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# A Study of Noise Exposures for Amusement Park Employees by Positions and Ride Categories

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# A Study of Noise Exposures for Amusement Park Employees by Positions and Ride Categories

by

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of the requirements for the degree of
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## ABSTRACT

Millions of workers in the United States encounter daily noise exposures in their workplace, associated with millions of dollars in workers compensation annually. Many industries have beenwell studied for the presence of hazardous noise, but little exposure data exists for the amusement park industry.

Major attractions found at amusement parks fall within one of three categories and in each of those categories, five employee positions are common. This thesis sought to identify if there aredifferences in potential employee noise exposure among the ride types and if there are differences in noise exposure among the employee positions.

The analysis of the data indicated that dark ride types may be the loudest type of the three common types and that no position was found to be the loudest. The greeter position was likelythe least noisy position for most ride types.

# CHAPTER ONE:

# INTRODUCTION

Occupational noise is considered one the most common workplace hazards throughout the world, with routine exposures among 600 million workers worldwide and 30 million workers in the United States [Centers for Disease and Control and Prevention (CDC), 2018], (Wang et al., 2017), (Gitanjali & Ananth, 2003). According to the Centers for Disease Control and Prevention, ten million individuals in the U.S. have noise induced hearing loss (NIHL) because of occupational noise exposure (CDC, 2018).

A NIHL is caused by damage to the structures within the ear and is often called a hearing impairment (CDC, 2018). In addition, NIHL has safety and social implications when employees are prevented from communicating with co-workers, friends, and family [National Institute for Occupational Safety and Health (NIOSH), 2018]. This occupational injury can occur when there are excessive noise exposures in the workplace and may be intensified with noise exposures from outside the workplace. Not only do those who have NIHL suffer quality of life issues (Ciorba et al., 2012) they may suffer sleeping disorders, electrocardiogram abnormalities, and hypertension (Gitanjali & Ananth, 2003).

Speech bandwidths extend from 200 to 8000 hertz (Hz), however the region between 600 and 4000 (Hz) is the most critical to voice intelligibility (Berger, 2003). Since both hearing loss and noise can interfere with voice intelligibility, it may prevent employees from hearing instructions or warnings and should be considered in a risk analysis of the workplace.

Previous studies have focused on heavy industries such as mining, logging, and manufacturing (NIOSH, 2021), but little data has been analyzed that support amusement, gambling, and recreation industries found in the NAICS code of 713 (United States Executive Office of the President, 2022). Amusement parks with screaming guests; and loud background music; and themed entertainment areas could cause an environment that exceeds current limits on noise exposure. The United States Department of Labor lists 154,550 amusement and recreation attendants in the year 2020, which may increase with the demand for entertainment [United States Department of Labor (USDOL), 2021].

## CHAPTER TWO:

## BACKGROUND AND LITERATURE REVIEW

### Background on Noise Assessment

Sound that can travel thorough an elastic medium, is propagated as a wave of compressions and rarefactions and any sound in the workplace can be seen as occupational noise (OSHA, 2013). Noise is measured in units of sound pressure called decibels (dB), a logarithmic scale.

OSHA's hearing conservation program requires employers to monitor noise exposure levels to identify employees exposed to noise at or above 85 decibels (dB) an 8-hour time-weighted average (TWA) measured on the A scale, using slow response (OSHA, 2002). In addition to monitoring, OSHA's Occupational Noise Standard 1910.95 also requires a written program, audiometric testing program, a training program and recordkeeping (OSHA, 2008).

Identifying sources of noise can be the first step in controlling occupational noise. This can be accomplished by area measurements with a sound level meter configured to capture a Leq or a Lavg reading. OSHA's Technical Manual states that a Leq is the true equivalent sound level measured over the run time, and that is functionally the same as an L average (Lavg), except that the exchange rate is set to 3 dB and the threshold is zero (OSHA, 2013). Lavg thresholds typically follow the settings of OSHA's Hearing Conservation Amendment with the use of 80 dB threshold and an exchange rate of 5 dB (OSHA, 2013). The threshold used for Lavgs may result in levels that are notably lower that the actual levels in the environment since they only capture readings that meet or exceed the threshold (OHSA, 2013). To prevent the artificially low readings from a Lavg reading, Leqs are preferred.

**Background on Noise Assessment in Entertainment Industry**

Although many noise studies of other industries exist, very little data exists for the recreation industry (Gilbertson et al., 2017), (Kramer, 2014) Only two thorough studies were found for noise exposure in amusement parks including a recent thesis that reported carnival ride employees. The most robust information about noise exposure of amusement ride operators was reported by Gilbertson. Noise data from the gambling industries were also researched as they also fall under the same North American Industry Classification System (NAICS) code 713 (United States Executive Office of the President, 2022) and one Canadian gambling study was found.

Using the Gilbertson's study, (Gilbertson et al., 2017). The study found that rides which were operated with thematic music has significantly higher noise levels than those without music. Kramer's thesis focused only on sampling for noise at outdoor carnivals. Because carnivals are a temporary operation that are completely outdoors, there may be differences in noise exposures compared to indoor, permeant amusement parks. The study found personal dosimetry collected on 20 employees where they operated only one carnival ride during the study. Results of the study found that 80% exceeded the OSHA action limit. (Kramer, 2014). The international study of overall health and safety concerns in a Canadian casino did not provide quantified levels of noise exposures. However it used a risk analysis tool of hazard mapping and found that the patrons of the casino and the gaming machines to be main cause of noise.

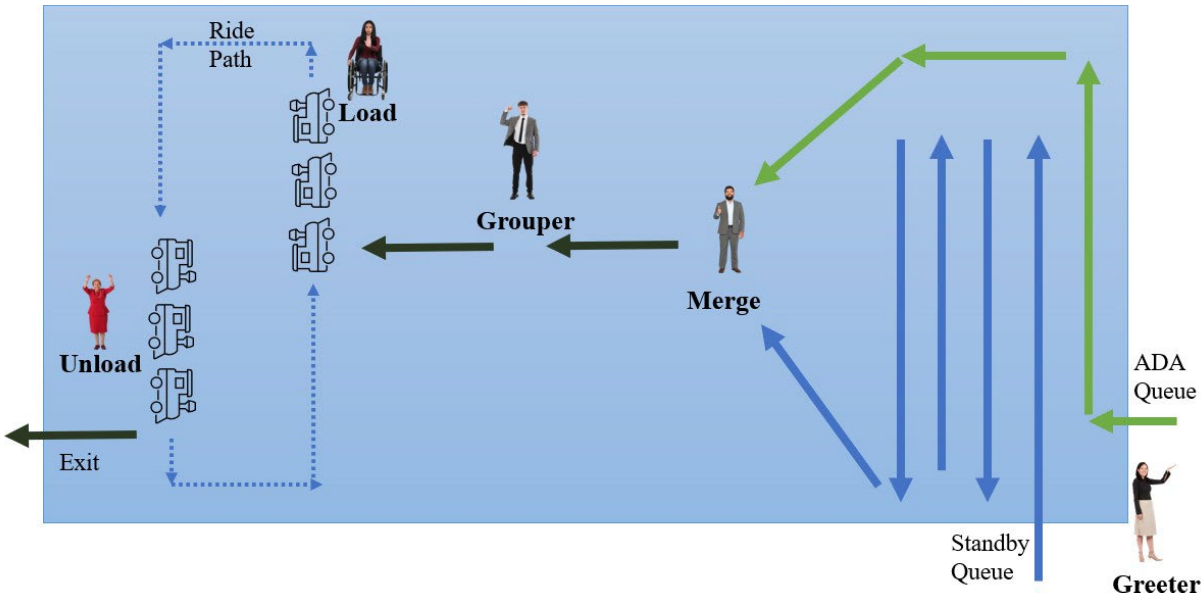
The literature review provided insight that attractions employees at theme parks may be at risk of over exposure to noise and identified that the noise may be generated by background music and guests of the entertainment venue.

**Study Details**

In amusement parks it is common for the employees to hold qualifying training for a specific attraction and to perform different positions within the operation of that attraction. Five common positions for attractions operations are greeter, merge, grouper, load and unload as illustrated in Figure 1. The greeter position can be found at the beginning of the standby attractions queue, and a shorter queue line which is designed for a reservation of the attraction or a guest with disabilities who may not be able to traverse the longer standby queue. Greeters encourage patrons to enter and are typically found outdoors. Merge position is found within the attraction building or covered structure which merges the two queue lines together to allow for better throughput of the attraction. Next, the grouper position will allocate guest parties into corresponding lines which leads to the load position employee, who assists guests entering ride vehicles. Once the ride vehicle has navigated the full ride path, the guests will encounter the unload position. This position assists guests out of ride vehicles and where they then can exit the attraction. Each position described here has its own noise exposure and are found commonly in large amusement parks operations. Front-line employees typically rotate through all positions every 45 minutes to prevent fatigue within the same attraction.

**Figure 1**

*Schematic of an Attraction with Operator Positions*




*Note.* Used with permission from Microsoft

While there are many different rides found in an amusement park, they can be categorized into three kinds: high energy rides, dark rides, and water rides. An example of a high energy attraction is a steel track rollercoaster. High energy rides tend to be the most thrilling, with the longest wait times and queues at amusement parks. They also typically require the highest guest height requirements, which in turn makes these attractions less family friendly. High energy attractions can operate completely indoors as like dark rides, outdoors or a combination of both. High energy attractions always exert G forces on the guest. It is common sense to think that these types of attractions will induce the highest level of patron's exciting screams and high paced, thrilling music is used to fill the queue and attraction to encourage the fun.

Dark rides feature a ride vehicle that slowly moves along a track in a building with low lighting and showcases animated figures in a story type setting. These attractions are the most family friendly. Dark rides are almost always found indoors with immersive music without intense passages and only exert low to no G-forces on the guest.

Water rides, which are also referred to as flume rides, involve a boat traveling through water on a track. These attractions range from slow moving and calm with little to no G-forces to quick and thrilling with some G-forces exerted. Slow moving is more family friendly than the quick and thrilling.

**Research Objectives**

The purpose of this thesis was to compare area noise exposure data from common positions held by hourly amusement park employees in different ride categories to prioritize noise sampling strategies by finding the loudest position and the loudest ride type.

There are other ride types with different types of employee positions, usually only needing two or three employees to run the attraction and much less likely to have high noise levels.

The following were the study hypotheses:

H1: There are differences in noise exposure among the employee positions.

H2: There are differences in noise exposure among the ride types.

## CHAPTER THREE:

## METHODS

### Experimental Design and Procedure

The Leq samples were gathered to profile specific job assignments, also referred to as task analysis. The data was collected and analyzed by either an in-house Certified Industrial Hygienist (CIH), or by a member of the Industrial Hygiene team under the supervision of the CIH and the author was able to confirm documented calibration records and sampling protocol.

The data was collected by using an appropriately pre and post calibrated, type II sound level meter (SLM). The SLM equipment used to collect the data was either a Quest™ SoundPro™ Sound Level Meter SE-DL (TSI incorporated, Shoreview, Minnesota) or a Quest™ 2900 Sound Level Meter of the same manufacture. Both SLMs were found to be within factory calibration. Pre and post calibrations were conducted with either a Quest QC-10 or QC-20 acoustic calibrator, which were found to be within factory calibration as well. The documented records associated with each data point represented that all samples' results must be within 0.5 dB during pre- and post-calibration.

The SLMs were positioned to prevent the user or surrounding equipment to influence the recorded noise levels and was placed approximately five feet above the ground to simulate hearing space zone. The SLM's settings recorded noise exposure using a three dB exchange rate, with the response set to slow, a criterion level of zero with a sampling rate at one second and each sample was between thirty minutes to one hour. An example of a type II SLM is see in Figure 2.

**Figure 2**

*Example of a Type II SLM*

*Note:* https://www.osha.gov/otm/section-3-health-hazards/chapter-5 https://www.osha.gov/otm/section-3-health-hazards/chapter-5

**Data Analysis**

Descriptive statistics and a two-way ANOVA with effects tests for the type of ride, operator position and a type of ride by operator position was conducted using both JMP (version 16) and SPSS (version 27) software were used. The analysis allows for a comparison of noise exposures for the five positions versus ride categories.

## CHAPTER FOUR:

## RESULTS

The analysis of the 180 $L_{eq}$ samples that follows was conducted using data gathered in ten different attractions over a period of five years. The ten attractions were all operated by the same employer and averages were only collected during peak periods of high patronage in the theme park representing worst case scenarios.

The samples in the following analysis came from one of three ride types, including high energy rides (n = 4), dark rides (n = 3) or water rides (n = 3). Each attraction's name was renamed with a generic title as to sanitize the data.

Each of the 180 samples were also categorized into one of the five different types of positions, greeter (n = 48), grouper (n = 22), load (n = 44), merge (n = 29) and unload (n = 37). All employees that rotate between these positions frequently throughout their workday have the same, hourly role. The employer rotates employees through these roles approximately every 45 minutes to prevent fatigue and to allow for breaks. No demographic information of the employees who were working was sampling was conducted was collected.

Basic descriptive statistics including sample size (n), mean and standard deviation (sd) for the 180 Leq samples as the dependent variable are reported in Table 1. Of the overall 180 Leq samples, the mean was 81.7 and a standard deviation of 3.9. For the three ride types, water, dark and high energy there were 42, 61 and 77 samples collected with a mean of 81.0, 82.9 and 81.0, with a standard deviation of 3.5, 4.2 and 3.9 respectively.

The highest mean reported for all positions in all ride types was the grouper position in dark rides (89.3 dB), although there was only one observation. The next three highest means seen is for the load position in dark rides (84.1 dB, sd = 3.5), the load position at high energy rides (83.5 dB, sd = 2.2) and grouper position at water rides (82.7 dB, sd = 2.5). The three lowest means seen in the table is the merge position at dark rides (81.2 dB, sd = 5.3), the greeter position at water rides (79.6 dB, sd = 3.9), and the greeter position at high energy rides (77.2 dB, sd = 3.3). Without using the average at the grouper position in dark rides (89.3 dB), the highest mean is the load position in dark rides (84.1 dB, sd = 3.5) and the lowest mean is the greeter position at high energy rides (77.2 dB, sd = 3.3). It should also be noted that two of the highest means were loader and two of the lowest means were found at greeter, which could suggest that they represent the two spectrums in the analyzed samples.

To further analyze the data, an analysis of variance with an associated effects test was conducted. Table 2 represents the information gathered from the two-way ANOVA performed with an alpha set to 0.05 ($\alpha = 0.05$).

As seen in Table 2, there was a significant difference ($P < 0.0001$), so an effects test was conducted. Table 3 describes the F statistic using an alpha of 0.05. The ride type, operator position and the ride type by operator position were found to be significant.

The effects test details regarding the ride type and operator position are seen in Table 4. Levels which are not connected by the same letter are found to be statistically significantly different using JMP software.

**Table 1**

*Descriptive Statistics for Leq Samples*

| | Greeter | | | Grouper | | | Merge | | | Load | | | Unload | | | Total | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ride Titles | n | μ (dB) | sd | n | μ (dB) | sd | n | μ (dB) | sd | n | μ (dB) | sd | n | μ (dB) | sd | n | μ (dB) | sd |
| Water Ride | | | | | | | | | | | | | | | | | | |
| Water 1 | 3 | | | 0 | | | 3 | | | 4 | | | 4 | | | 14 | | |
| Water 2 | 3 | | | 1 | | | 1 | | | 4 | | | 4 | | | 13 | | |
| Water 3 | 5 | | | 6 | | | 1 | | | 0 | | | 3 | | | 15 | | |
| Total | 11 | 79.6 | 3.9 | 7 | 82.7 | 2.5 | 5 | 81.2 | 4.4 | 8 | 80.7 | 3.2 | 11 | 81.5 | 3.5 | 42 | 81.0 | 3.5 |
| Dark Ride | | | | | | | | | | | | | | | | | | |
| Dark 1 | 0 | | | 0 | | | 5 | | | 5 | | | 4 | | | 14 | | |
| Dark 2 | 11 | | | 1 | | | 5 | | | 9 | | | 5 | | | 31 | | |
| Dark 3 | 4 | | | 0 | | | 7 | | | 3 | | | 2 | | | 16 | | |
| Total | 15 | 82.4 | 3.5 | 1 | 89.3 | - | 17 | 81.2 | 5.3 | 17 | 84.1 | 3.5 | 11 | 83.9 | 2.9 | 61 | 82.9 | 4.2 |
| High Energy | | | | | | | | | | | | | | | | | | |
| Energy 1 | 6 | | | 9 | | | 2 | | | 9 | | | 6 | | | 32 | | |
| Energy 2 | 7 | | | 3 | | | 2 | | | 4 | | | 5 | | | 21 | | |
| Energy 3 | 8 | | | 2 | | | 2 | | | 4 | | | 3 | | | 19 | | |
| Energy 4 | 1 | | | 0 | | | 1 | | | 2 | | | 1 | | | 5 | | |
| Total | 22 | 77.2 | 3.3 | 14 | 83.3 | 3 | 7 | 81.9 | 2.3 | 19 | 83.5 | 2.2 | 15 | 80.9 | 3.5 | 77 | 81.0 | 3.9 |
| Overall Total | 48 | | | 22 | | | 29 | | | 44 | | | 37 | | | 180 | 81.7 | 3.9 |

**Table 2**

*Analysis of Variance*

| Source | DF | Sum of Squares | Mean Square | F Ratio | F |
|---|---|---|---|---|---|
| Model | 14 | 822.9 | 58.8 | 4.83 | - |
| C. Total | 179 | 2829.6 | - | - | <0.0001 |

*Note:* (α = 0.05)

**Table 3**

*Effects Test by Source*

| Source | DF | Sum of Squares | F Ratio | Prob > F |
|---|---|---|---|---|
| Ride Type | 2 | 134.9 | 5.5 | 0.005 |
| Operator Position | 4 | 307.7 | 6.3 | <0.001 |
| Type * Position | 8 | 208.8 | 2.1 | 0.03 |

*Note:* (α = 0.05)

The effects test for ride types showed that dark rides (82.9 dB) are noisier than Energy and Water (81.0 and 81.0 dB respectively). The effects test for operator position showed that the Grouper position had the highest mean (83.4 dB), but that the Load position was a close second at (83.2 dB). The Greeter position was found to be the least loud at 79.4 dB.

An interaction test for ride type by operator position was performed showed significant finding. The Greeter position on Energy rides was the lowest at 77.2 dB. No other consistent observations were made.

**Table 4**

*Effects Details for Ride Type and Operator Position*

| Source | Mean (dB) | Letter Assignment* |
|---|---|---|
| Ride Type | | |
| Dark | 82.9 | A |
| Energy | 81.0 | B |
| Water | 81.0 | B |
| Operator Position | | |
| Grouper | 83.4 | C |
| Load | 83.2 | C |
| Merge | 81.4 | CD |
| Unload | 81.9 | D |
| Greeter | 79.4 | C |

*Note:* * Levels not connected by same letter are statistically significantly different
($\alpha = 0.05$)

# CHAPTER FIVE:
# DISCUSSION & CONCLUSIONS

## Discussion

The lowest noise was found at energy rides, at the greeter position at 77.2 dB and the second lowest noise occurred at energy rides in the greeter positions (79.6 dB).

Information provided in the same table also shows that the dark, grouper position only had one Leq sample, where the dark, load position had 17 samples. Since both positions were found to be in dark rides, it could be considered that that ride type has the loudest exposure. Dark rides are family friendly and can be considered less thrilling and are not known for the shrieking and shouting of fans of high energy attractions. The background music of the themed story-type attraction may be a large contributor to noise levels since they are always found in enclosed buildings, whose walls may reverberate leading to the increased noise levels found.

The merge position least square means were highest, in the high energy attractions at 81.9 dB, and both the dark rides and water rides were found to be at 81.2 dB. This analysis did not provide reliable indication that any position was the loudest, it did however show that the greeter positions were likely to be least noisy position. This is expected because the greeter position is located outdoors and is at the very entrance of the queue where patrons of the attraction typically do not congregate or create noise. There also is typically less, intensified background music in this unenclosed area.

The literature review provided that there may be an overexposure of noise to employees, but the data collected in this study shows that they may be less at risk at this particular location.

Although efforts were made to ensure appropriate pre- and post-calibrations were conducted and that the trained professional placed the sound level meter in such a way to capture the best sample was made by reviewing internal operation guidelines, it is possible that other factors may have affected the quality of the Leq samples. Another source of error was data transcription from multiple records. Beyond ordinary diligence, a standard procedure for data transcription was not followed.

The employer may choose to conduct continued analysis of Leq from additional attractions within the organization or theme parks with similar ride types and positions. Specifically in the case with one observation, additional data should be gathered from the grouper position in dark rides. Concrete conclusions regarding the loudest attraction type and position could lead appropriate capital planning for retrofitting attractions with engineering controls or in the design review of new attractions.

**Conclusion**

The purpose of this thesis was to compare area noise exposure data from common positions held by hourly amusement park employees in different ride categories to prioritize noise sampling strategies by finding the loudest position and the loudest ride type. the study hypotheses that there are differences in noise exposure among the employee positions and that there are differences in noise exposure among the ride types.

Overall, the averages of all ride positions in each ride type were found to be very close (water, 81.0; dark, 82.9; and energy, 81.0), where dark ride types were found to be the noisiest type of attraction compared to high energy rides and water rides. This may be attributed to the nature of most dark rides being an enclosed building with loud, story-telling music.

Although this analysis did not provide consistent evidence that any position was the loudest, it did however show that the greeter positions were likely to be least noisy position. This is likely because the role is always found outdoors in all attractions away from background music and only has limited exposure to patrons of the amusement park. This study could be studied further by gathering additional samples in more attractions across different locations and employers.

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## APPENDIX A

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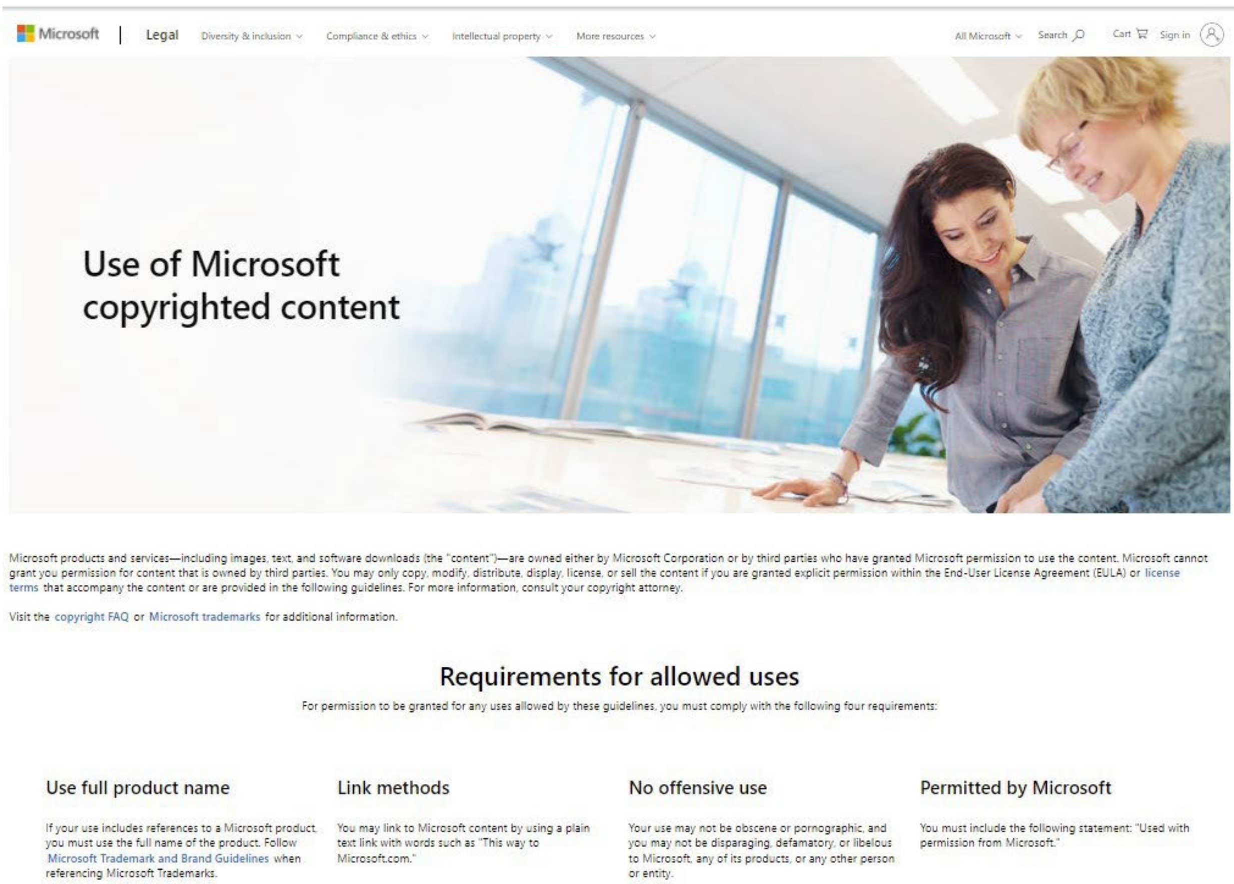
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