Occupational Noise Exposure in Small Scale Hand Tools Manufacturing (Forging) Industry (SSI) in Northern India

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Abstract: Occupational noise has been recognized as hazardous for the human beings. A high noise level in forging shops is considered to lower the labour productivity and cause illness however occupational noise is being accepted as an integral part of the job. The present study has been carried out in 5 small scale hand tool forging units (SSI) of different sizes in Northern India in Punjab. Noise levels at various sections were measured. OSHA norms for hearing conservation has been incorporated which includes an exchange rate of 5 dB (A), criterion level at 90 dB (A), criterion time of 8 h, threshold level=80 dB (A), upper limit=140 dB (A) and with F/S response rate. Equivalent sound pressure level (L_{eq}) has been measured in various sections of these plants. Noise at various sections like hammer section, cutting presses, punching, grinding and barrelling process was found to be >90 dB (A), which is greater than OSHA norms. A cross-sectional study on the basis of questionnaire has been carried out. The results of which revealed that 68% of the workers are not wearing ear protective equipments out of these 50% were not provided with PPE by the company. About 95% of the workers were suffering speech interference though high noise annoyance was reported by only 20%. It has been established that the maximum noise exposure is being taken by the workers as they are working more than 8 h a day for six days per week. More than 90% workers are working 12 to 24 h over time per week which lead to very high noise exposure i.e. 50 to 80% per week higher than exposure time/week in USA or European countries^{15, 16}.

Key words: Occupational health, Noise exposure in SSI, Hearing conservation

Introduction

Occupational noise exposure has been identified as very prominent hazards for drop forge hammer operators all over the world. A high noise level in forging shops is considered to lower the labour productivity and cause illness. The main sources of noise in these shops are: drop-forging and free-forging hammers, eccentric forging

presses, oil fired furnaces, equipment for finishing the hot forged products (grinding process and barrelling process), work-station fans, and cooling the machinery, etc. The small scale companies are emphasising more on profit making through productivity enhancement. In developing countries like India beside the economical growth and technological changes, the companies are striving for increasing the sales turnover, thus the workers are more stressed for the productivity along with the additional burden of noise exposure. The small scale hand tool man-

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Fig. 1. Sequence of processes in a forging unit.

Manufacturers of developing countries are lagging far behind in implementing hearing conservation, noise control programmes and occupational health & safety programmes. Consequently the workers of hand tool forging units are exposed to the noise levels beyond the permissible limits. High noise exposure not only affects the communication among the workers but also lead to the other physiological, psychological and physical effects on the workers.

Noise at Work Place

In most of the small scale industries noise is perceived as a necessary evil. Since noise is an integral part of machinery in operation therefore it is being accepted “as a part of job”. This attitude is persisting in a number of organizations especially among the management and workers of older industries where the traditional methods and machinery are still being used. As far as the SSI is concerned especially the iron & steel units where heavy forging presses and drop hammers are main machinery assets, noise control efforts are still lagging behind. The sequence of operation of manufacturing the hand tools is shown in Fig. 1. The work place in most of the SSI is very congested due to lack of availability of space. The simultaneous running of blanking and punching presses, drop hammers, grinders and barrels etc. make the shop very noisy. The exposure to such a noisy environment is inevitable unless the proper hearing protection is taken. Most of the operations at different locations generates high noise > 90 dB (A) (Beyond the permissible limits). The impact produced by a hammer falling on a plate can generate an impulse whose peak level and duration can be varied 140–470 ms⁸). All continuous, intermittent, and impulsive noise between the levels of 80 and 130 dB (A) must be included in the exposure assessment. Continuous noise is a noise whose maxima occurs more often than once per second. Thus impulsive noise is assumed to have peaks occurring less often than once a second, and is limited to peak sound pressure levels of 140 dB¹⁰).

In this scenario the exposure to high noise is conse-

quently followed by the noise induced hearing loss (NIHL), Physiological and Psychological effects. A number of studies have been carried out in last few decades regarding the assessment of occupational noise exposure and its auditory and non auditory health effects. In one study occupational noise exposure of truck drivers was found hazardous to hearing¹²). Most of the studies have been carried out in developed countries, whereas the under developed countries like India are still lagging behind to explore the occupational health issues. One of the studies in India reports that workforce of two textile plants was at high risk of developing NIHL and other associated ailments¹⁵). Indian factory act - 1948 lay down a limit of 90 dB (A) for 8 h/day but the Indian working hours are 48/wk which leads to high noise exposure. Most of the workers are illiterate and semiliterate and they are not aware of the exposure norms and hazardous effects of noise¹⁶).

Subjects and Method

The present study has been carried out in five SSI forging units located in Punjab state of northern India. These units are making hand tools like spanners, wrench, pliers, bench vice, hammers, axes etc. The number of employees in each unit is shown in Table 1. The number of workers in these units varies from 50 workers to 500 workers. A cross-sectional study has been conducted involving 451 randomly selected male workers. The age of workers ranges from 20 yr to 55 yr (Table 2). A comprehensive questionnaire was formulated to assess the subjective information. The questionnaire included age, noise exposure, working hours, use of protective measures, noise annoyance and awareness about NIHL (Appendix-A). The questionnaire was pretested and then was used to assess the information. The information was collected through personal interviews. Since the workers are mostly illiterate or less educated therefore statements of the questionnaire were translated in both local languages of the state i.e. Punjabi and Hindi. A five point scale was used to calculate the overall response for questionnaire parameters. The response choice weight ranges includes 4 (Always), 3 (Often), 2 (Sometime), 1 (Seldom) and 0 (Never). The other questions were having yes or no response i.e. 1 or 0 weights.

Noise Measurement

Workers were explained about the noise measurement procedure before the measurement was started at each section. The workers were allowed to observe the monitoring procedures and later on they were told about their exposures as recommended in¹¹). The noise exposure was

Table 1. Number of workers interviewed in each section of each unit

Forging Unit	1	2	3	4	5	Total
Workers Interviewed in Sections						
Blank cutting	3	6	9	9	10	37
Blank Heating	2	6	6	6	10	30
Drop Forging	4	12	14	14	18	62
Punching	2	8	9	9	12	40
Broaching/machining	2	9	10	12	18	51
Belt Grinding	4	8	10	12	18	52
Wheel Grinding	4	8	10	12	18	52
Duplex grinding	NA	2	4	6	10	22
Barrelling	NA	2	2	3	6	13
Straightening	NA	3	2	3	6	14
Gauging	2	2	4	4	6	18
Sizing	1	2	4	4	6	17
Nickel Plating/Painting	2	4	6	8	12	32
Gen Set	1	2	2	2	4	11
Workers interviewed	27	74	92	104	154	451
Total Employees	50	150	350	450	500	1,500
Percent Response rate (%)	54	49	26	23	30	30

Table 2. Distribution of age groups and years of exposure to noise under relevant processes

Age	20–24	25–29	30–34	35–39	40–44	45–49	50–55
Number of Subjects	67 (15%)	90 (20%)	90 (20%)	67 (15%)	67 (15%)	45 (10%)	23 (5%)
Exposure (yr)	1–2	3–5	6–10	11–15	16–20	21–25	>25
Number of Subjects	45 (10%)	90 (20%)	112 (25%)	90 (20%)	59 (13%)	36 (8%)	18 (4%)
Age	20–24	25–29	30–34	35–39	40–44	45–49	50–55
Number of Subjects	67 (15%)	90 (20%)	90 (20%)	67 (15%)	67 (15%)	45 (10%)	23 (5%)
Exposure (yr)	1–2	3–5	6–10	11–15	16–20	21–25	>25
Number of Subjects	45 (10%)	90 (20%)	112 (25%)	90 (20%)	59 (13%)	36 (8%)	18 (4%)

assessed by using a Quest sound level meter “ANSI 43-1997 (R2002) Type-1, model SOUNDPRO SE/DL”. OSHA norms for hearing conservation were incorporated including an exchange rate of 5 dB (A), criterion level at 90 dB (A), criterion time of 8 h, threshold level=80 dB (A), upper limit=140 dB (A) and with F/S response rate. The measurements in A-weighted sound pressure level were done. The measurements were recorded through data logging facility of the sound level meter and then transferred to computer for further analysis. The inbuilt quest make software was used for calculation and analysis. The measurement of noise was done in units with serial no. 1, 3 & 5 (Table 1). The sound pressure level at different locations of each section among these units differed up to ± 0.5 dB (A). Since the machinery and layout of these units was almost of the same pattern i.e. congested type. In all the five units the process are carried out one adjacent to another. There is no isolation among different sections e.g. hammer section and other

sections like punching, barrelling, and grinding etc. The workers are actually exposed to these noises since the workers have very less movement and they remain seated at one place during the working hours, except the movement of very few helpers within the same section. As a prevailing practice the workers are given 30 min lunch break and two tea breaks (5 min each) excluding the work time of 8–12 h. Most of the work locations have an almost steady noise production except the drop forge hammers and punching/blanking presses. The sound pressure was recorded for 15 min each time on each work station and one long term recording for 4 h was done. There was hardly a difference of 0.5 to 1.0 dB (A) between long term recording and short term recording. At each section sound pressure was recorded at least 4–5 times at different locations where the workers actually work or movement of the workers was most frequent. All the workers work at one place throughout the day excluding the helpers for material handling. There were

1–2 helpers in section like hammer, grinding depending upon the size of the unit. The noise measurements were done in a circle of 1–2 feet radius from the ear of the workers. The sound pressure near the worker's head/ear and at 5 to 10 feet away from the head was differed by 0.5 to 1.0 dB (A) at grinding section and 0.5 to 1.5 dB(A) at barrel section and drop forge section. Equivalent sound pressure level has been measured L_{eq} in various sections of these plants.

Results and Discussion

Noise levels

Results of the noise measurements reveal that overall noise level and exposure to noise in forging units under study ranged from 86.5 and 110 dB (A) L_{eq} . The details of L_{eq} , L_{min} , L_{max} and L_{pk} values are shown in Table 3. The daily exposure of workers in sections like blank cutting, forging, punching press, wheel and belt grinding, barrelling section, broaching, gauging and sizing etc. exceeds maximum exposure limit of 90 dB (A) specified by OSHA and Indian factories act. The noise exposure

Table 3. Noise measurements at various sections of small scale hand tools manufacturing forging plants

Blank Cutting	L_{eq} (A) dB	L_{min} (A) dB	L_{max} (A) dB	L_{pk} (A) dB	Belt Grinding	L_{eq} (A) dB	L_{min} (A) dB	L_{max} (A) dB	L_{pk} (A) dB
Location -1	101.9	92.5	115.0	135.2	Location -1	94.9	90.4	98.9	112.9
Location -2	101.2	92.9	116.1	135.4	Location -2	94.5	90.2	98.4	112.5
Location -3	101.6	92.3	115.6	134.9	Location -3	95.5	90.8	99.2	112.9
Location -4	102.4	92.8	115.9	135.1	Location -4	94.9	90.6	99.2	112.6
Drop Forge	L_{eq} (A) dB	L_{min} (A) dB	L_{max} (A) dB	L_{pk} (A) dB	Barrelling	L_{eq} (A) dB	L_{min} (A) dB	L_{max} (A) dB	L_{pk} (A) dB
Location -1	102.1	94.8	115.1	135.0	Location -1	99.2	92.1	103.8	118.4
Location -2	101.7	95.5	110.9	129.8	Location -2	101.9	94.7	113	134.6
Location -3	100.6	90.8	113.3	134.8	Location -3	105.3	98.8	111	124.2
Location -4	101.2	94.0	116.0	125.2	Location -4	110.2	98.0	115.0	129.2
Location -5	101.7	92.9	118.6	134.6	Location -5	107.0	93.5	113.5	126.5
Location -6	101.2	82.4	115.7	134.8					
Location -7	103.8	92.2	118.6	140.9					
Punch Press	L_{eq} (A) dB	L_{min} (A) dB	L_{max} (A) dB	L_{pk} (A) dB	Straightening	L_{eq} (A) dB	L_{min} (A) dB	L_{max} (A) dB	L_{pk} (A) dB
Location -1	98.9	93.5	111.2	126.3	Location -1	96.5	87.2	106.4	128.5
Location -2	99.8	94.6	107.7	127.7	Location -2	95.6	86.4	105.4	126.4
Location -3	101.1	95.1	109.9	127.2	Location -3	94.6	86.4	104.4	127.5
Location -4	100.2	94.0	109.0	126.9	Location -4	95.6	87.4	106.4	128.5
Location -5	101.2	95.0	109.9	126.2					
Broaching	L_{eq} (A) dB	L_{min} (A) dB	L_{max} (A) dB	L_{pk} (A) dB	Gauging-Sizing	L_{eq} (A) dB	L_{min} (A) dB	L_{max} (A) dB	L_{pk} (A) dB
Location -1	101.9	94.7	113.6	134.6	Location -1	93.3	88.1	104.0	120.1
Location -2	99.1	92.1	103.6	118.4	Location -2	92.6	87.1	103.4	119.5
Location -3	96.1	92.4	98.2	112.9	Location -3	93.1	87.9	103.8	121.0
Location -4	96.5	91.1	98.9	118.2	Location -4	92.9	87.9	103.9	119.8
Wheel Grinding	L_{eq} (A) dB	L_{min} (A) dB	L_{max} (A) dB	L_{pk} (A) dB	Nickel Plating	L_{eq} (A) dB	L_{min} (A) dB	L_{max} (A) dB	L_{pk} (A) dB
Location -1	96.1	92.4	98.2	112.9	Location -1	88.0	82.8	106.2	121.3
Location -2	96.5	91.1	98.9	118.2	Location -2	87.9	84.7	105.9	119.9
Location -3	94.6	90.2	98.9	113.0	Location -3	88.1	83.8	106.1	120.7
Location -4	95.6	91.2	98.4	114.0	Location -4	87.9	84.5	105.7	119.6
					Location -5	86.5	82.4	103.2	118.8
Duplex Grinding	L_{eq} (A) dB	L_{min} (A) dB	L_{max} (A) dB	L_{pk} (A) dB	Gen Set	L_{eq} (A) dB	L_{min} (A) dB	L_{max} (A) dB	L_{pk} (A) dB
Location -1	94.7	90.5	104.1	120.0	Location -1	96.1	91.1	102.1	125.6
Location -2	93.8	89.8	99.4	115.3	Location -2	96.5	90.8	102.0	124.5
Location -3	94.7	90.5	104.1	120.0	Location -3	95.9	91.2	100.6	123.6
Location -4	93.8	89.8	99.4	115.3	Location -4	96.8	91.4	102.3	125.5

in other work areas like nickel plating, machine section, die section is recorded less than 90 dB (A), but is quite higher than the limits used for assessment of noise for community noise¹⁵⁾. The direct application of OSHA norms in Indian SSI is not valid because most of the plants operated more than 8 h/d and six d/wk i.e. exposure time is 48 h/wk. In the interview it was reported by most of the workers that they opt for 2 to 4 h/d over time i.e. 12 to 24 h/wk (Table 4). This fact was also established by the managers of the plants. Therefore the workers are under total exposure of 20 to 32 h (i.e. 50–80%) per week higher than exposure time per week in USA or European countries^{14, 15)}. Chronic exposure to noise levels typical of many workplaces can cause risk of acute myocardial infarction death. Exposure to high intensity noise of 88–107 dB (A) 6–8 h/d for long duration (10–15 yr) can cause biochemical changes which make the workers prone to cardiovascular pathology^{1, 6)}.

Subjective response to noise

The subjective response was collected from 451 workers randomly selected from each of the five units (Table 1). The distribution of workers in each age group

and experience group is shown in Table 2. The results of the questionnaire interviews revealed that 5% of the workers reported always annoyed, 15% often, 22% sometime, 20% workers were seldom annoyed and 38% never felt annoyed with high noise levels. The same could be attributed to the workers acceptance of noise as a part of their job, secondly the increasing adaptability with the increasing exposure to high noise levels. Noise annoyance was more among age group of 30–34 and exposure group of 5 yr of work experience as compare to other groups (Table 5). The overall noise annoyance level on a five point scale was 1.29. Nevertheless the occupational noise annoyance combined with nightshift work, and work satisfaction can cause ill effects on blood pressure²⁾. As far as the head ache due to work place noise is concerned only 5% reported always and 10% with often report of head ache this was observed in newly employed workers which could be attributed to their adaptability to the environment and hearing threshold loss. The overall head ache level due to work place noise was 1.76 on a five point scale. In case of speech interference 30% of the workers reported high, 25% moderate, 25% workers reported low and 15% reported least speech interference

Table 4. Subjective response %age (N) and level of each factor on 5 point scale (weight range 0–4) ratios of workers for various questions

Response Choice	i)	ii)	iii)	iv)	v)	Level
Question						
1) Noise annoyance	5% (23)	15% (67)	22% (99)	20% (90)	38% (171)	1.29
2) Head ache due to noise	5% (23)	10% (45)	50% (225)	25% (113)	10% (45)	1.76
3) Speech Interference	30% (135)	25% (113)	15% (67)	25% (113)	5% (23)	2.50
4) Awareness of noise ill effects	40% (180)	60% (270)	NA	NA	NA	NA
5) Hearing disability	65% (292)	35% (158)	NA	NA	NA	NA
6) Awareness of benefits of PPE	70% (315)	30% (135)	NA	NA	NA	NA
7) Management enforces to wear PPE	30% (135)	70% (315)	NA	NA	NA	NA
8) Use of PPE by workers	5% (23)	7% (32)	8% (36)	12% (54)	68% (306)	0.70
9) Cause of not/irregular using PPE	30% (157)	10% (45)	20% (135)	40% (113)	NA	NA
10) Working hours/day	15% (67)	85% (383)	NA	NA	NA	NA
11) Weekly overtime	10% (38)	15% (58)	35% (134)	40% (153)	NA	NA
12) Level of satisfaction with work environment	30% (135)	24% (108)	26% (117)	15% (67)	5% (23)	2.59

For questions 1, 2, 3 & 8 choice options are i) - Always, ii) - Often, iii) - Sometime, iv) - Seldom, v) - Never.

For questions 4, 5, 6 & 7 choice options are i) - Yes, ii) - No.

For questions 9, 10, 11 & 12 ref. Appendix-A.

Table 5. Distribution of noise annoyance w.r.t. age group and years of exposure

Age Range (yr)	20–24	25–29	30–34	35–39	40–44	45–49	50–55	Total
Noise Annoyance Number of workers	28 (10%)	70 (25%)	84 (30%)	62 (22%)	28 (10%)	6 (2%)	2 (1%)	280
Exposure (yr)	1–2	3–5	6–10	11–15	16–20	21–25	>25	Total
Noise annoyance Number of workers	42 (15%)	84 (30%)	70 (25%)	42 (15%)	28 (10%)	11 (4%)	3 (1%)	280

due to high noise levels. The workers engaged in hammer section, punching/blanking, grinding, broaching and barrelling sections were the main sufferers of speech interference. The overall speech interference level on a five point scale was 2.5, which is second highest among all parameters. As only 40% of the workers reported awareness about the hazardous effects of noise, this factor is very much related to the fact of high percentage (68%) of workers almost not wearing PPE. Where as only 5% workers reported always use, and rest of the workers reported some time, often and seldom use of PPE at work place. As observed at the time of survey these workers were mainly from forging section, grinding section, punching press, blank cutting, machining and barrelling sections. The overall level of use of PPE on a five point scale was 0.70, which is the least observed parameters; the use of PPE is the most important and critical parameter but least preferred and prevailing. As far as the reasons for not using PPE were concerned 35% of these feel uncomfortable, 10 were not habitual of wearing the PPE, 30% due to their negligence and 25% were not getting PPE. High percent of hearing disability can be directly related to the high noise level, longer exposure time and also with the high ratio of workers not using PPE. As shown in (Table 4) 85% worker are working more than 8 h/d, and 90% of these workers are doing 12–24 h over time/wk which lead to very high noise exposure i.e.

50 to 80% per week higher than exposure time/wk in USA or European countries^{15, 16}. These long working hours and overtime are additional sufficient grounds for considering health hazardous in the work place²⁰. The workers usually wear ear plugs, turban and cotton as PPE as shown in (Fig. 2). It is very much clear that only 12% of workers are using ear plugs, 20% are wearing cotton & turban (inappropriate ear protection) and 68% are not using ear protection. This fact reveal that majority of the workers are directly exposed to high level of noise 92–110 dB(A) L_{eq} without using PPE (Fig. 3). Chronic exposure to such kind of noise levels typical of many workplaces can cause risk of acute myocardial infarction death¹. A long exposure to noise over 85 dB(A) might be a risk factor for high BP, contributing to an increase in BP in the population and possibly inducing major

Fig. 2. Use of Ear Protection by the workers.

Fig. 3. Workers without proper PPE at forging, grinding and barrelling sections respectively.

increases of BP among sensitive individuals³). Noise exposure has been known to cause hearing loss for over a century, it is only recently that exposure limits have been legally adopted however; strict enforcement of current permissible exposure levels would not eliminate occupational hearing loss from industry⁴). Such a higher exposure to impulsive and continuous noise can be responsible for NIHL and biochemical changes which may need further investigation. The NIHL can be seen in the form of PTS or TTS, since the forging workers those who are engaged in hammer section are also exposed to temperature and physical load therefore the TTS driven by noise exposure is enhanced by heat and workload⁷). The revision of occupational Indian Noise standard is recommended at par with International/European standards⁵). Hearing protection must be provided at no cost to employees and must be worn by all workers exposed to a TWA of 90 dB (A) and above. Exposure to high levels of impulse noise (despite the use of ear protectors) is more detrimental to hearing than are high levels of continuous noise (event continuous with slightly impulsive features). Impulse noise can produce permanent threshold shifts at certain frequencies after a clearly shorter duration of exposure than continuous noise¹³). The whole discussion on the bases of results of measurements and subjective responses it is concluded that the workforce of SSI forging units is at a high risk of chronic effects of occupational noise. This may lead to auditory, physiological and psychological impairments of the SSI workforce which can be investigated in future scope. Further study can be extended with investigation of autonomic tone of the exposed workers. Therefore the future scope of the present study is very wide in the country. The authors recommends that exposure limit stipulated by OSHA of 90 dB (A) for 8 h/d shall be followed with caution. It is also recommended to establish a hearing conservation programmes including the noise assessment, awareness among workers and audiometry.

Conclusions

The small scale industries of developing countries like India are still far behind in implementing occupational health and safety programmes. The present study was specifically focused on hand tools manufacturing (forging) plants the crux of the study can be enumerated as follows:

1. Majority of the workers are not wearing hearing protective equipments and suffer from NIHL. Main reasons were their negligence, feeling of un-comfortableness and are not provided by the management.
2. Mostly workers are illiterate or very less educated even under primary or middle and are not fully aware

of the hazardous effects of noise.

3. Almost all the workers are highly exposed to high noise levels [>90 dB (A)], 60 to 72 h/wk without proper ear protection, which is very high as compared to OSHA norms.
4. There is a dire need to implement the noise working hours standard and hearing conservation programmes under ethical/legal control.
5. The SSI should be encouraged and facilitated to implement hearing conservation programmes under a good association with occupational health and environment professional.
6. The workers should be motivated to use PPE and educated for NIHL and other non auditory affects of noise exposure.

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Appendix-A

Questionnaire for Interview.

Name Age Work Experience.....

1. Do you feel annoyed with high noise level at work place?
i) Always, ii) Often, iii) Sometime, iv) Seldom, v) Never
2. Do you have problem of head ache due to noise at work place?
i) Always, ii) Often, iii) Sometime, iv) Seldom, v) Never
3. Does noise causes speech interference?
i) Always, ii) Often, iii) Sometime, iv) Seldom, v) Never
4. Are you aware of hazardous effects of noise?
i) Yes ii) No
5. Do you have hearing disability due to work noise?
i) Yes ii) No
6. Do you know the benefits of using the protective equipments?
i) Yes ii) No
7. Do management enforce you to wear the protective equipments?
i) Yes ii) No
8. How much you use personal protective equipments (PPE) at work place?

Level of use	i) Always	ii) Often	iii) Sometime	iv) Seldom	v) Never
Type of PPE					
Ear Plugs					
Cotton					
Safa/Turban					
Other					

9. If you do not use the protective equipments always, then specify the reason?
i) Feel uncomfortable, ii) Do not have habit, iii) Due to negligence, iv) Not provided by the company
10. What is working time/day?
i) 8 hours ii) > 8 hours
11. How much overtime/week you have?
i) 5–10 hours, ii) 11–15 hours, iii) 16–20 hours, iv) 21–24 hours
12. Rate your satisfaction with your work environment?
i) Highly, ii) Moderate, iii) Low, iv) Least, v) Not at all

(Signature of Worker)