Microwave Hearing Effect

Rigger Safety in the Telecommunications Industry

By Denis Boulais

Exposure to radiofrequency (RF) radiation may result in many health effects such as cataracts, headaches, burns and various thermal effects on the body (Boulais, 2014a). Microwave hearing effect is also attributable to RF radiation. With the human body consisting of more than 70% water, RF radiation results in vibration of water molecules within the body, thereby causing injury via a thermal effect. The best way to explain this effect is by comparison to a microwave oven, which quickly heats foods with high moisture content. Heated in a microwave, the filling of a jelly donut can be extremely hot, while the outside is only slightly warm. It all comes down to the higher moisture content of the jelly (Boulais, 2015a).

IN BRIEF

- **Pulsed radiofrequency radiation is an invisible hazard that may cause exposed workers to hear noises for which there is no visual explanation.**
- **This article explores whether this may result in workplace incidents caused by concentration loss.**
- **This article discusses the hazard, its risks and risk controls in relation to this phenomenon.**

Pulsed RF radiation from radar installations can cause slight temperature increases in the brain, which can cause a thermoelastic wave in the head that is detected by the cochlea (Chou & Guy, 1982). This can cause the person exposed to perceive phantom sounds, such as chirping, buzzing, hissing, clicking or knocking noises (Lin, 1978). The sounds are perceived, but there is no visual explanation for the noises; this is known as microwave hearing effect (Frey, 1962).

This article aims to address a gap in the literature by determining whether microwave hearing effect may result in distraction during high-risk work at height, which may then result in injury. To achieve this goal, the article addresses several key research objectives:

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- To assess awareness and knowledge of microwave hearing effect within a target population of telecommunications riggers employed by a large telecommunications services company.
- To determine the proportion of that population that may have experienced the effect and their recollection of knocking, clicking, chirping, buzzing or hissing.
- To determine to what degree those who have experienced the effect consider it a workplace distraction.
- To determine whether the matter was reported where experienced and, if not, to determine why it was not reported.

This article starts with a summary of microwave hearing effect, then presents the results of a questionnaire administered to a target population of telecommunications riggers (n = 99). The article then presents analysis of the results to address the research objectives and draws viable conclusions.

A note about rigger competency: Throughout Australia, respective safety regulators issue high-risk work licenses to riggers; their level of competency is defined as basic, intermediate or advanced. The study presented consists of 100% male riggers; based on experience, this is reflective of the current telecommunications rigger population in Australia.

Microwave Hearing Effect

Microwave hearing effect was first documented in 1947, experienced by people who were standing close to radio antennas. Their reports were met with skepticism because at that time the ear was thought to have no sensitivity to electromagnetic waves in the 300 MHz to 300 GHz range. This might explain why the first systematic study of microwave hearing effect did not occur until many years later, in 1961 (Elder & Chou, 2003). In that study, it was documented that human subjects reported hearing buzzing sounds when exposed to RF energy from radar. Research has identified that sounds also can be induced in hearing-impaired people (Frey, 1962).

Microwave hearing effect occurs when a pulse of electromagnetic radiation is perceived as a clicking, hissing, chirping, knocking or buzzing sound where the electromagnetic radiation is pulsed. The perception threshold depends on the frequency of the radiation, pulse duration, pulse width and the pulse's peak power (Stuchly, 1979). The relevant standard in Australia refers to basic restriction limits; however, it appears that the effect is often still perceived. In fact, the author was originally of the impression that the perception was uncommon until a few senior riggers mentioned it, hence the motivation to conduct this project.

Some have proposed that the effect occurs within the temporal lobe of the brain (Frey, 1962). One study found that earplug use actually increased the perceived RF-induced sound because earplugs significantly reduce external environmental ambient noise levels (Elder & Chou, 2003). Telecommunication riggers work at great height where the solitude of the height also reduces ambient noise, which may increase their risk.

Globally, no occupational safety or health data are available on this effect, primarily because it may be experienced only where exposure limits are breached by those in control of emissions. Furthermore, those exposed may not understand the effect and, therefore, do not report it. However, the facts are that radiofrequency is pure physics and the human brain is pure biology, so it is highly likely that the phenomenon has been experienced globally.

Microwave hearing effect is often overlooked in RF training because the perception of RF-induced sounds is not considered an adverse health effect at threshold exposure levels (Elder & Chou, 2003). It should be noted that induction training in this area focuses primarily on the harmful effects of RF radiation. Under conditions of exposure, a situation may arise during which there may be prolonged periods of such sounds that may become an annoyance or distraction, although the restrictions of the standard are designed to limit or avoid such annoying or startling auditory effects (ARPANSA, 2002). While no adverse health effects to the body exist at threshold exposure levels, such distractions may result in incidents.

The high-risk work of telecommunications riggers often involves manual handling activity at significant height (Boulais, 2015c). An example of risk may involve a rigger mounting an antenna from an elevated work platform on a tower 164 ft in the air. In the Australian outback, the perception of hissing may cause a rigger to believe a deadly brown snake has climbed the tower. The perception of buzzing may cause the rigger to think an aggressive wasp nest is nearby. The distraction may cause the rigger to drop an unsecured item such as a bolt, nut or wrench. While these items may be lightweight, they can ricochet off the mounted antenna and strike hard outside the exclusion zone established below. Such high impact can damage property below or result in medical and tower rescue emergencies (Boulais, 2014c).

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Risk Control

Risk controls in relation to pulsed RF radiation must be determined based on the risk associated with the respective site. The site controller likely would have a wide range of risk control measures in place with which telecommunications riggers must comply. These may include establishing exclusion zones, posting signage and providing site-specific induction.

Telecommunications riggers should be trained in RF radiation control measures and may apply any or all of the following suggested measures to ensure their safety while working around pulsed RF radiation. Any risk control strategies applied should be coordinated with the controller of premises.

•In areas where RF radiation emission exposure is indicated, transmitting equipment must always be switched off and isolated.

•Ensure that the relevant radiation emitter is contacted to coordinate the isolation process.

•Ensure that isolation is confirmed with the emitter prior to starting work; this must always be verified with a personal RF monitor.

•Ensure that workers have completed RF radiation awareness training.

•Ensure that workers are aware of the requirement to report an exposure, particularly when their personal RF monitor detects an exposure.

A personal RF monitor alarms when the occupational exposure limit is reached or exceeded, and the worker must depart an area once the monitor alarms. A personal RF monitor must be used to measure RF energy when arriving at a job, and the monitor must remain on throughout the job to ensure that no RF exposure exists. Even where it is confirmed that antennas are not emitting, the personal RF monitor must remain switched on.

Table 1

Microwave Hearing Effect & Telecommunications Rigger Safety

Primary Statistical Data

Rigger age group	
16-24	0
25-34	25
35-44	29
45-54	30
55-64	15
65+	0
Years of experience	
5 years	23
10 years	32
15 years	12
20 years	25
25 years	7
25+ years	0
Rigger competence	
Basic	36
Intermediate	26
Advanced	37
Previous military experience	
Yes	22
No	77
Military type	
Army	18
Navy	4
Air Force	0

Secondary Statistical Data

Awareness of effect	
Initially aware	56
Not initially aware	43
Experience of effect	
Experience of the effect	49
No experience of the effect	50
Distraction of opinion	
Was a distraction	37
Was not a distraction	12
Distraction level rating	
Minor	19
Moderate	16
Major	2
Incident reported	
Reported	20
Not reported	29
No awareness with experience of effect	
Basic	13
Intermediate	6
Advanced	0
Years' experience vs. experience of effect	
5 years	17
10 years	14
15 years	7
20 years	7
25 years	4
25+ years	0
Competency vs. distraction rating	
Basic	
Minor	7
Moderate	11
Major	0
Intermediate	
Minor	6
Moderate	5
Major	2
Advanced	
Minor	6
Moderate	0
Major	0
Military experience vs. incident report	
Military experience	12
No military experience	8
Years' experience vs. awareness	
5 years	6
10 years	12
15 years	10
20 years	23
25 years	5
25+ years	0
Perception of effect	
Knocking	13
Clicking	23
Buzzing	13
Chirping	0
Hissing	0
Other	0

Results Table Key

Australian safety regulators issue a basic, intermediate or advanced competency rigger's license to riggers as a result of training, experience and testing.

During the questionnaire, a rating was coded by a grade on a 10-point scale based on rigger opinion of distraction level. Minor was 0 to 5; moderate was 6 to 8; major was 9 or 10.

Results

Table 1 details the results of the study. A total of 99 questionnaires were completed for a response rate of 100%.

Discussion & Conclusions

Research Objective 1: Assess Awareness

The first research objective was to assess awareness and knowledge of the microwave hearing effect among the target study population. A total of 56 participants (56.6%) were aware of the effect, which is a good result considering the literature states that it is physiologically harmless at threshold exposure levels. There is also a low focus on this effect at induction as industrial RF radiation can also result in other more harmful health effects. Of the 56 riggers who demonstrated awareness, 23 (41.07%) had 20 years' work experience. Considering that only 25 of the riggers surveyed had 20 years' experience, this finding is significant.

Most concerning was the number of participants who were not aware of the effect, yet when it was described to them, they recalled experiencing the effect. Of the 19 participants in this category, 13 (68.42%) were basic-level riggers. Again, this finding is a sound case for more competency-based induction training in this area. Previous research has highlighted poor basic rigger awareness in RF safety around near RF fields (Boulais, 2015a). Research has also indicated that regular training can lead to improved safety awareness (Boulais & Winder, 1997). The outcome also suggests that as riggers become more experienced their awareness of the effect may increase.

In conclusion, it is apparent that more training in this RF-specific area should occur at induction. The literature places significant emphasis on the physiological aspects of the effect, hence what the literature fails to address is that the effect may be indirectly harmful and result in significant incidents at height as a result of the effect's distraction.

Research Objective 2:
Determine Population Experiencing Effect

The second objective was to determine the proportion of the target population that may have experienced the effect and their recollection of knocking, clicking, chirping, buzzing or hissing. Forty-nine riggers claimed to have experienced the effect. This may suggest that certain RF emitters may not have adhered to basic restrictions. The author notes that several riggers could not recall the estimated time frame of the occurrence; most stated it occurred at least 5 years prior. With perception being a large foundation of this research, speculation may lead to some error, which suggests the need for validation questions in the questionnaire.

It is evident from the literature that in 2002 the relevant RF radiation standard in Australia (ARPANSA RPS3) introduced exposure limits relating to pulsed exposures. Recent review of the current ARPANSA RPS3 standard by an expert panel in March 2014 indicated that the limits published in 2002 remain valid and effective in reducing exposure (ARPANSA, 2014).

In conclusion, regarding terms of perception of the effect, only knocking, clicking or buzzing were reported, where clicking dominated at 23 (46.93%). When this was further examined the perception of buzzing truly dominated within the older age group. While most of the older riggers could not pinpoint when they experienced the effect, the data suggest that modulation of signals may have differed over the years, as perception can vary depending upon frequency, power density, pulse width and duration (Boulais, 2015a).

Research Objective 3:
Determine Distraction Level

The third objective was to determine to what degree those who have experienced the effect

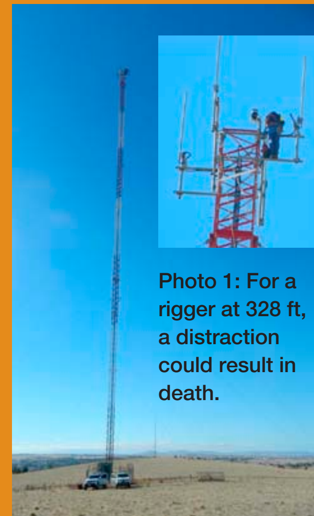

Photo 1: For a rigger at 328 ft, a distraction could result in death.

Photo 2 (above): Looking up at a 98.4-ft tall tower. Photo 3 (left): Looking down the inside of a 328-ft tower.

Microwave Hearing Effect & Rigger Safety Questionnaire

Questionnaire number and date: ______________________

As part of a review of microwave hearing effect related safety we are seeking information from you about your awareness and possible experiences of the effect when working in the field. There are no right or wrong answers.

Age: ❑ 16-24 ❑ 25-34 ❑ 35-44 ❑ 45-54 ❑ 55-64 ❑ 65+

Experience: ❑ 5 years ❑ 10 years ❑ 15 years
❑ 20 years ❑ 25 years ❑ 25+ years

HRWL level: ❑ Basic ❑ Intermediate ❑ Advanced

Military exposure: ❑ Yes ❑ No

Area: ❑ Army ❑ Navy ❑ Air Force

Q1) Are you aware of the phenomenon called microwave hearing effect? ❑ Yes ❑ No
If Yes, please describe it.

Q2) Do you believe you have experienced this effect? ❑ Yes ❑ No
If Yes, would you please describe what you experienced and would the experience have occurred more than 5 years ago?

Q3) Would you consider it a distraction while you are working?
❑ Yes ❑ No
If Yes, would you describe the distraction as minor, moderate or major?

Q4) Have you reported the experience(s) as an incident(s)?
❑ Yes ❑ No
If No, were there any specific reasons why you didn't report it?

consider it a workplace distraction. Of the 49 participants who reported an experience of the effect, 37 (75.5%) reported it as a distraction. When this was further examined, 19 (51.35%) rated the distraction as minor, while 16 (43.24%) considered it moderate and only 2 (5.40%) considered it major.

While the health effects at threshold exposure levels are considered by the literature as harmless, what the literature does not discuss is the high-risk nature of the manual handling activity the rigger may be performing at extreme height when the effect may be perceived. In light of previous findings, the author was concerned that basic-level riggers may consider the degree of distraction differently than would a more advanced rigger.

Of the 37 riggers who reported it as a distraction, 18 (48.64%) were basic riggers. Considering that basic riggers only comprise 36.36% of the overall participants, this finding is significant. Advanced-level riggers comprised 37.37% of the study, yet only 6 (16.21%) reported the effect as a distraction. Further analysis indicates that 11 (61.11%) of basic-level riggers rated the effect as a moderate distraction. The remaining 7 (38.88%) basic-level riggers rated the effect as minor. By comparison, the 6 advanced level riggers all rated the effect as minor.

In conclusion, the outcome suggests that basic-level riggers may be at greater risk due to the effect and, thus, require more awareness training. It may also be ideal to pair basic-level riggers with advanced riggers for mentoring on jobs near radar installations or simply not be placed on jobs near radar installations. Training must include information that the sounds perceived may mimic the sounds of environmental hazards inherent to Australia. Examples include hissing (snakes), buzzing (wasps), chirping (predatory birds), clicking and knocking (riggers communicating from below work areas at height).

Research Objective 4: Determine Whether Reported

The fourth objective was to determine whether experiences of the effect were reported when experienced and, if not, to determine why those incidents were not reported. Of the 49 participants who recalled an experience, 20 (40.81%) reported it as required. It was a concern that 29 (59.18%) of riggers who experienced the effect did not report it, particularly as incident reporting is an excellent trigger of risk control strategies being implemented. Of the 29 who did not report the experience, 13 (44.83%) cited red tape as the reason, whereas 16 (55.17%) indicated they were not aware it was a hazard that required reporting. Clearly this identifies a requirement for more awareness and reporting training.

It was identified that of the 20 participants who reported the experience as an incident, 12 (60%) were from a military background. With 22 participants in the study having a military background, this clearly demonstrates that the riggers with military background are more likely to be compliant in reporting incidents.

In conclusion, this outcome may provide the company some insight about incident reporting and possibly support a recommendation to strategically pair military and nonmilitary riggers to foster the development of a positive improvement in safety culture. The literature indicates that those with military background are more likely to report incidents than those with no military background (Johnson, 2014). Furthermore, it is more likely that those with military background may have a greater awareness of the effect near radar. **PS**

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