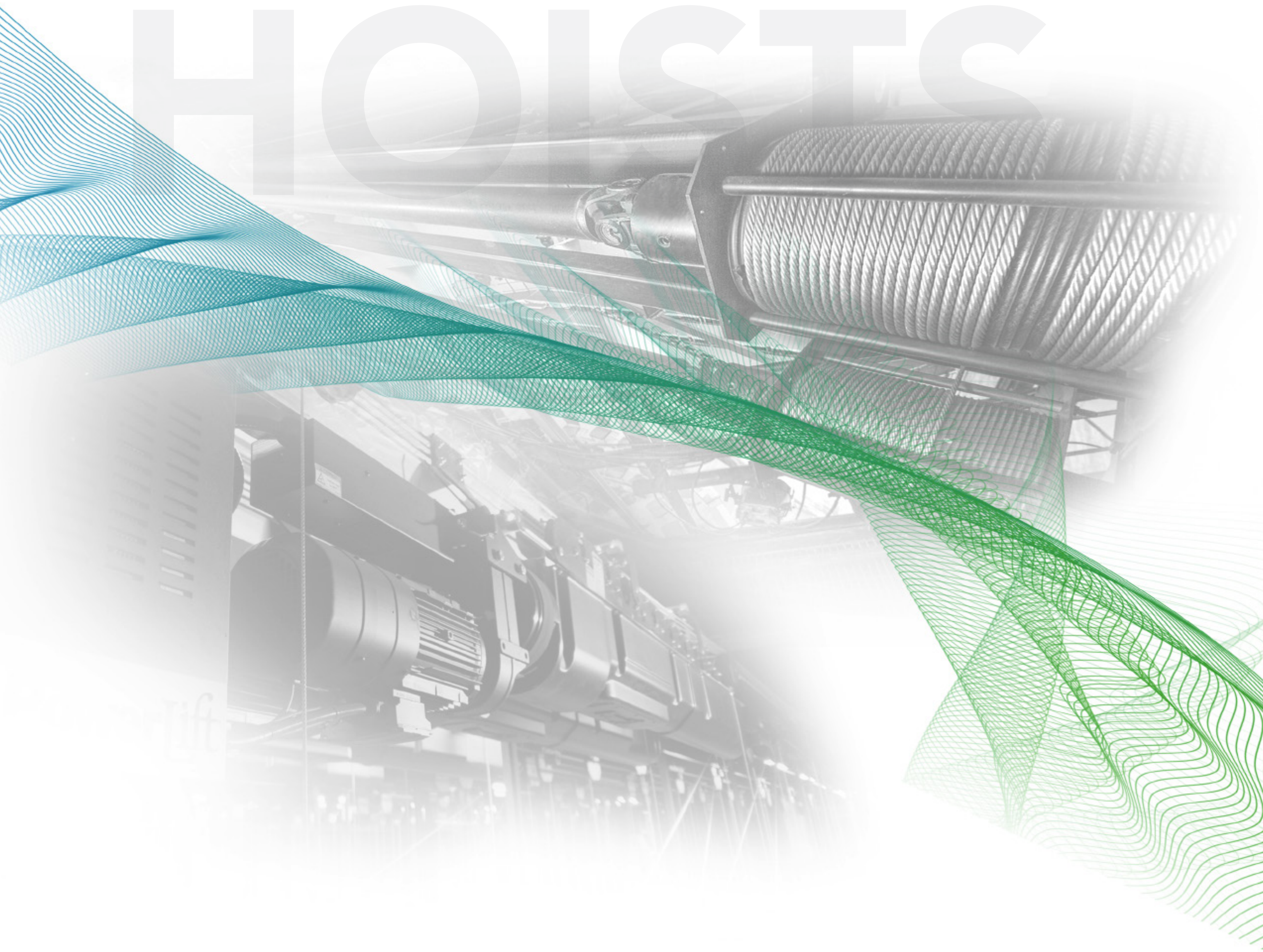

HOISTS IN ENTERTAINMENT APPLICATIONS:

What You Should Know About Redundant Brakes and Controller Functions

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Overview – Different Hoists for Different Applications

Applications of lifting equipment to the entertainment industry are considerably different from applications for general industry. Factors such as the speed of the hoist, visibility of the load and lighting conditions can vary greatly from those expected for construction and manufacturing.

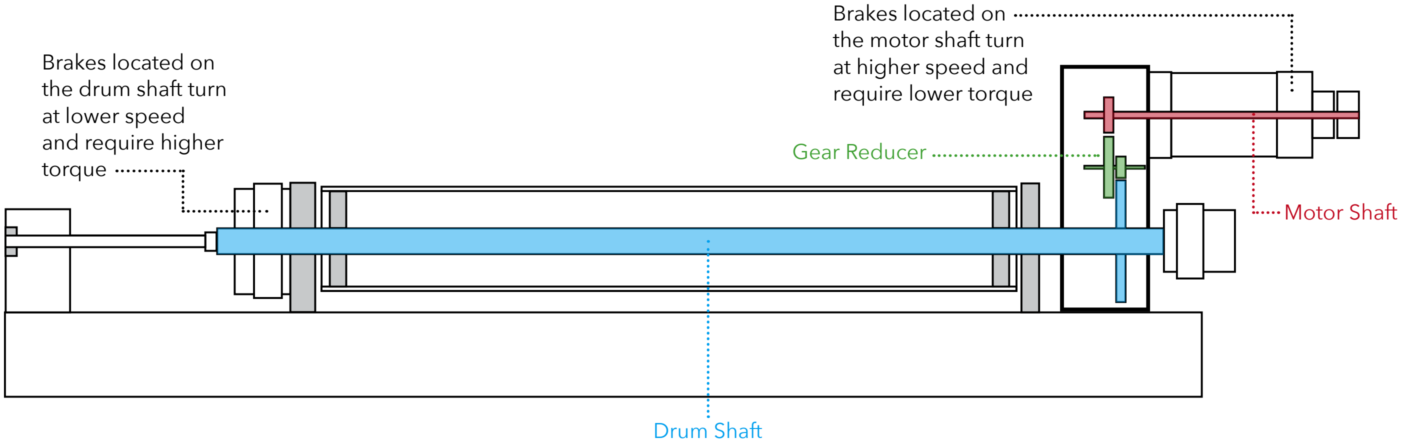
In the entertainment industry, one of the most basic distinctions is that it is anticipated that performers and technicians will need to occupy the space below the suspended or moving loads. This is in stark contrast to industrial hoisting where walking beneath the load is typically prohibited. Whereas the industrial and theatrical equipment standards have many requirements in common, the additional risk created by operational requirements in entertainment is manifested in published standards in several ways.

One of the requirements specific to theatrical equipment is for two independent means of stopping and holding the suspended load when the hoist motor is deenergized. These brakes can be located together or apart, and in various locations within the power transmission; the machine designer must consider the brake locations in conjunction with the system in its entirety to ensure a reliable design.

Brake Locations

Redundant brakes are now a requirement common to theatre equipment standards in both the United States and Europe. This was not the case in the U.S. until relatively recently. ANSI E1.6-1 Entertainment Technology – Powered Hoist Systems was first published in 2012. Prior to that time many hoisting machines included only one holding device, consistent with the practices of general industrial lifting. The combination of the adoption of standards and the increased hoist manufacturing volume has presented an opportunity for manufacturers to innovate, invest more engineering and product testing to optimize the designs for performance, economy, and conformance to the standards. Brakes are one of the most important features on a hoist and can also be one of the most costly. Considerable time and effort has gone into optimizing their design.

Figure 1:
Example of a Power Transmission for a Drum Hoist



A basic power transmission for a wire rope hoist can be seen in Figure 1. The motors typically turn at thousands of revolutions per minute, and they have a relatively low torque compared to that required to turn the drum and lift the load. The gearing reduces the speed and multiplies the torque of the motor, and it is the output shaft of the gear reducer to which the drum is connected. A brake connected to the motor shaft requires a torque comparable to that of the motor, which is small compared to that required to turn the drum. A brake connected to the shaft on the output (drum) side of the reducer requires much greater torque to arrest the same load. Neither the European nor the U.S. standards require that brakes to be located at any specific location in the power train for a typical theatrical hoist application.

Integrating Functions of Machinery and Controls

Hoist builders anticipate and take steps to prevent a wide variety of conditions that could lead to loss of control of the lifted load, including failure of any of the hundreds of components that make up the machine. The mechanical elements in the path between the lifted load and the motor or brakes are critical in this regard, and there are several widely used methods for mitigating the risk of failure. The first is simply increasing the strength of the component. A greater design factor decreases the likelihood of failure under a wider range of circumstances, therefore critical elements tend to be designed more conservatively. Another way is redundancy, where included in the design is a second component or other feature that will prevent the loss of the first from resulting in the load being released. An additional method of controlling the risk of failure is the inclusion of sensors and logical functions to ensure that the components are not subject to loads outside that for which they are designed. Risk control methods such as these are used alone or in combination depending on the severity of the hazard to which the user would be exposed in the event of a failure.

EN 17206 is a European stage equipment standard that offers specific guidance about how redundancy, design factors, and control functions can be combined in power transmission design. The standard requires two brakes and does not specify where the brakes are located. It does, however, require specific calculations and design factors for any components between the drum and the brakes. These calculations require the designer to consider the dynamic loads on the components in normal use, in the case of emergency stops, and uncontrolled stops such as those that occur when power supplied to the machine is lost.

The standards also identify sensors and onboard processors to monitor and prevent the user from applying forces outside those anticipated by the design. A sensor to measure the torque on the rope drum is included on each machine. The torque is measured continuously and compared to the allowable limits. If an overload condition occurs, either at rest or in motion, the controller will disable travel in a controlled fashion and signals the user to correct the load hoist to within the limits. The load sensor can also identify underload conditions, thereby helping to alleviate slack line conditions and limit the possibility of resulting shock loads.

On hoists where accelerations can be varied by the user, the controller will ensure that start and stop durations are within the limits of use. The speed of the rotating drum is also continuously monitored and compared to the commanded value. This measurement helps to identify snag conditions as well as uncontrolled movement. The intention is to monitor for and prevent conditions, in both normal use and in the case of accident or misuse, that will result in forces outside of the design envelope. Other sensors monitor the status of the equipment itself. The open/close status and the response of each brake is monitored at every move and in the event of an aberration the controller will prevent the machine from being operated until the condition can be rectified.

Conclusion

Many successful theatre hoists designs are in use around the world today and the preference for the location of the brakes within the transmission varies by region. Manufacturers around the world have collaborated to publish standards that provide guidance to engineers designing responsible solutions in any case. Sensors, programmable electronics, and the methods by which they are employed to improve machine safety also continue to advance rapidly along with tools for analyzing and designing components. All of these factors combine to present opportunities for newer and more efficient designs.

STANDARDS:

ANSI E1.6-1 – 2012: Entertainment Technology – Powered Hoist Systems. Published by Entertainment Services and Technology Association.

EN 17206:2020: The Standard for Stage Machinery Design. Published by British Standards Institution.

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