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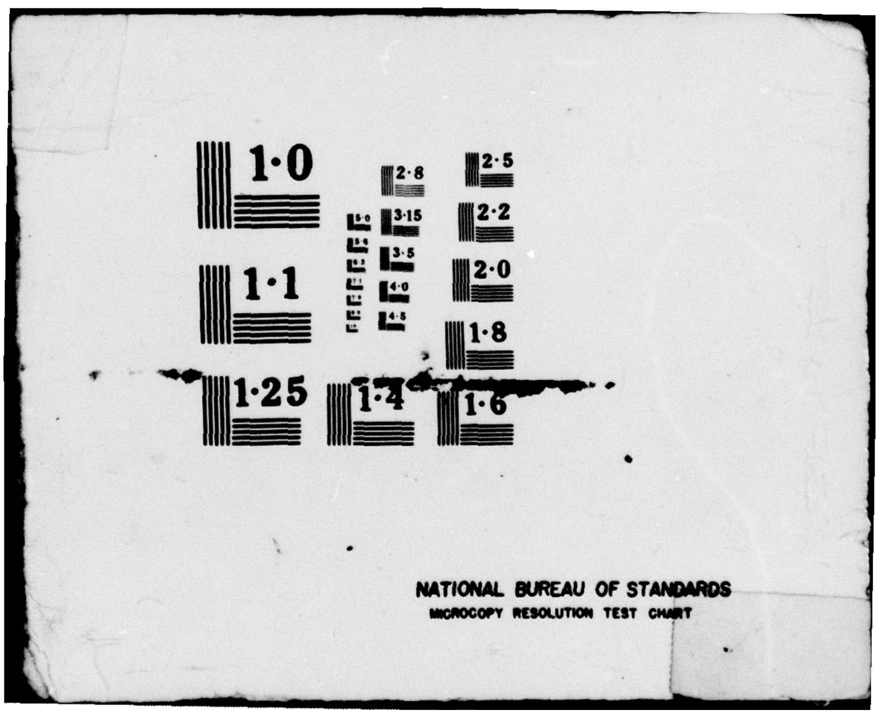
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(6) INVESTIGATION OF NOISE HAZARDS IN THE
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ABSTRACT

Although the sound pressure levels occuring in the engine test cell, CFB Baden-Soellingen, are extremely intense (137 dBA) with a J79 engine running at military power, the attenuation provided by Canadian Forces standard-issue earmuffs is sufficient to reduce the noise at operators' ears to more tolerable levels (108 dBA).

Moreover, the noise doses sustained during engine check-outs permit average work periods of up to 49 minutes per day in the test cell with engines running.

INTRODUCTION

The CF 104 engine test cell at the Canadian Forces Base Baden-Soellingen is housed in a converted Alert Hangar (Building 86B, Figure 1), immediately off the south end of the airfield runway. Improvements to, or replacement of the facility have been under consideration[1], since the installation is not equipped with the mufflers, baffles and diffusers necessary to control the propogation of noise into nearby communities.

The test-cell office and operating cab are separated from the engine test bay by reinforced concrete walls (Figures 2 and 3). However, personnel must spend time beside the test stand as the engine goes through initial runups from idle to maximum power, causing concern over the physiological consequences of exposure to such intense levels of acoustic energy.

It was not thought that these levels exceeded 150 dB, the level considered as the upper limit for whole-body exposure to steady-state noise (Burns, 1968), particularly since such non-auditory manifestations of excessive exposure to noise above 140 dB (e.g., extraordinary fatigue, nausea, disorientation) had not been observed among test-cell crews. However, a detailed investigation of the noise hazard-to-hearing associated with the operation of the test cell was required, and the DCIEM Sonics Section was requested to undertake the study[2]. This was carried out between April 6 and 12th 1979, the results of which are presented in this report.

PROCEDURE AND RESULTS

Overall and octave-band sound pressure levels were measured with a Bruel and Kjaer 2215 Sound Level Meter at a typical operating position beside the engine test stand (see Figure 4). The spectra observed with a J79 engine running at 80 per cent and at military power are shown in Figure 5. The respective A-weighted sound pressure levels were 122 and 137 dBA. Clearly, hearing protection must be worn at all times when personnel are exposed to noise of these intensities.

The one-half inch condenser microphone supplied with the Bruel & Kjaer Sound Level Meter was substituted with a Knowles subminiature electret-condenser microphone, plus an appropriate power conditioning

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1 Aircraft Maintenance and Development Unit (AMDU) Project A711661 (MPO), 5 May 1978.

2 Message 211405Z March 1979 (Surg 205).

circuit (Killion and Carlson, 1974). This microphone is small enough to fit into an ear canal, and the cable connecting the microphone to the meter is sufficiently flat to maintain the acoustic seal of an earmuff worn over an ear fitted with such a microphone (see Figures 6 and 7). In this manner, the sound pressure levels under an earmuff, worn by a person located at Location 4 beside the test stand, were measured directly for the J79 engine running at 80 per cent and at military/power (see Figure 8). The A-weighted sound pressure levels for these two conditions were 97 and 108 dBA respectively. Based on the noise control regulations contained in the Canada Labour Code IV (Revised 1973), daily exposure to the noise produced by the J79 engine on the test stand, for persons wearing SSC 258L earmuffs, should not exceed two hours at 80 per cent power or 30 minutes at military power.

Noise readings from static conditions do not always give a realistic assessment of the hearing-damage potential associated with a given operation. In the case of the test-cell situation, the noise varies over a wide range of intensities as the engine is run from idle to military power with after burner. Moreover, engine technicians move in and out of the most intense noise areas. One method of assessing the actual noise exposure experienced by persons working in noise environments is to equip them with noise dose meters which are worn throughout the normal work period (Rood and Baines, 1976).

A noise dose meter measures the accumulated acoustic energy to which the wearer has been exposed over a given time period (weighted to approximate the damage caused to the ear by energy of varying intensity), usually expressed as a percentage of the maximum allowable noise dose (90 dBA for 8 hours). Thus a 100 per cent dose represents the limit that an individual should sustain over 8 hours and percentages in excess of this represent over exposures.

There is a presumed trading relationship between noise dose and exposure duration. For example, the U.S. Occupational Safety and Health Act (OSHA) and the Canada Labour Code assume a 5-dB trade-off. That is, a noise dose of 90 dBA for eight hours is considered equivalent (in terms of potential hazard to hearing) to 95 dBA for four hours or 100 dBA for two hours etc. Each time the noise dose is increased or decreased by 5 dB, the permitted exposure duration should be halved or doubled.

The International Standards Organization (ISO, 1970) assumes a more conservative 3 dB (equal energy) relationship between dose level and exposure duration. That is, a noise dose of 90 dBA for eight hours is equivalent to 93 dBA for four hours, 96 dBA for two hours, or 99 dBA for one hour etc. It was this more conservative criterion that was used in this investigation.

The noise dose meter was fitted with a Knowles subminiature electret-condenser microphone as described previously, and attached to the wearer's ear-canal entrance. The wearer was instructed to carry out his usual duties, and don and doff earmuffs as he normally would when moving in and out of the noise.

An engine check-out typically lasts from one and one-half to three hours, half of which is required for the transfer of the engine to or from the test stand, connecting fuel and control lines etc. While this is occurring, CF 104 take-offs from either end of the runway produce peak RMS sound pressure levels of about 122 dBA in the test-cell hangar. Take-offs average approximately six or seven per hour and test-cell crews cover their ears as they occur. While the engine is running on the test stand, engine technicians spend at least half of their time in the test cab (Figure 9), where the ambient sound pressure level at military power is 75 dBA, or in the test-cell office (Figure 10) where the ambient sound pressure levels at 80 per cent and military power are 83 and 109 dBA respectively (see Figure 11). Earmuffs are worn in the office whenever an engine is running on the test stand.

The most significant noise exposures therefore occur when personnel are working around the test stand with the engine running. This tends to vary from 15 to 40 minutes per test, depending on the problems encountered with a particular engine.

In this study, personnel wore the noise dose meter during four engine check-outs. Although the meter was worn for the entire check-out, the times during which wearers were in the test cell with the engine running (i.e., the time when the most significant exposure occurred) were carefully clocked.

The percentages of daily allowable noise dose measured during these engine checks are plotted in Figure 12 as a function of the time spent by the wearers in the test cell with the engine running. Not surprisingly, there was considerable variability in noise dose with exposure duration: 31 per cent for 12 minutes, 23 per cent for 17 minutes, 26 per cent for 25 minutes, and 49 per cent for 40 minutes. This was presumably due to the proportion of the exposure time that the engine was running at maximum power, the location of the dosemeter wearer while in the noise, and the effectiveness of the earmuffs worn by the individual in attenuating sound[3].

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3 When standard rim glasses are worn under earmuffs, for example, increased acoustic leakage reduces the attenuation of the muffs by as much as 8 dB (Forshaw and Stairs, 1973).

Of interest in this study was the estimated time that these individuals could remain in the noise until a 100 per cent noise dose was reached. Assuming that the dose samples observed were representative of a complete noise dose, the times required to achieve 100 per cent doses were determined by extending the lines drawn from the origin through the data points to their intersections with the horizontal line representing 100 per cent noise dose.

This procedure yielded duration times of 39, 74, 82 and 96 minutes for 100 per cent doses, as shown in Figure 12. The mean and standard deviation of the four samples were 73 and 24 minutes respectively; the 83rd percentile duration for 100 per cent daily noise dose ($x-\sigma$) was 49 minutes.

CONCLUSIONS

Although the noise levels in the test-cell hangar with an engine running at military power are extremely intense, the attenuation provided by the Safety Supply Company 258L earmuffs, particularly in the octave bands (50 to 2000 Hz) where the most intense J79-engine noise occurs, is sufficient to reduce the noise levels at an operator's ears to more tolerable levels. Moreover, the noise doses sustained during engine check-outs permit average work periods of up to 49 minutes per day in the test cell with engines running.

ACKNOWLEDGMENTS

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4. KILLION, M.C. & CARLSON, E.V. (1974). A subminiature electret-condenser microphone of new design. J. Audio Eng. Soc., 22, 237-243.

5. ROOD, G.M., & BAINES, D.C. (1976). A meter for the measurement of noise dose under circumaural hearing protectors. Royal Aircraft Establishment Technical Memorandum FS96. Farnborough, England.

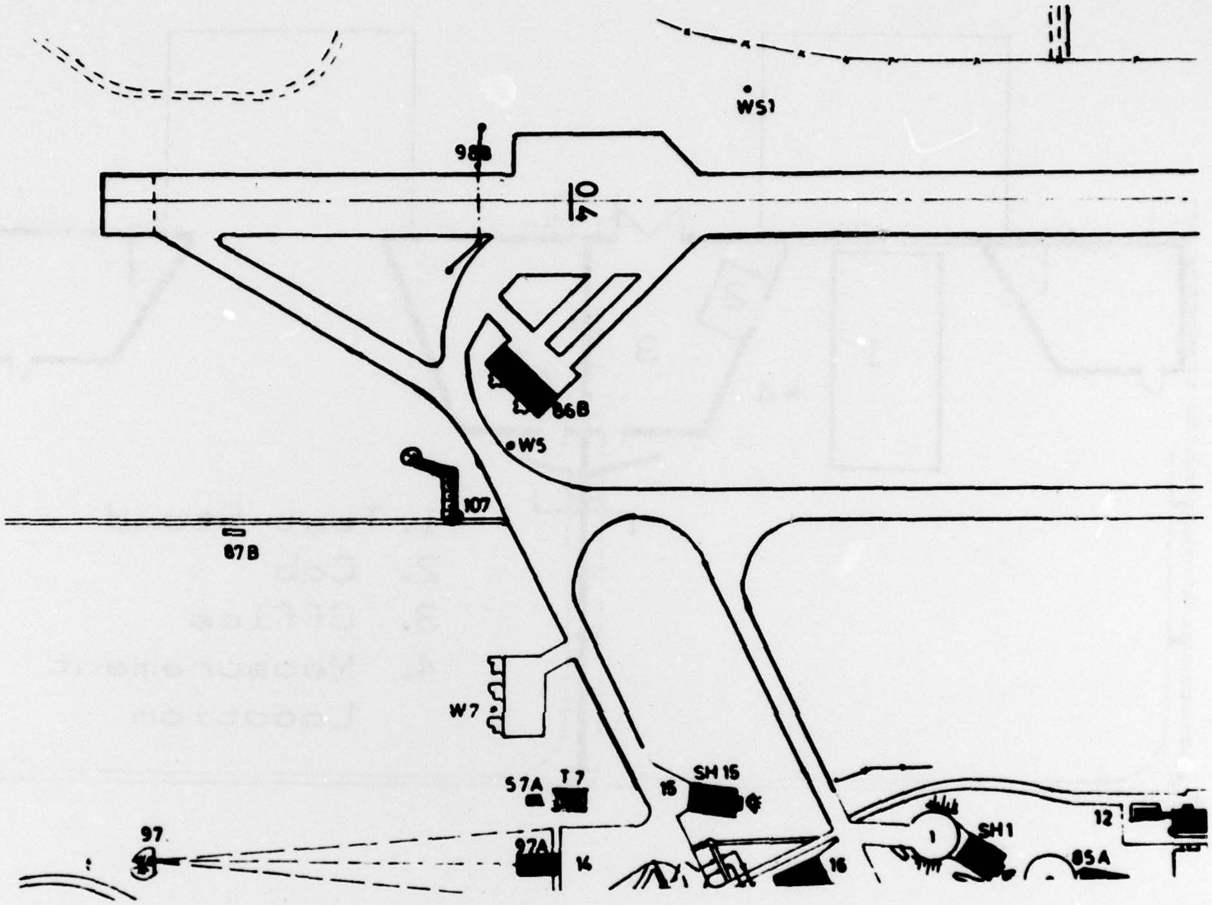

FIGURE 1: South end of Baden-Soellingen airfield showing engine test cell (Bldg 86B).

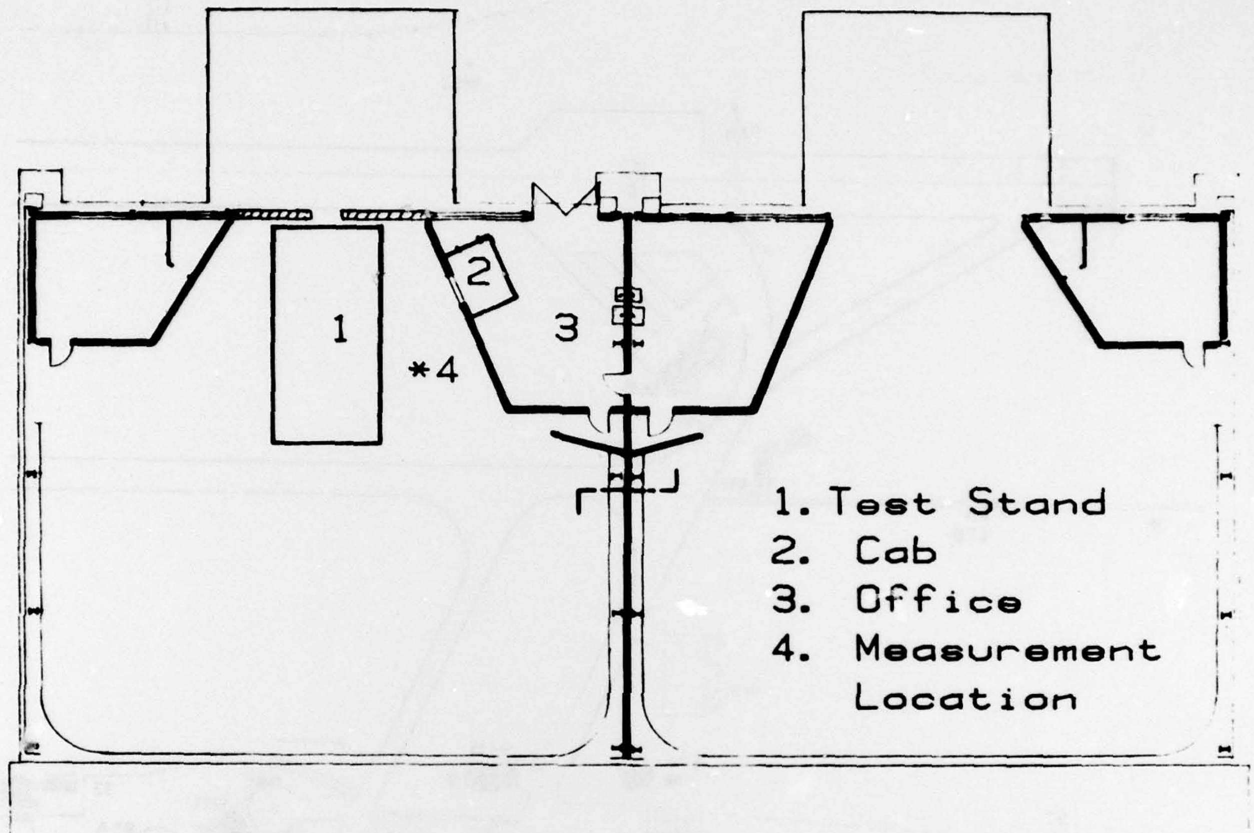

FIGURE 2: Plan of engine test cell hangar.

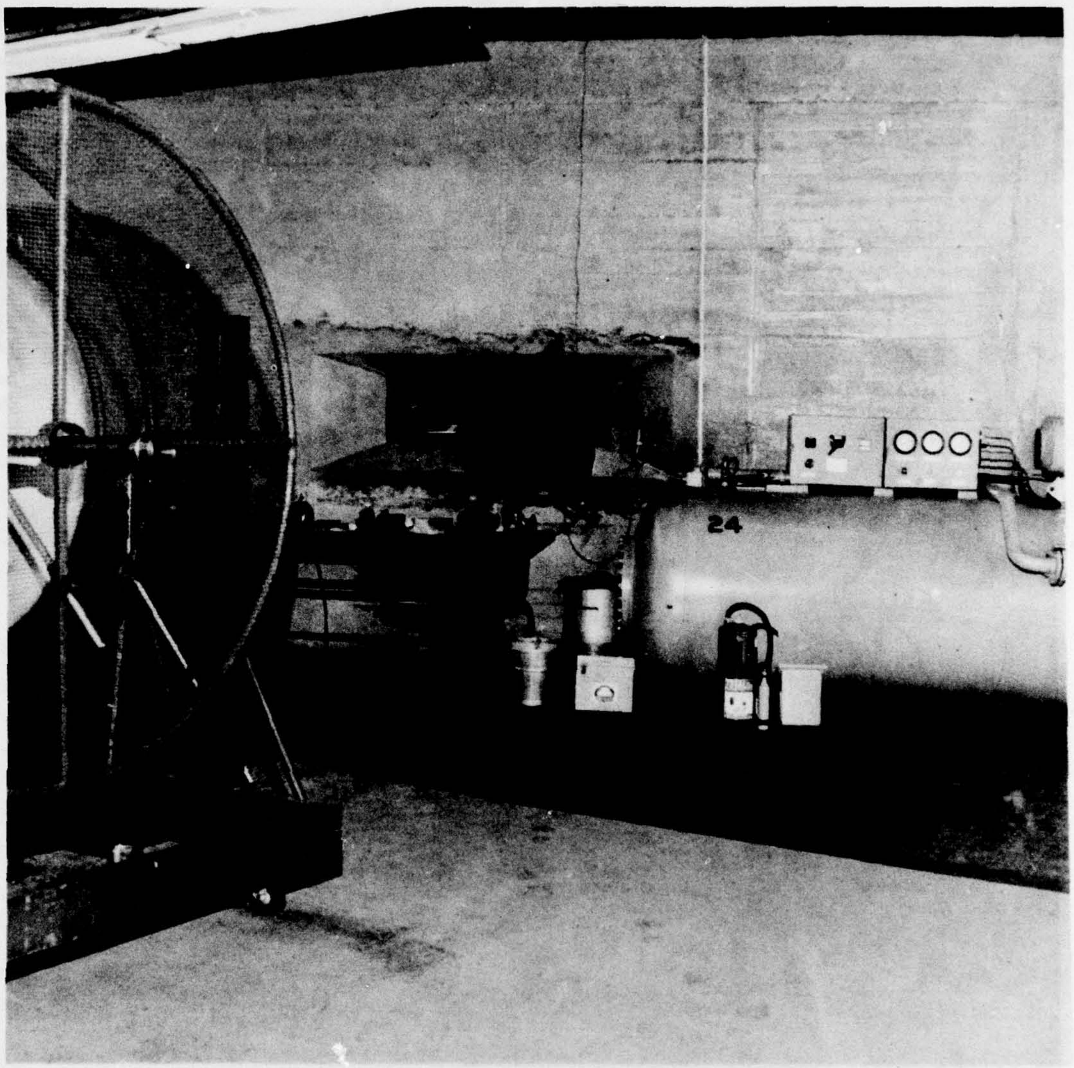

FIGURE 3: Interior of test bay showing concrete wall (with viewing window) separating test cell office and control cab from test bay.

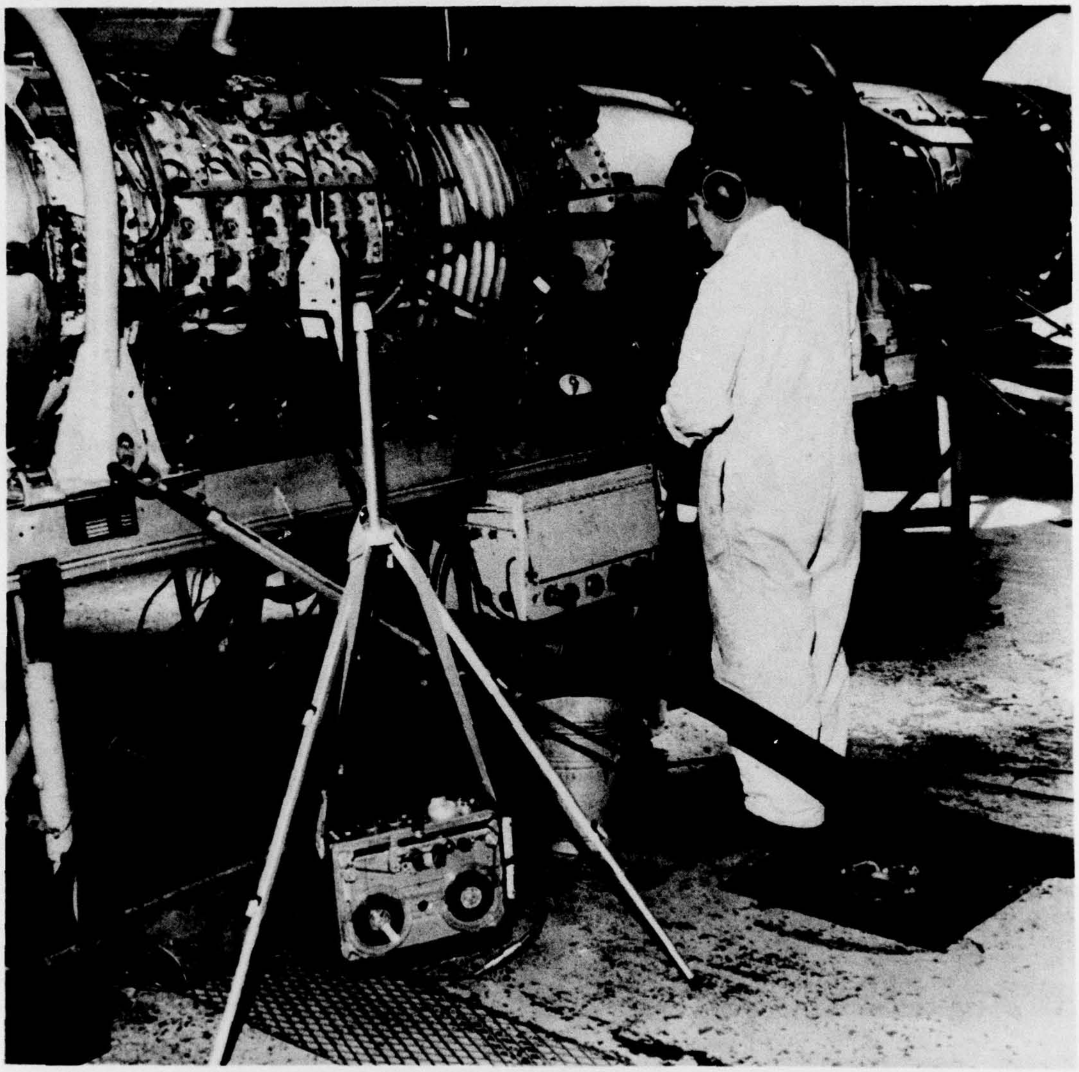

FIGURE 4: Typical operating position beside engine test stand (Location 4, Figure 2), with tripod-mounted B&K 2215 Sound Level Meter and instrumentation recorder in place.

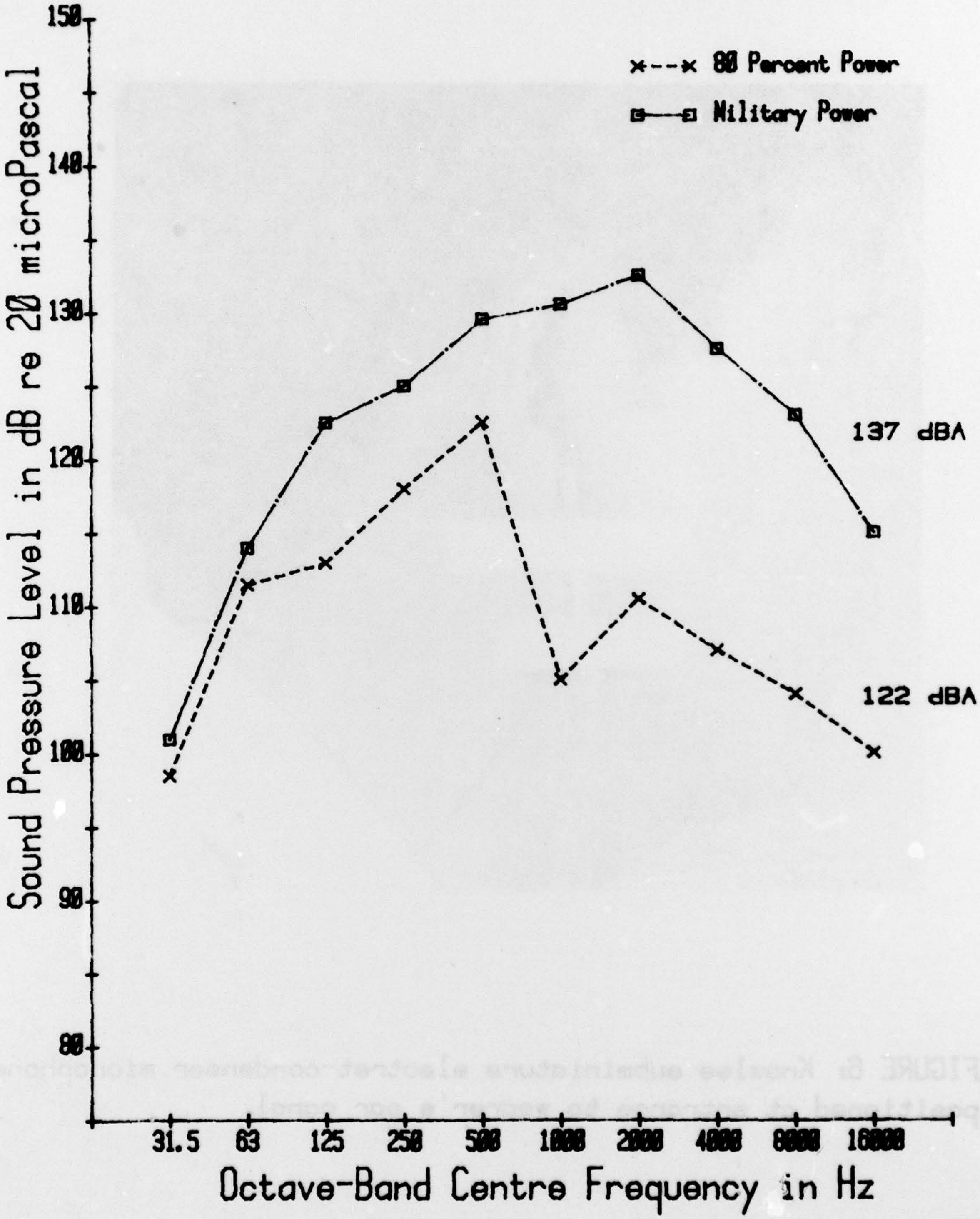

FIGURE 5: Octave-band sound pressure levels at typical operating position beside engine test stand for two power settings.

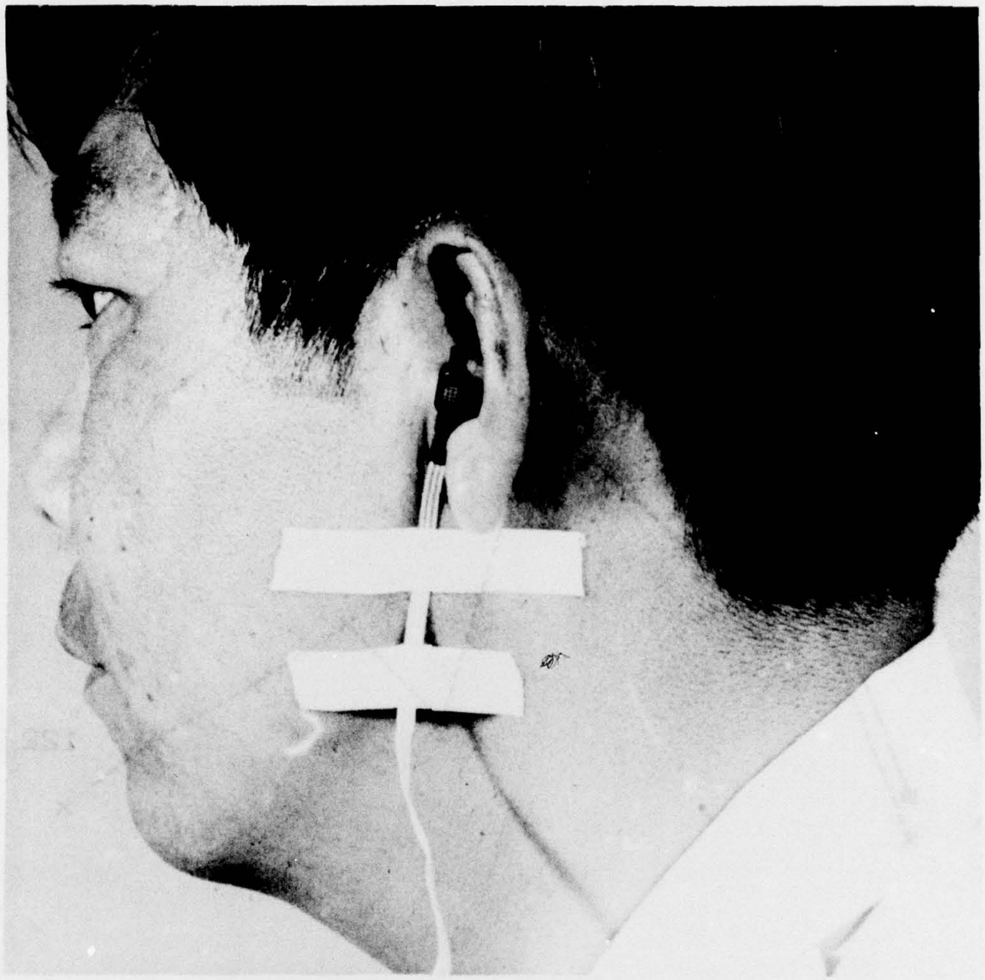

FIGURE 6: Knowles subminiature electret-condenser microphone positioned at entrance to wearer's ear canal.

FIGURE 7: Safety Supply Company 258L earmuff over the subminiature electret-condenser microphone.

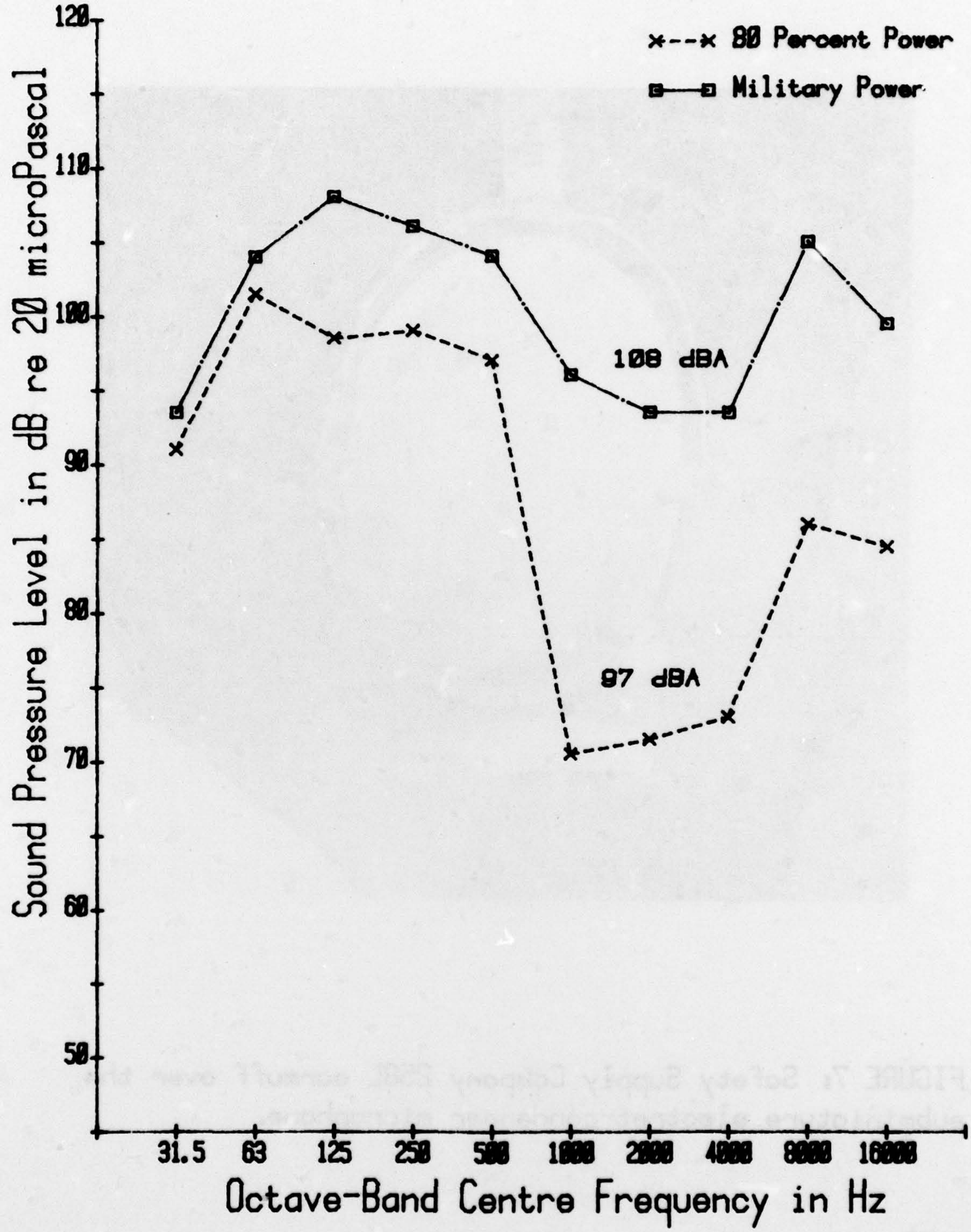

FIGURE 8: Octave-band sound pressure levels under the earmuff of operator at typical position beside engine test stand for two power settings.

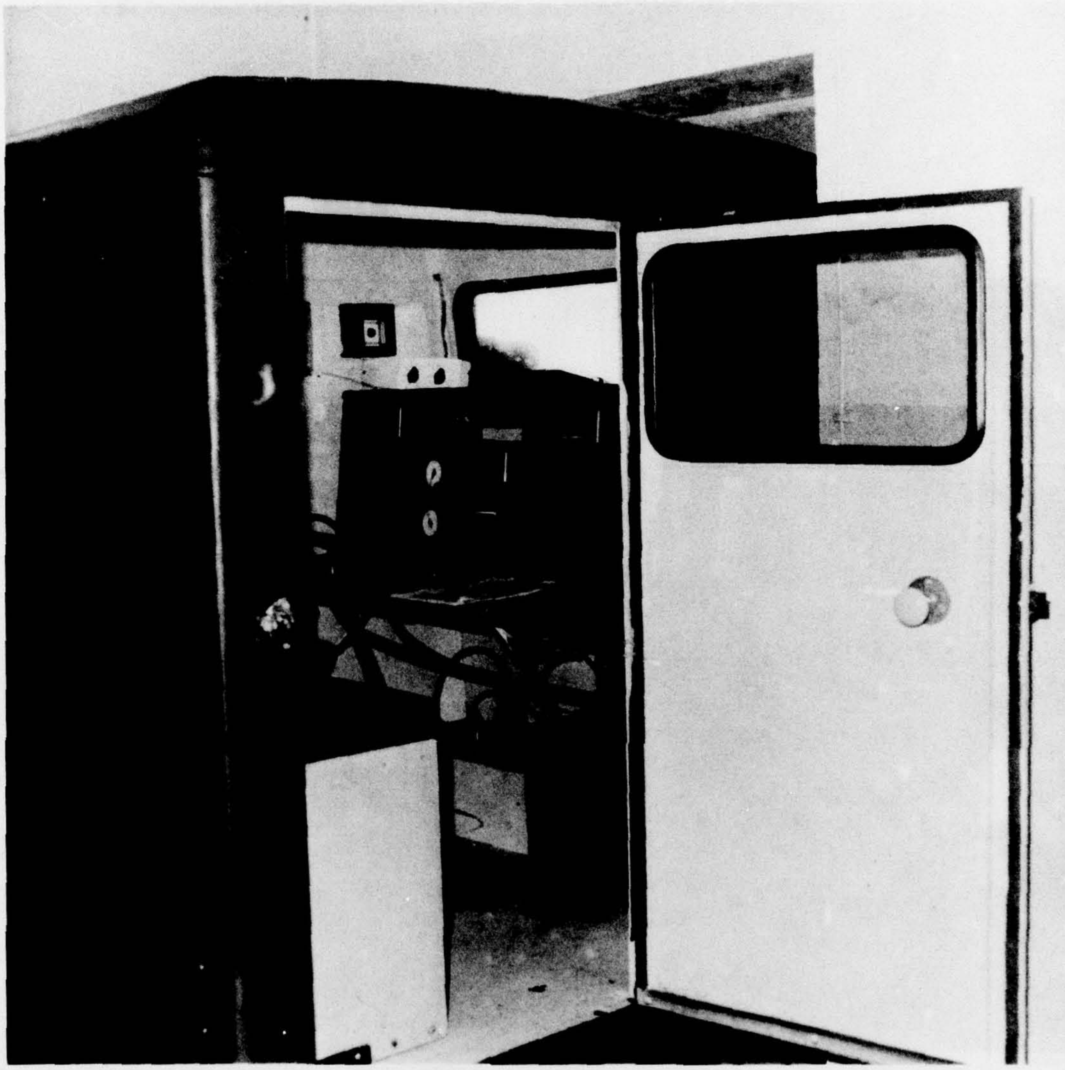

FIGURE 9: AMDU 1200K Operating Cab.

FIGURE 10: Interior of test-cell office with AMDU Operating Cab to the left.

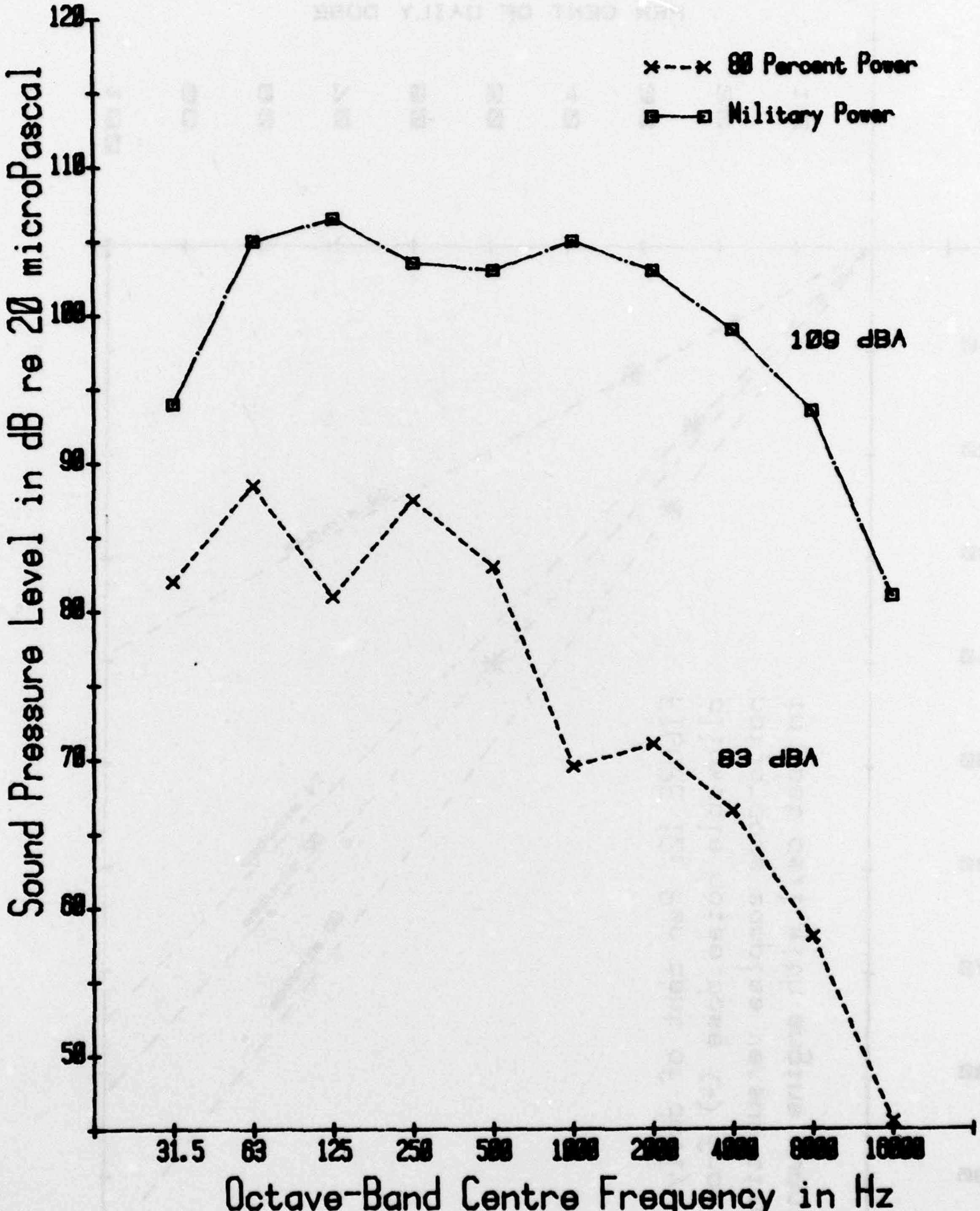

FIGURE 11: Octave-band sound pressure levels in the test-cell office for two power settings of the J79 engine running on test stand.

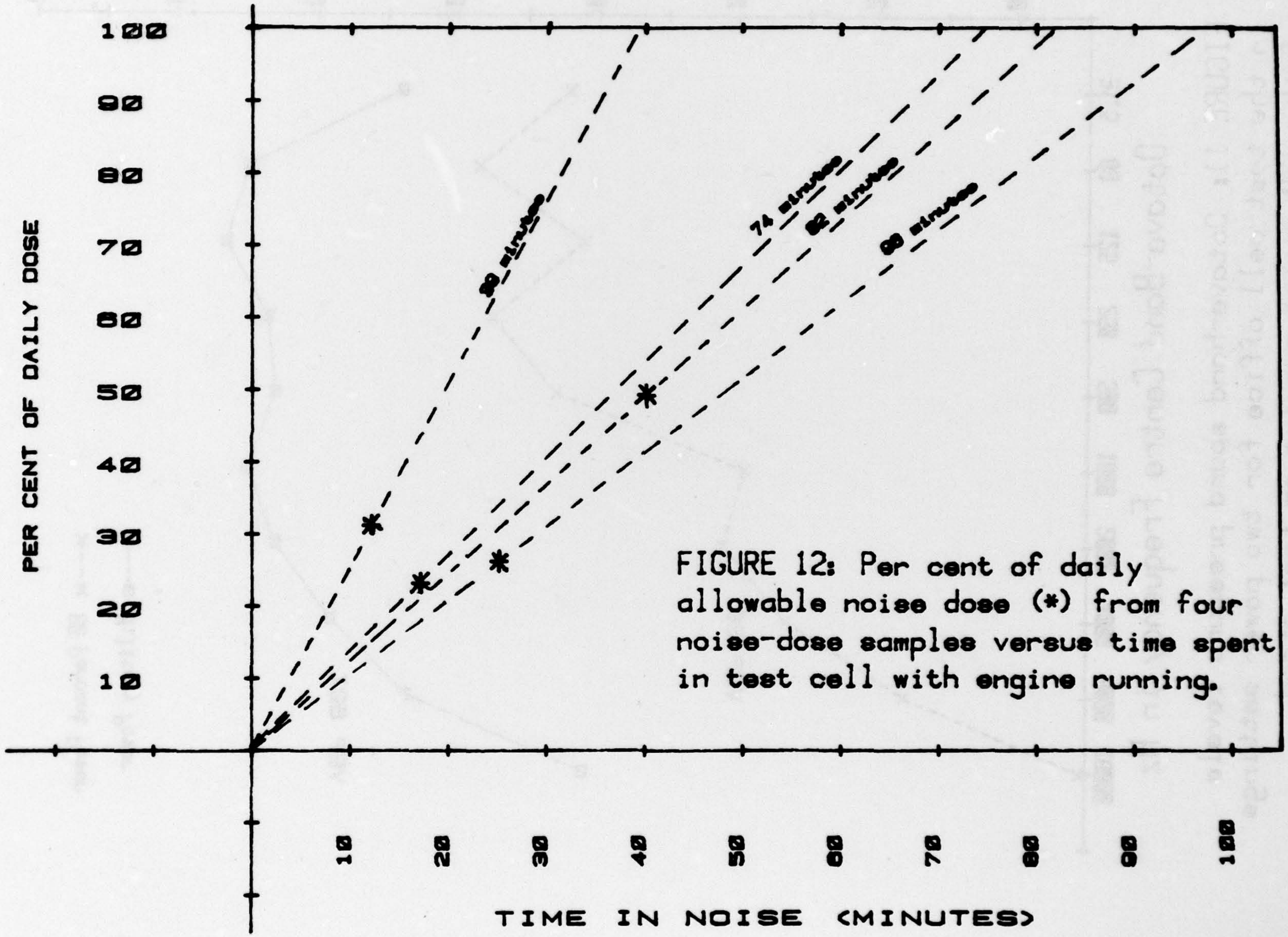

FIGURE 12: Per cent of daily allowable noise dose (*) from four noise-dose samples versus time spent in test cell with engine running.