Assessment of the Noise Exposure of Call Centre Operators

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Call centres now play a major role in the daily operations of financial, technology and utility companies, as well as public bodies. It is predicted that 2002 will see 2.3% of the total British workforce employed in call centres. However, local authority enforcement officers, unions, voluntary organizations, employers and employees have all expressed concern that there are hazards to health and safety unique to this new and developing industry. One of the potential hazards reported in the press is hearing damage from using headsets. In a Health & Safety Executive funded project, the noise exposure of 150 call centre operators was evaluated, in call centres which included financial services, home shopping and telecommunications services. The results show that the daily personal noise exposure of these call centre operators is unlikely to exceed the 85 dB(A) action level defined in the Noise at Work Regulations 1989. The risk of hearing damage is therefore extremely low. Exposure to higher noise levels is possible, for example from fax tones, holding tones and high pitched tones from mobile phones. However, the duration of these events is likely to be short and they are therefore unlikely to have a significant effect on the operators’ overall noise exposure. A practical method of limiting exposure to unexpected high noises from headsets is to ensure that the headsets incorporate acoustic shock protection that meets the requirements of the Department of Trade and Industry specification 85/013. In the UK, this limiter ensures any noise above 118 dB is not transmitted through the headset. Operators should receive regular training on the headset and telephone equipment they are using. This training should include correct use of the headset and the volume control facilities, and advice on how and when to clean and maintain the headsets.

Keywords: acoustic shock; call centres; headsets; hearing damage; noise exposure

INTRODUCTION

Call centres are one of Britain's fastest growing industries as increasing importance is being placed on customer services. They now play a major role in the daily operations of financial, technology and utility companies, as well as public bodies. The Trade Union Congress (TUC) publication *It's Your Call* (TUC, 2001) concluded that although estimates of the number of call centres and numbers employed vary widely, even conservative figures suggest that there are >400000 full-time equivalent jobs. This is more than exist in the textile and clothing industry and more than the combined workforce of coal mining, steel and vehicle production. In 2001, call centres accounted for 1.8% of all employment in the UK. Predictions are that 2002 will see 2.3% of the UK working population employed in up to 5050 call centres. Almost all of these jobs have been created in the last 10 yr. Local authority enforcement officers, unions, voluntary organizations, employers and employees have all expressed concern that there are hazards to health and safety unique to this new and developing industry.

The lack of reliable and relevant information on the hazards and level of risk associated with working in call centres prompted the Health & Safety Executive (HSE) to commission two pieces of research, both carried out by the Health and Safety Laboratory (HSL). In one project, the physical and psychological health risks of call centre working practices were examined and factors that could reduce these hazards were identified. The findings were published in Local Authority Circular 94/1 (rev) (HSE, 2001). In the second project, the noise exposure of call centre oper-
ators was assessed because one of the health hazards specifically linked with the call centre industry is the risk of hearing damage from using headsets. The results of this second project are reported here.

MATERIALS AND METHODS

The HSL study consisted of 15 visits to a range of different call centres. At each call centre, the following information was obtained to enable an assessment to be made of the noise exposure of call centre operators:

- background noise levels;
- noise levels generated by the headsets;
- information on typical working patterns.

Background noise levels

The background noise levels in each call centre were monitored for between 4 and 5 h using four Cirrus 701 dosemeters. The dosemeters were positioned throughout the call centre to give a representative sample of typical background noise levels.

Noise exposure from headsets

The main source of noise exposure for call centre operators is likely to be through their headsets. Users of headsets are protected by the Noise at Work Regulations 1989 (HSE, 1989), however, it is difficult to apply existing guidelines to measurements of noise exposure from headsets. In the HSL study, the noise levels produced by the headsets were measured using the Knowles Electronics Manikin for Acoustic Research (KEMAR), shown in Fig. 1. The KEMAR manikin is a head and torso model with average adult dimensions. It has simulated pinnae (outer part of the ear) that have been designed to give a good acoustic approximation to the average human ear. The small pinnae were used for these measurements. The opening of the ear canal fits onto a Zwislocki ear canal–eardrum simulator with a Brüel & Kjær (B&K) 4134 half-inch pressure response microphone at the eardrum position. Figure 2 shows the ear canal–eardrum simulator fitted inside the KEMAR manikin head. Measurements were only made at the left ear of the KEMAR manikin. The right ear was sealed to prevent sound reaching the microphone through the opening.

The noise levels produced by the headsets were measured within the ear of the KEMAR manikin. However, exposure limits defined in the Noise at Work Regulations 1989 (HSE, 1989) apply to an equivalent level existing outside the ear rather than within the ear itself. An experimentally determined, frequency-dependent transfer function measured by Rice et al. (1987) was used to convert the level measured at the eardrum microphone to the equivalent unobstructed field level. This is the level of a sound field undisturbed by the presence of the manikin, and is referred to as the corrected noise level in this report. Burkhard and Sachs (1975) also published a transfer function they had determined for the

Fig. 1. The KEMAR manikin.
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KEMAR manikin. Comparisons of these transfer functions by Walles (1988) and Lloyd (1992) showed that for speech, both gave comparable results.

At each call centre, measurements were made at the workstations of 10 operators using a spare set of equipment (usually a headset and/or amplifier) which was the same type as that used by the operators. The spare headset and/or amplifier were typically connected into a second socket on the operator’s telephone turret, usually used for training purposes. Where only one headset socket existed, the equipment was connected to a splitter box designed and built by Plantronics, which enabled a second headset to be connected to the single socket on the turret. The two headsets connected to the operator’s turret received exactly the same noise level. Any volume controls were set by the operator to give their normal comfortable listening level. Any changes made to the volume control by the operator during the measurement period were noted.

The spare headset was fitted onto the KEMAR manikin. The microphone at the eardrum position measured the noise levels generated by the headset. Measurements at each workstation were made over a 15 min period.

Other information

The following information was collected at each call centre:

• details about the general call centre environment (e.g. age of call centre, how many workstations, do operators hot-desk, whether it was noisy, etc.);
• details of the equipment used by the operators;
• for each operator whose noise exposure was monitored, their preferred volume control setting, the type of calls typically handled, corrected noise level and the measurement period;
• details of the operators’ work patterns to estimate the duration of their noise exposure.

To ensure consistency of the information collected, a questionnaire was used at each call centre.

There have been reports in the literature of operators being exposed to incidents of acoustic shock. This is defined as a sudden increase in high frequency noise transmitted through a headset. It is usually caused by interference on the telephone line. Each operator who took part in the HSL study was asked whether they had been exposed to very high noise levels through their headset that had resulted in them experiencing pains or ringing in the ears or dulled hearing. They were also asked to identify noise sources they perceived as a nuisance (e.g. the caller’s background noise that was transmitted to the operator through the headset).

RESULTS

The call centres

Noise measurements were made in 15 call centres across the following industry sectors:

• business and other services;
• call centre outsourcing, including inbound and outbound (i.e. telesales) calls;
• public and voluntary;
• financial services (e.g. banks, building societies);
• hotels and leisure;
• retail (e.g. home shopping);
• telecommunications and IT (e.g. directory enquiries, emergency services, fault reporting);
• utilities (e.g. electricity, gas, water).

The call centres that took part in the HSL study varied in size, employing between 70 and 1450 operators. The call centres had been operating from their premises for between 1 month and 16 yr. The older call centres had generally been refurbished within the
last 5 yr and therefore had a similar layout and design to the new centres.

The call centres were generally large open plan rooms with low reverberation; they had carpeted floors and low ceilings (some ceilings were covered with noise-absorbing acoustic tiles). They contained between 36 and 650 workstations. Occupation of these workstations during the measurement visits varied from 20 to 100% (mean occupation 70%). There was 1–3 m between adjacent workstations. None of the operators who took part in these measurements complained that workstations were positioned too close together. Approximately half of the call centres used partitions to separate individual workstations. The partitions were typically fabric covered screens up to 1 m high. Figure 3 shows a modern call centre.

The headsets
The operators used two different designs of headset.

- **Supra-aural headsets.** These have either one or two earpieces with a headband and foam pads that fit against the external ear(s). In the call centres that took part in the HSL study, 85% of the headsets were supra-aural monaural devices (one earpiece) and 10% were supra-aural binaural (two earpieces).

- **Insert (semi-aural) headsets.** These either have small earpieces that are positioned in the concha of the external ear or ear tips that fit into the entrance of the ear canal. Individuals should choose ear tips that fit their particular ear size. Only 5% of the headsets seen in this study were insert monaural devices.

In general, the headsets incorporated acoustic shock protection to limit the output of the headset’s receiver to meet the requirements of the Department of Trade and Industry (DTI) specification 85/013 (DTI, 1989). The headsets were fitted with a voice tube, a boom microphone or a noise cancelling microphone. Headset manufacturers recommend noise cancelling microphones for use in environments where the background noise levels are high.

At all but one call centre, the headsets were issued to individual operators. Where headsets were shared, we observed operators wearing headsets without the foam pads fitted; prolonged use of these resulted in pain and discomfort in and around the ears. The operators removed the foam pads to wear with other headsets because they were concerned about the potential health problems that may occur through sharing headsets.

The headsets were connected either directly to a telephone turret (also referred to as a telephone console), to a telephone turret via an amplifying unit or directly into a computer-based telephone system.

**Amplifying units**

An amplifying unit (also referred to as a universal adaptor) was used at some call centres to connect the headset to the telephone system. It enabled the operator to adjust the incoming calls transmitted through the headset to a comfortable listening level. The...
listening level was generally set using a thumb wheel or slide-switch control. The amplifying unit gave the operator a greater amount of control over the level of the incoming calls and was easy to use. The range of volume adjustments (i.e. the difference between the listening level at the minimum and maximum settings) varied between 18 and 22 dB, depending on the type of amplifying unit. The volume control on the amplifying units was generally set between the mid and maximum positions by the operators.

**Telephone systems**

At 75% of the call centres, the headsets were connected to a turret that had a volume control facility, usually in the form of a toggle switch that the operator could easily adjust. There was just one turret where the volume control feature was not obvious. For this system, the level of the incoming calls was adjusted using a series of keystrokes. The keystrokes were not marked as being associated with the volume control. The operators had not received training on this feature and therefore never used the volume control. The range of volume adjustments (i.e. the difference between the listening level at the minimum and maximum settings) provided by the turrets varied between 4 and 17 dB, depending on the type of telephone system.

At a large proportion of the call centres in this study, the operators set the turret volume at the maximum position. For many operators, the maximum volume gave comfortable listening levels, but many commented that they had difficulty hearing callers when background noise levels were high or if callers were quietly spoken. Ideally, it should be possible to make changes to the telephone system to adjust the range of listening levels available to the operators, while ensuring that the levels are kept below the limits defined in current legislation. For some systems, this was not possible, since the base level of the incoming calls was factory set within the hardware to an industry default. However, the flexibility to make these changes was observed for other systems. Parameters within the software, for example the objective loudness rating which enabled changes to be made to the received level into the turret, could be adjusted locally. Local adjustments were made via system commands that affected all the turrets connected to the system. These changes required technical expertise from the users and suppliers of the telephone system.

Other settings that could be controlled via the software included restoring the operator’s listening level to a default setting (usually mid position) either following every call or each time the operator logged onto the system. This feature would prevent operators listening at a higher level than necessary, which can sometimes happen if the previous caller has been quietly spoken or the operator previously using the workstation has used a higher volume setting.

Of the call centres in the HSL study, 25% used computer-based telephone systems. These systems generally incorporated the most sophisticated volume controls. Upper and lower limits were defined in the software of some systems and the operator was able to vary the level of incoming calls through the headset within this controlled range. These systems enabled the operator to adjust their listening level across a range from 10 to 17 dB depending on the particular system.

Another feature observed for computer-based telephone systems was that the operator could set the volume for received calls to a preferred level, which was stored in their individual profile. This profile, and therefore the preferred listening level, was restored each time the operator logged onto the system. At one call centre using a computer-based system, one of the keyboard keys had been programmed as an emergency mute button. When this key was pressed it immediately reduced the level of the incoming call to minimum. This prevented the operator being exposed to loud noises for long periods.

**Training**

All the call centres in the HSL study provided induction training for new operators. This generally included training on the correct use of headsets, for example placement of the microphone and use of the system’s volume control features. None of the call centres provided regular training after the induction course. Consequently, many of the operators did not change the level of incoming calls because either they had forgotten how to or it did not occur to them to do this, even when there was a need for it. In general, operators were responsible for reporting faulty headsets and at most call centres a replacement headset was issued immediately. The operators were generally not given any advice on how to clean and maintain their headsets. At some call centres, antiseptic wipes and spare foam ear pads were available which operators could use to clean and maintain their headsets, however, operators were generally not aware that these were available.

**Background noise**

The background noise levels in the call centres taking part in the HSL study were between 57 and 66 dB(A) [mean ± standard deviation (SD) 62 ± 2 dB(A)]. The background noise levels were not included in estimates of the operators’ daily personal noise exposures because they were negligible compared to the levels generated by the headsets: the background noise was >10 dB below the corrected noise levels generated by the headsets.
The overall impression during visits to all the call centres was that they were quiet with relatively little disturbance to those making and receiving calls. The main background noise was general conversation with callers and colleagues. Common sources of noise in office environments, e.g. telephones ringing, fax machines and printers, were absent in the call centres. At one call centre, the operators were allowed to listen to their own music, therefore in some areas of the call centre music was an additional source of background noise. However, even with music playing, the background noise levels in this particular call centre were similar to those measured in the other centres.

**Headset noise**

The main source of noise exposure through the headsets was from conversation (speech). During the project, 150 measurements were made of the equivalent unobstructed A-weighted levels (i.e. corrected noise levels) generated by headsets fitted on the KEMAR manikin, with speech as the input signal to the headsets. These corrected noise levels ranged from 65 to 88 dB(A) \([\text{mean} \pm \text{SD} 77 \pm 5 \text{dB(A)}]\). The distribution of these measured noise levels is shown in Fig. 4. Although the measured values spread across a 23 dB range, 70% lay within the mean \(\pm\) one SD, i.e. between 72 and 82 dB(A). Table 1 contains the corrected noise levels generated by the headsets fitted on the KEMAR manikin, when speech was input to the headsets. The results have been collated to give the mean, maximum and minimum values for each industry sector.

In addition to speech, operators received a variety of other noises through their headsets. These included: fax tones, carrier tones used to alert operators of an incoming call, holding tones, holding music. At maximum volume, the corrected noise level was 83 dB(A) for a fax tone, 95 dB(A) for a carrier tone and 88 dB(A) for a holding tone.

![Fig. 4. Distribution of corrected noise levels generated by headsets (speech input to the headsets).](image)

<table>
<thead>
<tr>
<th>Industry sector</th>
<th>No. of samples</th>
<th>Corrected noise levels [dB(A)]</th>
<th>Mean ± SD</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business/other services</td>
<td>11</td>
<td>78 ± 3</td>
<td>70</td>
<td>70</td>
<td>80</td>
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<tr>
<td>Outsourcing</td>
<td>10</td>
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<td>73</td>
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<tr>
<td>Financial</td>
<td>58</td>
<td>79 ± 4</td>
<td>70</td>
<td>86</td>
<td></td>
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<tr>
<td>Leisure</td>
<td>8</td>
<td>76 ± 3</td>
<td>71</td>
<td>80</td>
<td></td>
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<tr>
<td>Public/voluntary</td>
<td>15</td>
<td>74 ± 2</td>
<td>71</td>
<td>77</td>
<td></td>
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<tr>
<td>Retail</td>
<td>11</td>
<td>73 ± 5</td>
<td>65</td>
<td>79</td>
<td></td>
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<tr>
<td>Telecommunications/IT</td>
<td>39</td>
<td>79 ± 4</td>
<td>68</td>
<td>88</td>
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<tr>
<td>Utilities</td>
<td>10</td>
<td>75 ± 2</td>
<td>71</td>
<td>79</td>
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</table>
Noise exposure of call centre operators

Acoustic shock

None of the operators who took part in the HSL study had been exposed to noise they considered as exceptionally loud; none had experienced noises through their headsets that had resulted in ringing in the ears or dulled hearing.

At one call centre, there had been occurrences of acoustic interference. This was defined as ‘unexpected loud noises transmitted to the operator through the headset’. It was not clear what caused these acoustic interference events. During the HSL visit to this call centre, an operator reported an acoustic interference event. The event was captured by the telephone system and replayed through a spare headset fitted on the KEMAR manikin. The corrected noise level was 93 dB(A); the sound energy was concentrated in the one-third octave band centred at 3150 Hz.

Operators were asked to comment on sources of noise transmitted through their headsets that they considered annoying. The following were included:

- callers with loud voices;
- callers using cordless telephones;
- calls made from noisy environments (e.g. factories, homes with crying children and barking dogs, busy main roads).

Most complaints were made about mobile phones. Operators blamed poor reception and bad lines for the high pitched tones that were sometimes transmitted through the headsets. A particular problem with mobile phones was highlighted in call centres that provided directory enquiry services: operators were exposed to annoying tones generated when the caller started dialling the requested number while the operator was still on the line.

Operators’ daily personal noise exposure, $L_{EP,d}$

All the call centres in the HSL study collected detailed statistics relating to the calls handled by operators (e.g. the duration of a typical call and the call rate per hour) and the operator’s performance (e.g. how long the operator spends dealing with incoming calls). The call handling time, i.e. the amount of time the operators spend listening to the noise generated by their headsets, was obtained from a range of different parameters, including the following: talk time, wait time, working time, peak time, call duration and call rate per hour, total sign on time, productive time and time on-line. The call handling times ranged from 36 to 94% across the 15 different call centres.

Estimates of the operators’ $L_{EP,d}$ were made using the average call handling times and the corrected noise levels generated by the headsets for the range of shifts the operators worked in the call centre. The mean and maximum corrected noise levels were used in these calculations. The $L_{EP,d}$ estimates using the mean corrected noise levels were between 67 and 84 dB(A) [$\text{mean} \pm \text{SD} 74 \pm 4 \text{ dB(A)}$]. The $L_{EP,d}$ estimates using the maximum corrected noise levels were between 67 and 87 dB(A) [$\text{mean} \pm \text{SD} 79 \pm 5 \text{ dB(A)}$]. Table 2 contains the mean and maximum $L_{EP,d}$ estimates for each industry sector.

**DISCUSSION**

Fifteen call centres were visited as part of the HSL study to assess whether or not there is a risk to hearing from working in a call centre; the personal daily noise exposure of 150 operators was assessed as part of this project. The call centres represented a wide range of industry sectors.

Background noise levels in the call centres were between 57 and 66 dB(A). The main source of noise exposure for the operators was speech transmitted through their headsets. The corrected noise levels generated by the headsets fitted on the KEMAR manikin ranged from 65 to 88 dB(A). Taking into account the amount of time operators were typically handling calls, the $L_{EP,d}$ estimates using the mean corrected noise levels were between 67 and 84 dB(A). The $L_{EP,d}$ estimates using the maximum corrected noise levels were between 67 and 87 dB(A).

<table>
<thead>
<tr>
<th>Table 2. Daily personal noise exposure ($L_{EP,d}$) estimates</th>
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<tr>
<td><strong>Industry sector</strong></td>
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Individual $L_{EP,d}$ estimates using the mean corrected noise levels generated by the headsets did not exceed 84 dB(A), i.e. the 85 dB(A) first action level defined in the Noise at Work Regulations 1989 (HSE, 1989) was not exceeded. Individual $L_{EP,d}$ estimates using the maximum corrected noise levels reached 87 dB(A). However, the maximum $L_{EP,d}$ estimates exceeded the 85 dB(A) action level for only three of 150 operators. In all three cases, the operator was listening to a caller with a particularly loud voice at maximum volume. Despite the high noise levels transmitted through the headsets, the operators made no attempt to reduce the volume of the incoming call. These results highlight the importance of regular training for call centre operators. Although the majority of call centres in this study provided induction training for new operators, none provided regular training after this.

The operators were generally satisfied with the level at which they listened to calls through the headsets, although more than two-thirds were listening with all the available volume controls set at maximum. These results suggest that many volume controls are set too low for listening to speech. The operators are likely to have difficulties hearing conversations through their headsets if background noise levels are higher or if they have to deal with quietly spoken callers.

Call centre operators could be exposed to higher noise levels, for example fax tones, carrier tones, holding tones or high pitched noises from mobile phones. However, the duration of exposure to these higher levels is likely to be very short. For example, a carrier tone will last $<1$ s, and if the operator is exposed unexpectedly to a loud noise through the headset the duration of exposure will be the time taken to pull the headset away from their ear. Therefore, exposure to these events is unlikely to have a significant effect on the operator’s overall noise exposure.

None of the operators who took part in the HSL study had been exposed to noise through their headsets that had resulted in them experiencing ringing in the ears or dulled hearing. The main complaints received from the operators were about calls made from mobile phones and calls made from noisy environments (e.g. factories, homes with crying children and barking dogs, busy main roads). The TUC raised public awareness of acoustic shock as an occupational hazard for call centre workers with their report *It’s Your Call* (TUC, 2001). It described ‘freak sound bursts on telephone headsets which can leave victims in severe pain, with loss of short term memory and, in some cases, unable to work again’. Although operators may be shocked or startled by the noise, exposure to these unexpected acoustic events should not cause hearing damage as assessed by conventional methods based on the noise exposure limits defined in current legislation. Operators should be encouraged to report their exposure to all unexpected acoustic events to management, who should record the details of these incidents.

One practical way of limiting exposure to unexpected high noises from headsets is through headset design. Since 1991, major manufacturers have incorporated an acoustic (shock) limiter in the electronics of their headsets to meet the requirements of the DTI specification 85/013 (DTI, 1989). In the UK, this limiter ensures that any type of noise (e.g. conversation, short duration impulses) above 118 dB is not transmitted through the headset. This level may sound high, but due to the short duration of an acoustic shock and the reaction time of the operator to remove their headset, the operator’s resultant noise exposure is likely to be well below the action levels set in legislation.

Patuzzi et al. (2000) and Milhinch and Doyle (2000) are carrying out research in Australia to investigate other symptoms that allegedly result from exposure to acoustic shock events. These include tinnitus, pain, hypersensitivity to sound, vertigo, numbness/tenderness/soreness around the ear and neck, headache, fatigue, etc. Patuzzi recognizes that in general the levels of noise transmitted through the headsets are incapable of damaging the ear directly. It is more likely that the trauma is caused by excessive middle ear contractions which are triggered by stress and anxiety. Additional stress can make the situation worse by lowering the threshold for these contractions. For this reason, Patuzzi thinks that headset limiters (and similar systems) will not solve the problem and that stress management strategies will be essential to control the situation.

**CONCLUSIONS**

Noise measurements at 15 call centres across a wide range of industry sectors showed that the mean daily personal noise exposure of call centre operators is unlikely to exceed the 85 dB(A) first action level defined in the Noise at Work Regulations 1989 (HSE, 1989). The risk of hearing damage is therefore considered minimal.

Exposure to higher noise levels is possible, for example from fax tones, holding tones and high pitched tones from mobile phones. However, the duration of these events is likely to be short and they are therefore unlikely to have a significant effect on the operators’ overall noise exposure. A practical method of limiting exposure to unexpected high noises from headsets is to ensure that the headsets incorporate acoustic shock protection that meets the requirements of the DTI specification 85/013 (DTI, 1989). In the UK, this limiter ensures that any noise above 118 dB is not transmitted through the headset.
RECOMMENDATIONS

The results from the project have been used to draw up the following list of good working practices for headset users in call centres.

- Headsets should not be shared; where this cannot be avoided, operators should be given their own ear pads and voice tubes.
- Headsets should be fully adjustable and well maintained.
- The telephone system or associated equipment should incorporate an adjustable volume control that enables the operator to listen to incoming calls at a comfortable level. It may be possible to prompt operators to adjust their listening levels, for example by flashing up a message on the operator’s monitor.
- Headsets should be cleaned regularly; foam pads can be washed, wiping cables prevents them from becoming brittle and cleaning voice tubes (which can become blocked with food, dust, make-up, etc.) ensures that the level of signal transmitted to the caller remains audible.
- Operators should receive regular training that includes use of the headset and associated telephone equipment.
- Operators should be allowed time to make adjustments to their equipment and to clean and maintain it.

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REFERENCES