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ARCHITECTURAL ACOUSTIC FOR THEME PARKS

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ABSTRACT
The room acoustics, low noise mechanical and HVAC system, and a high quality sound system are the means to provide a high quality show for the audience. As the demand for increasingly exotic entertainment intensifies, more thoughtful design of architectural acoustics and noise control of mechanical systems to meet lower noise criteria will be required. While noisy roller coasters have been the norm in an amusement/theme park this has now changed. Now there maybe a requirement for extremely quiet auditoriums next to a wild roller coaster, where the audio content of the program is critical. This will play an even larger role in the whole spectrum of theme park acoustical design and noise control. The field of Acoustics and Noise Control will continue to be a major function for current expansions, and future theme park design [1].

1 - INTRODUCTION
New theme parks are being planned and built throughout the world. Existing parks are expanding to provide bigger and better thrill rides, and dark ride attractions to provide high quality family entertainment. Theme park attractions are similar to other projects. The difference is that the theme acts as the backdrop for the design. In addition, the noise impact from one attraction to another must be considered in the design process.

Since theme parks are show business the view the public sees is only a facade that is similar to a movie set. Behind the facade there is a great deal of mechanical equipment is required to operate the attraction, ride or show. The equipment might be electrical motors, pneumatic systems with air compressors, water and hydraulic pumps, sophisticated sound systems, and a variety of air conditioning equipment.

The attractions might be: a low noise criteria auditorium with a 3-D movie and laser show; live performances; a dark ride with sophisticated vehicles; roller coaster; and other thrill rides. The sound isolation required between scenes in the interior of a thrill ride or to contain the high energy sound system provides challenges and opportunities for the acoustic and noise control designer. Computer models are used to evaluate the array of noise sources and their interrelationships [1]. The purpose of this paper is to discuss recent Architectural Acoustics and Noise Control Engineering experience for Theme Parks.

2 - THE CRITERIA
At the beginning of any discussion of Architectural Acoustics the design criteria must be discussed. Two types of criteria are generally considered are: Reverberation Time (RT60) and the HVAC Noise Criteria (NC). The interior room acoustics criteria is RT60 and is dependent on volume and type of space. The RT60 ranges for room volumes of 1000 to 100,000 cu. ft. from 0.8 to 1.4 seconds at 500 Hz. Above room volumes of 100,000 cu. ft. the RT60 ranges from 1.2 to 1.4 seconds depending upon the type of space. The NC values are based on the consensus standard from The American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE). The Table 1 illustrates examples of the NC and RT60 criteria for various spaces.

LOCATION	NOISE CRITERIA	RT60
Kiddy Dark Rides	35	1.0 − 1.4
Adult Dark Rides	45	0.8 − 1.2
Walking Tours	35	0.8 − 1.2
Preshow and Post Show	35	1.0 − 1.4
Theaters	25-35	0.8 − 1.2
Outdoor (MEP equipment)	45	N/A
Retail	40	1.0 − 1.4
Fine Dining	35	0.8 − 1.2
Fast Food and Cafeteria	35-40	1.0 − 1.4
General Public Areas	40-45	1.0 − 1.4
Employee Break Rooms	40-45	N/A
Kitchen	45-55	N/A

Table 1: Typical criteria.

3 - NOISE SOURCES

Noise sources are in every corner of a Theme Park. This ranges from the most thrilling new coaster to the interior of a dark ride with a 3D multi-screen show with a massive sound system to all of the mechanical equipment to operate the show. Typical levels for various attractions are illustrated in Table 2 [1]:

SOURCE	dBA	CONDITION	NOTES
House of Blues	103	Max levels for show (116 dBL)	Reference [3], Author's Data
Auto Race Show-Theatre	94-96	Leq duration of race show	Author's Data
Cirque du Soleil Mystere Theatre Show Las Vegas	88	Leq near mix position for show	Reference [4], Author's Data
Themed movie attraction based on fires with simulated explosions	111 L1, 108 Leq	50 ft from sources in audience area	Author's Data
Flashback Roller Coaster	85-90	At grade below track at 40 ft	Author's Data
Aircraft motion based simulator attraction	98	Leq Inside theater for duration of ride	Author's Data
800 seat 3D with 3 screens movie attraction	97 Leq, 110 max	For a 15 minute show	Author's Data
Kids cartoon movie attraction in theater	102 L1, 96 Leq	Levels for show	Author's Data
Wild Arctic Ride Sea World Orlando, Fl	88	Motion based simulator ride Leq for show	Author's Data
Ride through popular movie attraction	101 L1	For a 5 minute ride through dark ride (108 dBL)	Author's Data

Table 2: Typical theme park noise levels.

4 - ARCHITECTURAL ACOUSTICAL CONSIDERATIONS FOR A DARK RIDE

The following discussion will focus on the design process and Architectural Acoustic implication for a Dark Ride

4.1 - Dark ride external noise intrusion

An example of this in a recent dark ride design is a wild west show performed in an outdoor amphitheater adjacent to a new movie themed dark ride. With levels of gunfire and other high level sound effects within 100 feet (31 m) distance a tilt up 9 inch (228.6 mm) concrete building with a 6” (152 mm) light weight concrete roof was selected to achieve the NC45 criteria inside the dark ride. The interior L90 sound levels of the dark ride sound system were compared to the L10 levels of the exterior noise to insure that the criteria could be achieved. The HVAC equipment was also evaluated to insure that the criteria could be achieved. In most cases this is not a major issue since a higher noise criteria is allowed for Dark Rides. In addition, the show audio levels can be quite high as noted above.

4.2 - Attraction entry experience

In most Parks, with a variety of attractions, the show lengths is from 7 to 15 minutes and may even be 30 minutes. The goal is to have a high volume of people per day going through the attraction. There may be as many as 18 to 25 shows per day with 100 to 800 per show. This is accomplished using a queue line and pre-show. The queue line usually shows advertising and something about the show on video screens located above the serpentine queue line. In a hot environment there may be cooling fans that can mask the audio if not properly evaluated. In many popular attractions there might be an overflow queue. In this situation the Guests might be near another attraction. A maximum level of 75 dBA has been used to provide a comfort level for this type of Guest area. The Guests then move into the pre-show. The pre-show is a longer and more thorough preview of the show. There might be live actors, multi-screen video, or both. The high sound levels from the show must be isolated from the pre-show to maintain the surprises in store for the Guest. Usually, show action doors separate the pre-show area from the show. The door systems can be: double acoustical doors with a 4 to 6 foot (1.24 to 1.86 m) air space; one acoustical door and one insulated metal door; or one heavy duty acoustical door with masonry walls. The walls must be designed to be compatible with the doors to have a good sound barrier. The HVAC system must be separated between the two spaces to eliminate noise intrusions.

4.3 - Dark ride interiors

The interior of an attraction must be designed for the reverberation criteria as shown above. For most dark rides the interior of the building is lined with a 2 to 4 inch (5.08 to 10.16 mm) black fiberglass. The ceiling might be sprayed with some type of absorptive insulation like a cellulose fiber for ease of installation. The wall material might extend half way down since the set pieces for the dark ride will vary in height. The purpose of this treatment is to sound condition the larger space. For a 50 ft (15.5 m) building the set pieces can vary from 12 to 30 ft (3.6 to 9.3 m). The sets are themed for the show. Above the sets there are catwalk systems, large HVAC ducts presenting large reflecting surfaces, lights, etc. The acoustical designer must work closely with the set designer and show producer to understand the show, the sound effects and sound system arrangements. Consideration of some absorption to reduce local reverberation must be given in the design process. Since the dark ride is lighted for the show there are many opportunities to place absorptive material, and other noise control materials as part of the show set design. Reference [1] illustrates specific case histories.

4.4 - Isolation between scenes

Usually the Guests ride in a vehicle. The vehicles in some of the newer attractions are computer controlled and have six degrees of movement. This allows the show designer to turn the Guest toward the action in the set to continue the story. As the vehicle moves from scene to scene there may be isolation doors, and the acoustical designer must be aware where the sound effects and sound system speakers are located are located in each scene. The isolation of sound from scene to scene is important. The story line must be preserved and not given away due to sound overflow from the adjacent scene. Therefore, the L90 sound level in one scene must be compared with the L10 level in the adjacent scene both through the show set and sound isolation wall, over the top of the wall, around the corner and into the next scene. The partitions between scenes might be heavy gage studs with multiple layers of sheet rock or in some cases light weight masonry has been used. The partition design is a challenge since the sound effects, audio, and show set design may come last in the design sequence while the partitions separating the scenes must be designed early in the process. A partition design in the range of STC55-65 usually provides satisfactory results. The design of the building interior acoustics, HVAC noise control, audio and sound effects noise control from scene to scene and adding absorption in the final show set design is a typical sequence in the design process. In addition, there is usually a great deal of low frequency sound energy within these attractions. There are always final adjustments that must be made and evaluated to insure that the attraction is true to the initial concept acoustically.

REFERENCES

1. **Howard K. Pelton**, Theme Park Noise Control, *Noise Control Engineering Journal*, Vol. 47(5), pp. 169-172, 1999