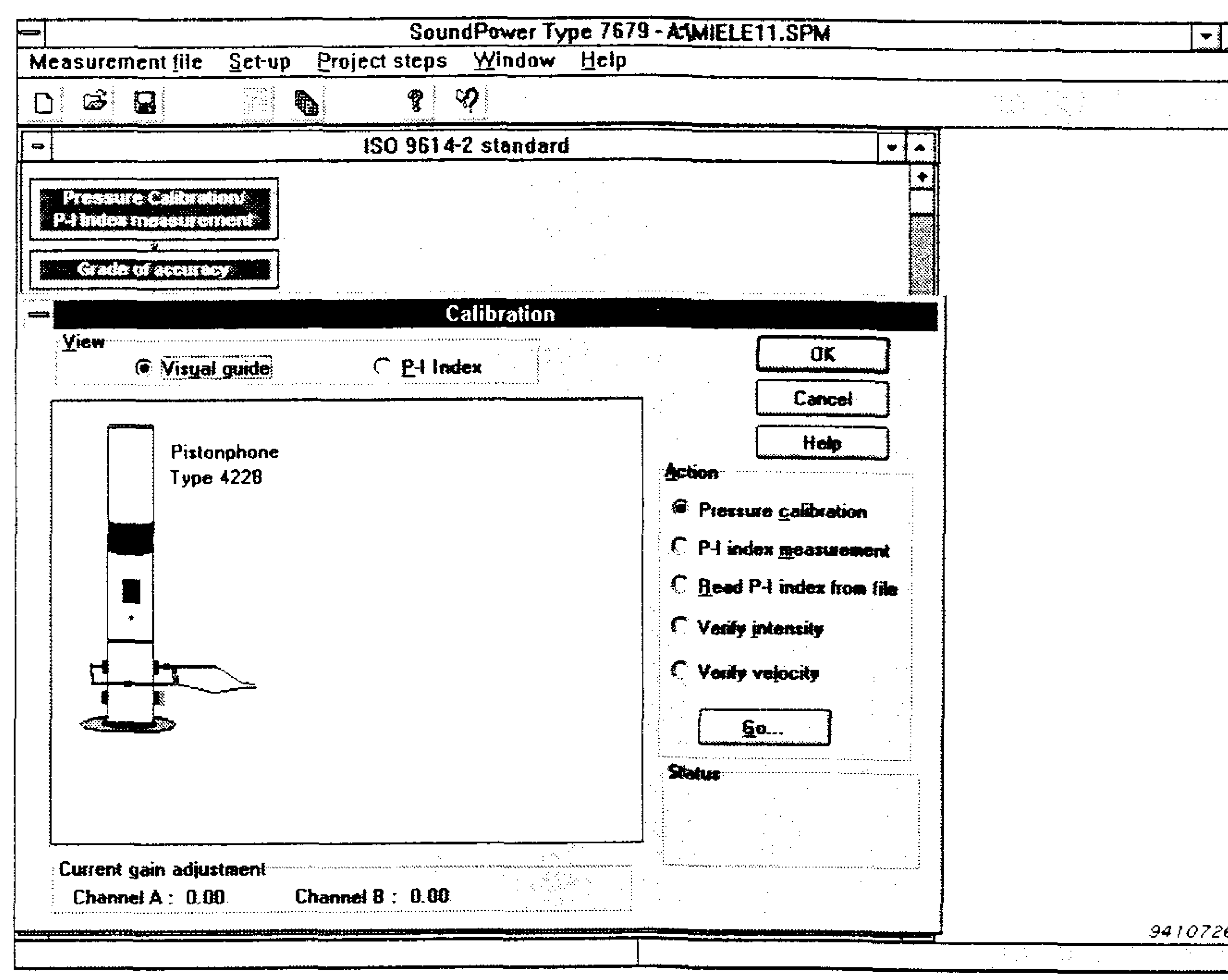


Fig.2. It is no problem to calibrate the equipment. The field in the flow chart turns green when calibration has been compleated correctly

According to the ISO standard, each area/partial subarea shall be scanned twice: vertical and horizontal. If the difference between these two measurements is too large, it means problems reproducing sound power determination (repeatability error). The standard prescribes a doubling of the scan line density, or which in most cases are to be recommended: divide the area into partial areas. But this is exactly the benefit of the Sound Power Program Type 7679, you do not have to consider the actions your self, the program will simply prompt the suggestions/possibilities when they arise.

Because a large area (1 m^2) is much more difficult to scan uniformly than a smaller one (e.g. 0.25 m^2), we begin dividing each side of the cubus into 4 partial areas. That means we have to scan two times 20 partial areas, 40 measurements all together.

The result of the measurement is illustrated in Fig. 4.

The measurement took only half an hour, calibration and reporting included.

Because the sound power determination can be made so fast, it tempts the operator to perform experimentations. In this case we would like to see the influence of partial areas and shoe-box size.

The measurement was therefore repeated with the same 1 m^3 box, but this time each of the 5 surfaces were not divided into partial areas. The measurement was done quicker this time (only 5 surfaces). It was not possible to fulfil the Engineering grade, because the repeatability was not fulfilled. Because the extraneous noise was low, the standard/software Type 7679 suggested that we increased the distance to the noise source. A new shoe-box was created of $2 \times 2 \times 1.5$ m^3, divided into 12 partial areas. And this time the Engineering grade was fulfilled.

According to the machine directive, only the overall A-weighted value is of interest. For our testobject the sound power was:

$$L_W = 69.3 \text{ dB(A) re 1pW}$$

The A-weighted power of all three determinations were within 0.5 dB!

One thing is getting a "good" result, another is knowing the precision of the result. The ISO standard indicates that according to the Engineering grade 2, the standard deviation is 1.5 dB. The standard deviation according to Survey grade 3 is 4 dB.

Regarding the physics of the room or the office assigned for the measurement, one of the main problems which, especially at low frequencies can influence the result, is that a relatively high negative intensity flow and/or standing waves can occur. This is due to reflections from the walls, and can be difficult to get rid of. One way is to move the tumbler drier around in the room, another is to go closer to the noise source, facing near field problems instead.

Extraneous noise problems are often caused, not by any external noise sources, but from the mirrored image of the noise source itself, through one of the walls. Fortunately the Type 7679 program will verify if there are any problems, and the program will prompt a solution to the problem — how to continue.

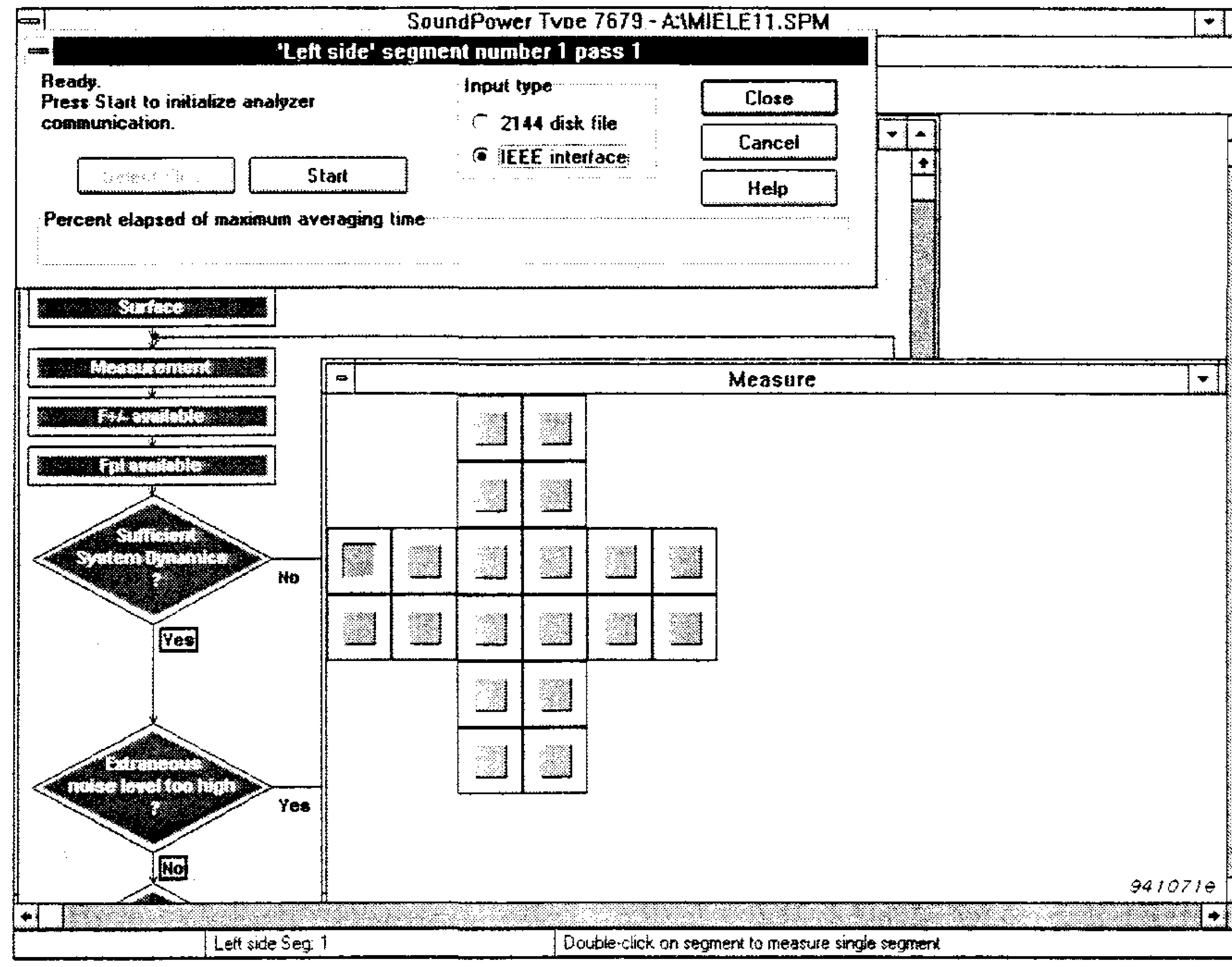


Fig. 3. During a measurement, the sound power program totally controls the analyzer. All important information can easily be seen on the screen, even from a certain distance

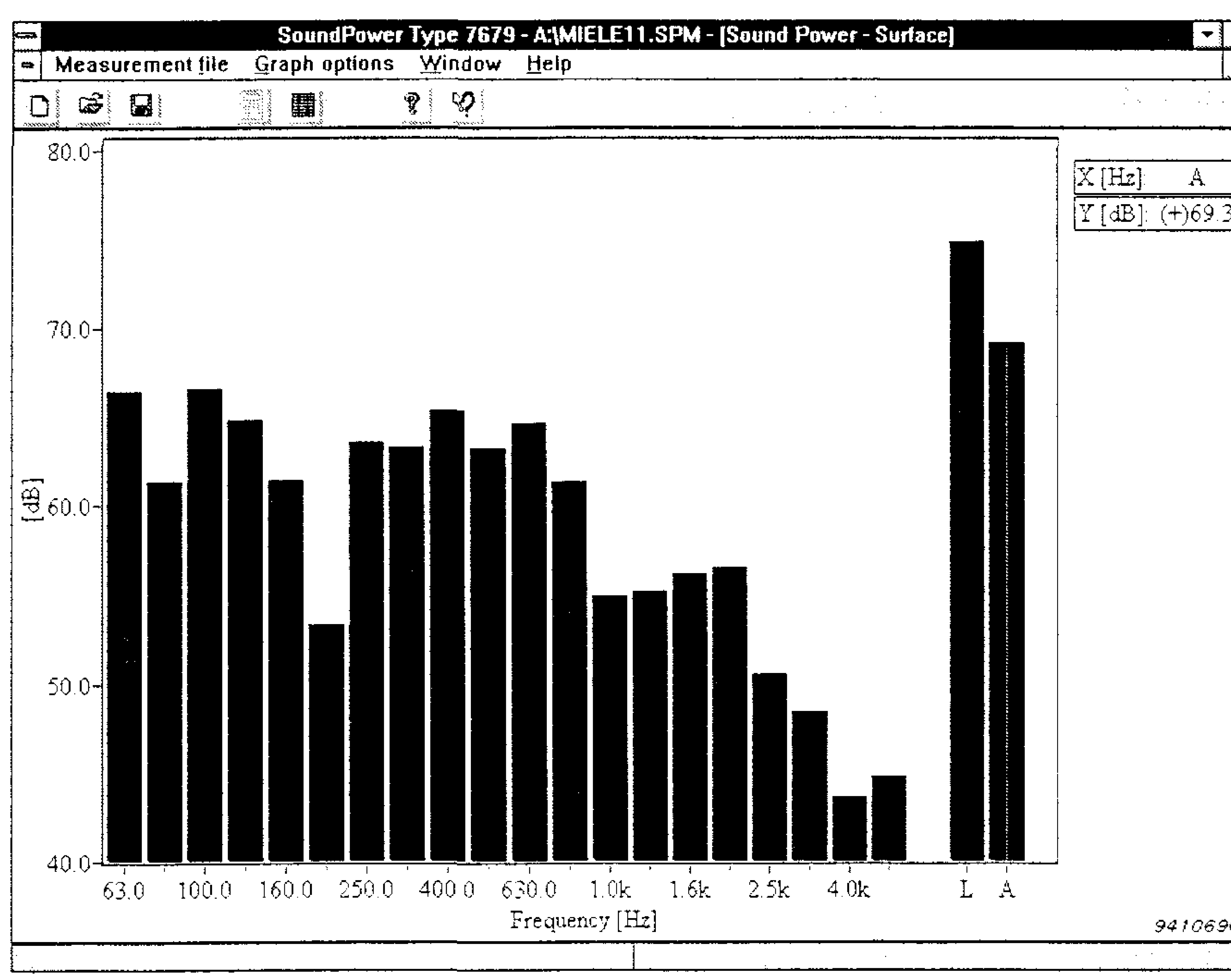


Fig. 4. To fulfil the machine directive, only the A-weighted Sound Power Level is of interest, but the spectrum may give an idea of how to reduce the noise level

Documentation

Most people today have difficulties finding the necessary time to write a comprehensive report about the measurement problem just concluded. To remedy for that, the software Type 7679 includes a "Report Generator". This part of the program enables you to make fast standard reports, even with your own company logo. If you are the "type" who prefers to make a personal report out of a spread sheet or texteditor program —no problems. Data and graphs can easily be exported to any other program running under windows.

Conclusion

By using the Sound Power Program Type 7679, we have determined the sound power according to the ISO 9614-2 standard, fast and efficient.

There is no doubt about that once experienced ISO 9614-1 (point method) people have tried to run this new program, they will be encouraged to measure according to ISO 9614-2 instead. Because the demands, given by the field indicators, are much easier to fulfil, the user will feel that ISO 9614-2 runs much faster.

From the results it appears that our measurement corresponds to the manufactures specifications, which of course also was to be expected.

An important thing that certainly will influence our result, is the measurement conditions. Should the measurements be performed with or without some special reference clothes in the tumble drier, and what about the outlet? Should it be open or should it be connected to a special tube?

But these "environment" problems are not something that producers of tumble driers are facing alone. For various equipment there (might) exists standards describing the measurement conditions. It is recommended always to contact the local standardization organisation. They will inform and supply the standards concerning your equipment.

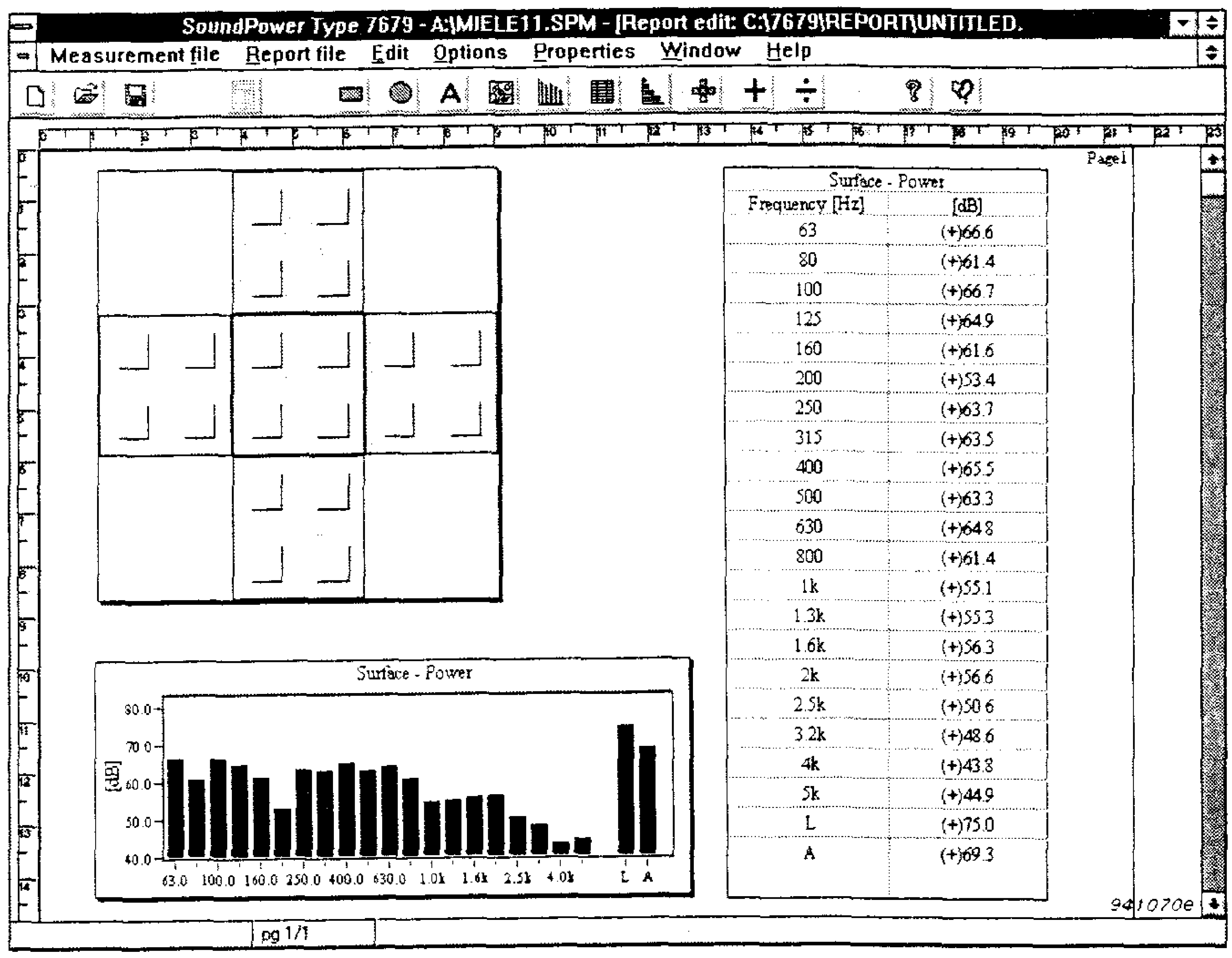


Fig. 4. The included report generator makes a comprehensive report in no time

The machine directive

According to the machine directive, only overall A-weighted values are of interest. But the machine directive does not indicate how the results should be obtained. For most people it is important that their measurements are made according to an international standard. That gives a sort of security. What the manufacture should state in his instruction manual depends of the A-weighted sound pressure level. The sound pressure level has not been measured, but it can be determined from the sound power level, if we know the acoustical environment. The directive says, that the sound pressure level should be measured in a room without any major reflections (nearly free field conditions).

A normal assumption for this is to regard the tumble drier as a point source. The emitted energy from a point source will be equally distributed over a hemisphere. And this allow us to the following conclusion:
We need to know the sound pressure level in free-field conditions 1 meter from the surface of the tumble drier (1.3 m from the centre), and 1.6 meter above the floor. The distance from "operators position of head" is then 2.06 meter from the centre of the tumbler drier. We therefore subtract the number of dBs corresponding to the area of a hemisphere 2.06 meter radius:
$10\text{Log}(2\pi r^2) = 14.3$ dB.

The sound pressure level is then:
69.3 dB(A) – 14.3 dB = 55.0 dB(A)
According to the machine directive, the manufacturer, only have to state that their tumbler drier is "low noise" ($L_p \leq 70$ dB(A) re 20μPa). But as a competitive parameter for the future, it might be a good idea to state the sound pressure level (at 2 m) and/or the sound power level:

L_p:	**56 dB(A) re 20μPa**
L_W:	**70 dB(A) re 1pW**

which corresponds to the manufacturer's specifications.

Instrumentation

To perform the sound power determination, the following Brüel & Kjær equipment has been used:

- Type 3562 Complete Sound Power System contains:
  - Type 2144 Analyzer
  - Type 3548 Sound Intensity Probe
  - Type 3541 Sound Intensity Calibrator
  - Sound Power Program Type 7679
- PC/MS-DOS computer running Windows 3.1
- National Instrument GPIB card
- IEEE – cable, e.g. AO 0265

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