SINCE publication of the "Recommendations for Standardization of Leads and Specifications for Instruments in Electrocardiography and Vectorcardiography" by the American Heart Association in 1967,1 many manufacturers of electrocardiographs have made major efforts to modify their instruments in order to meet the new and tighter standards. According to some estimates, hundreds of thousands of dollars have been spent by industry in this retooling effort. As expected, the price of the technically improved recorders had to be raised to some extent. However, a number of ECG manufacturers have not followed suit and have ignored part or all of the more demanding specifications. Due to the lesser production cost, a substantial price difference can exist between those instruments which do meet these specifications and those which do not. Thus, manufacturers of instruments meeting AHA specifications are at a considerable disadvantage competitively.

Informal inquiry into the buying habits of electrocardiographers has shown that only rarely are detailed performance specifications requested. In most cases, the assumption is probably made that all instrument makers manufacture electrocardiographs of equal or comparable performance.

As stated earlier, such an assumption cannot be made for instruments of recent design and even less for equipment that had been in use for some time. Unfortunately, the consequences of inadequate recording equipment are not sufficiently appreciated and are frequently underestimated. Only a few of the most striking distortions shall be listed here. Thus, for example, an inadequate low frequency response, usually resulting in a time constant of less than 3.2 sec, may lead to serious distortions of ST segments and T waves, particularly after large monophasic QRS complexes. Normal ST segments may become depressed and downward sloping, and ST elevations, seen after acute infarcts, may take on almost normal configurations when the time constant is too short. In a sample of tracings on which errors caused by low frequency response problems were studied, approximately 11% of the records had significant ST errors when a time constant of only 0.8 sec was used.2

In the 1967 version of the AHA recommendations, the upper end of the frequency response for direct writers was extended to 100 Hz in order to improve the accuracy of QRS amplitude measurements which may be reduced by a lesser response. When an upper frequency limit of 50 Hz, as recommended in the previous version of AHA recommendations for electrocardiography,3 is used,
amplitude errors of 1 mm or more can be expected in approximately 20% of all records.4

The influence of high and usually unpredictable skin-electrode impedance on leads based on voltage-dividing networks, such as Wilson’s central terminal and most of the newer, corrected lead systems, was recognized. Reports in the literature indicate that skin impedances in the neighborhood of 100,000 ohms are not uncommon. These conditions will inevitably lead to considerable errors in ECG potentials when coupled with voltage dividing networks using resistor values in the range of 10,000 to 50,000 ohms. Therefore, input impedance requirements as seen from the patient leads were specified accordingly in the AHA recommendations. Linearity of response across the full width of the recording paper represents another important requirement for electrocardiographs. Inadequate linearity can cause distortions of considerable amplitude which may seriously influence ECG interpretation in cases with high voltage. Common mode rejection, gain stability, maximum noise level, accuracy of paper speed, and many other requirements were specified in more detail to improve the fidelity of recordings.

Special attention needs to be given to ECG monitoring systems which are in wide use in intensive care units. In normal operation they are meant to serve as gross indicators of ECG abnormalities, and performance of these units is often intentionally degraded to provide “cleaner” tracings. If records for clinical ECG interpretation are desired, these monitor electrocardiographs should not be used because of the excessive distortions which may result. Some units are equipped, however, with a simple switch which allows regular ECG recording without distortion.

What is the electrocardiographer to do now to make certain that his instrument meets all recommended requirements? First, at the time of purchase of new electrocardiographs, he should insist on performance specifications which are in agreement with the AHA recommendations.1 This should be done carefully and in as much detail as possible. Second, he should purchase at the same time a testing device for electrocardiographs similar to the one described in the same recommendations. This simple instrument, consisting of a few resistors and a capacitor, was intended for daily testing of electrocardiographs in order to make sure that they meet at least minimum requirements of frequency response, linearity, input impedance, and common mode rejection. Instruments of this type have been made available recently by several ECG manufacturers. The procedure is simple and can be performed by ECG technicians after minimum training. This simple test should be complemented by more thorough periodic checks by electronic technicians or engineers.

Following such a routine will not only increase the confidence of the user but will also help to avoid errors in interpretation which may be due to faulty equipment performance. Efforts of manufacturers to design better medical instruments need to be supported and helped by more discerning medical customers who truly appreciate the need for more reliable diagnostic tools.

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The "New" Electrocardiographs: A Step Toward Greater Fidelity in Recording
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doi: 10.1161/01.CIR.42.5.771
Circulation is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
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Print ISSN: 0009-7322. Online ISSN: 1524-4539

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