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RESEARCH ARTICLE

Evaluation of Material Handling Workers Using Snook's Table: A Case Study

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ABSTRACT - Material handling presents numerous occupational hazards for workers, with the efficient transfer of heavy items being essential for operational efficiency. Precise execution of tasks according to industry standards is paramount to maintaining product quality and minimizing defects. However, workers' adoption of awkward postures can adversely affect their health and hinder their ability to meet company targets. Originally focused on determining safe lifting limits, Snook's Table has evolved into a comprehensive tool for assessing ergonomic risks associated with various manual tasks. Its adaptation to changing workplace dynamics underscores its importance in promoting workers' health and safety. In this study, Snook's Table was employed to evaluate workers' posture, distinguishing between healthy and awkward stances. A risk index was provided, where scores exceeding 1.0 indicated high-risk conditions. Eight workers were assessed across pulling, pushing, lifting, and carrying activities. The results revealed that 5 workers exceeded the 1.0 risk index in pushing activities, while none surpassed it in pulling tasks. However, 6 workers scored more than 1.0 in lifting and carrying activities, indicating potential risks associated with these tasks. To mitigate such risks, aided tools like trolleys can improve the Snook's Table index and prevent awkward postures. Additionally, the 3D Static Strength Prediction Program (3DSSPP) evaluates postural balance to enhance worker safety. Improving postures and utilizing aided tools not only reduces the risk of worker injuries but also enhances work effectiveness. By addressing ergonomic concerns and implementing preventive measures, companies can create safer work environments while optimizing productivity.

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1. INTRODUCTION

Material handling workers are individuals who are responsible for the movement, storage, and control of materials in various industries, such as manufacturing, warehousing, distribution, and logistics (Workplace Safety, n.d.). Their work mainly involves lifting, pushing, pulling, and moving objects using their hands. Manual material handling (MMH) poses a significant concern regarding human-machine interaction, as carts may operate in environments with parameters that differ from those used in their design, thereby exposing workers to the risk of musculoskeletal disorders (Greco et al., 2018).

Snook's Table was developed by Dr. Stover Snook and Dr. Vincent Ciriello from the Liberty Mutual Research Institute as a scientific way of determining safe weights and forces for manual material handling tasks. It gathers data on weights and forces chosen by workers to determine the maximum acceptable limits for lifting, lowering, pushing, pulling, and carrying tasks (Mohammadi et al., 2013). Snook's Table has the capability to determine the percentage of male or female workers who can perform certain jobs (Kandananond, 2018). It offers additional adjustments and refinements to the original equation to account for different variables, such as the lifting technique, asymmetrical lifting, and other task characteristics. By using Snook's Table, ergonomists and occupational health professionals can estimate the risk of musculoskeletal injuries associated with manual lifting tasks. This provides guidelines for determining the recommended weight limit and acceptable lifting conditions based on the specific parameters of the task.

2. LITERATURE REVIEW

2.1 Material Handling

Material handling is the movement, storage, protection, and control of movement and goods from one location to another throughout various stages of manufacturing, distribution, consumption, and disposal by pulling, pushing, lifting, carrying, and lowering (Dev, 2022). It encompasses a wide range of activities, equipment, and systems designed to facilitate the efficient and safe handling of materials in industrial settings. The purpose of material handling is to reduce costs, improve productivity, and optimize supply chain operations in various industries. Material handling also refers to the systematic and scientific method of moving, packing, and storing material in an appropriate and suitable location. The main objectives of material handling are as follows:

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i) It determines the appropriate distance to be covered.
ii) It facilitates the reduction in material damage to improve quality.
iii) It reduces overall manufacturing time by designing efficient material movement.
iv) It improves material flow control.
v) It facilitates the creation and encouragement of safe and hazard-free work conditions.
vi) It improves productivity and efficiency.
vii) It promotes better utilization of time and equipment.

It is critical for manufacturing organizations to identify the importance of material handling principles in promoting the job improvement process. Manual material handling significantly increases health hazards for workers, particularly from lower back injuries. Figure 1 shows an example of how material handling works (Massey, 2017).

Manual material handling can impose significant risks as a result of doing activities like lifting and lowering, pushing and pulling, rotating, carrying, and holding against an object. These risks can have adverse effects on both workers and the company (Kusuma et al., 2023). For example, lifting, carrying, pushing, or pulling heavy objects manually can lead to strains, sprains, back injuries, and musculoskeletal disorders. Improper lifting techniques, repetitive motions, and overexertion are common causes of these injuries, which can have a long-term impact on the workers' health.

Figure 1 shows that the number of occupational injuries in Malaysia was 21,534 cases in 2021, a 34.1% decline from 32,674 cases recorded in 2020. This subsequently reduced the rate of occupational injuries per 1,000 workers by 0.75 points to 1.43 in 2021, as opposed to 2.18 in 2020. Such a decrease can be attributed to the COVID-19 pandemic, in comparison to more than 20,000 cases reported throughout 2012 to 2018 (Department of Statistics Malaysia, 2022). Manual material handling is one of the dangerous tasks in workstations (Rajendran et al., 2021). Aside from the impact on physical health, workers involved in manual material handling are also vulnerable to other risks like falling objects and trip hazards as a result of improper stacking, inadequate storage systems, or unstable loads, thus causing serious injuries (Caster Concept, 2023).

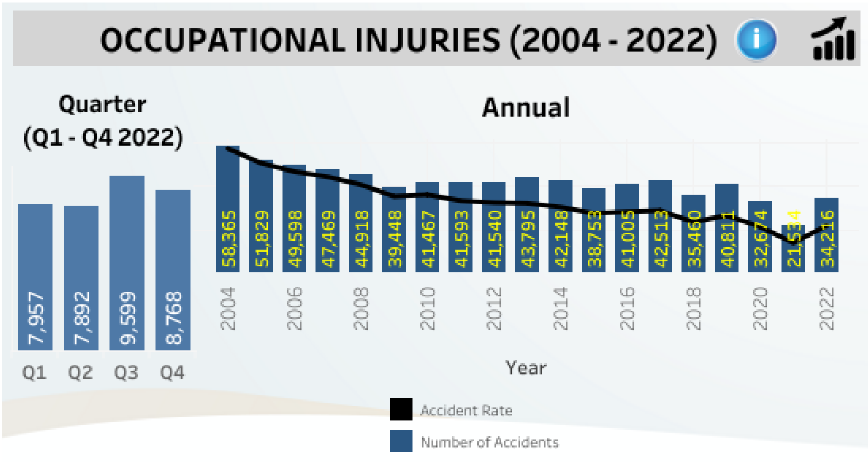

Figure 1. Occupational injuries rate in Malaysia (2004-2022)

2.2 Snook's Table

Snook's Table was first introduced by Dr. Stover Snook and Dr. Vincent Ciriello at the Liberty Mutual Research Institute for Safety to establish design objectives, quantified in pounds of weight or force, acceptable for a specified percentage of the population (Raymundo et al., 2019). This is accomplished by comparing information for each of the distinct manual handling tasks to the relevant table. If the task-specific data does not align with the values provided in the table, workers must choose the nearest higher table value that closely matches the actual requirements of the task (Bang, 2022). Snook's Table is often used to assess a variety of manual handling tasks, such as lifting, lowering, pushing, pulling, and/or carrying (Middlesworth, 2012). A risk index value of 1.0 or less is a nominal risk to healthy employees, while a value greater than 1.0 denotes that the task is high risk for some fraction of the population. Specifically, a risk index value below 0.85 is considered low risk, 0.86 to 0.99 is considered medium risk, and more than 1.0 is considered high risk (Snook & Ciriello, 1991). As the lifting index increases, the level of injury will increase correspondingly. Therefore, the goal is to design lifting jobs with a lifting index of less than 0.85.

Figure 2. Example of lifting posture

Table 1. Example of Snook's Table for lifting posture

Floor to Knuckle (Below 29 in)		Horizontal Distance (Front of Body to Hands) (in)								
		7			10			15		
		Distance of Lift (in)			Distance of Lift (in)			Distance of Lift (in)		
Frequency		10	20	30	10	20	30	10	20	30
1 / 8 h	1 / 8 h	51	48	42	42	40	35	40	37	31
1 / 30 min	2 / 1 h	37	35	31	31	31	26	29	29	24
1 / 5 min	12 / 1 h	33	33	29	29	26	22	26	24	22
1 / 2 min	30 / 1 h	33	33	29	26	26	22	26	24	22
1 / 1 min	1 / 1 min	31	31	26	26	24	22	24	22	20
1 / 14 s	4.3 / 1 min	29	26	24	24	20	20	24	20	20
1 / 9 s	6.7 / 1 min	26	24	22	22	20	18	22	20	18
1 / 5 s	12 / 1 min	22	20	18	18	15	15	18	15	15

Figure 2 shows an example of lifting posture with the risk index calculation is illustrated in Table 1. It can be observed that the distance from floor to knuckle is below 29 inches. Further details of the table are as below:

i) Lift lower point – Floor to knuckle (below 29 in)
ii) Horizontal distance – 7 inches (front of body to mid-line of hands)
iii) Frequency - 1 action every 5 minutes (12 action per hour)
iv) Distance of lift – 30 inches (distance from store to the racks)
v) Design goal obtain cross the frequency with distance lift – 29

Based on the design goal from the Snook's Table and the load weight, the risk index is calculated as:

$$\frac{load\ weight\ (pounds)}{design\ goal} \tag{1}$$

The weight of goods lifted is 35.5 pounds; thus, the risk index is:

$$\frac{35.5\ pounds}{29} = 1.22 \tag{2}$$

The risk index is 1.22, which exceeds 1.0. Hence, the lifting posture is at high risk.

3. METHODOLOGY

A comprehensive study involving 8 workers was conducted as a case study, focusing specifically on a targeted store. Additionally, a similar investigation was held at a small and medium-sized enterprise (SME) located in Kangar, Perlis, Malaysia, which involved 8 respondents to assess the level of ergonomic risk factors (Yusuf et al., 2023). The aim was to measure the risks associated with tasks such as lifting, carrying, pushing, and pulling heavy objects. Interviews were held with the respondents to gather data on distances covered, the weights of objects handled, and the postures adopted by them.

This information was then meticulously analyzed using Snook's Table, a tool based on Bernard's adapted Table, to evaluate the level of risk involved in each task. Results exceeding 1.0 indicated a high risk, potentially leading to workers' discomfort or injury. Subsequent recommendations were provided to mitigate risks by correcting postures and implementing safer work methods. This dual case study approach provided valuable insights into occupational hazards associated with material handling tasks in both retail and SME settings.

4. RESULTS AND DISCUSSION

4.1 Results

Figure 3 shows the recorded results for the lifting task. The red line indicates the guide for the risk index value, which is set at 1.0. There are 6 workers whose risk index values exceed the red line, but Workers 1 and 5 have the highest indices. This is because they handle heavy loads mainly at the store compared to other workers. Worker 3 has the lowest index as he primarily handles the payment counter. Besides, factors such as frequency of lifting, duration of lifting tasks, and proper lifting techniques may also influence the risk index values.

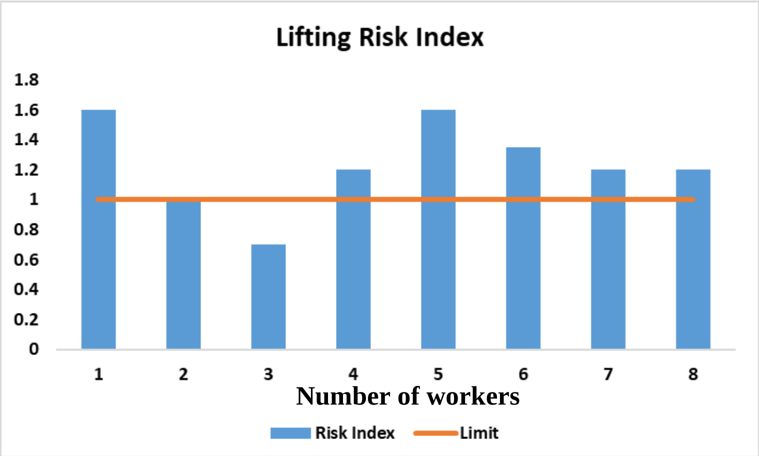

Figure 3. Graph of lifting task risk index

The risk index for the carrying task is shown in Figure 4, with 6 out of 8 workers scoring more than 1.0. The workers' high-risk index is attributed to carrying loads at about waist height and covering 8 meters, equivalent to 27 feet. Workers 3 and 6 have the lowest carrying risk index, as the distance travelled by them with the goods or items is approximately 2 meters. Meanwhile, factors such as load weight, frequency of carrying, and posture while carrying may also contribute to the risk index values.

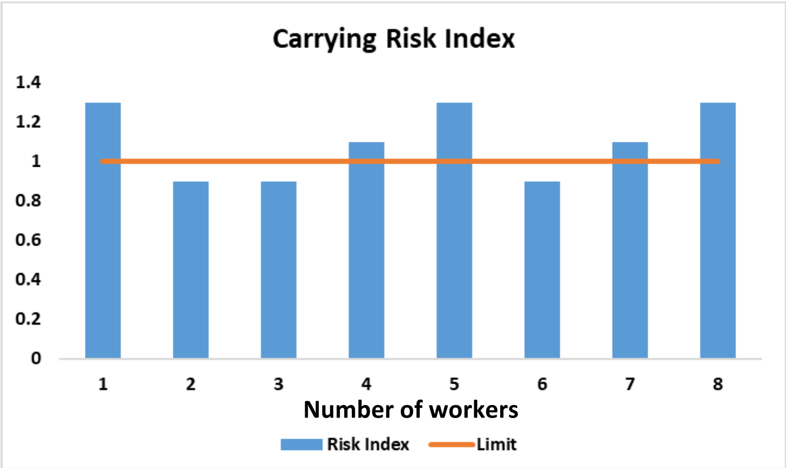

Figure 4. Graph of carrying task risk index

Figure 5 shows the risk index for the pushing task in both initial and sustained modes. The values for both initial and sustained modes are over 1.0 due to the workers' posture while working. The method used by the workers can expose them to injuries, especially considering the load-pushing distance of approximately 29 meters (97 feet). Moreover, the frequency of workers pushing is 1 every 5 minutes, accumulating to 12 rounds in one hour. The load transferred via the pushing method is also heavy. These factors contribute to the risk index value exceeding 1.0, as it involves a longer period and covers a considerable distance. The graph indicates that three workers (Workers 1, 4, and 5) have a risk index value over 1.0 for both initial and sustained modes. Workers 7 and 8 have a risk index of over and below 1.0 for the sustained and initial modes, respectively.

Figure 5. Graph of pushing risk index

Contrary to the pushing index, all risk indices for the pulling task are below 1.0 (see Figure 6). This is because workers use material handling equipment to transfer the load. The effect of material handling equipment in the pulling task reduces the load to be pulled, making handling easier as workers travel to handle the loads. Additionally, the use of material handling equipment not only reduces physical strain but also contributes to a safer working environment by minimizing the risk of injuries associated with manual handling tasks.

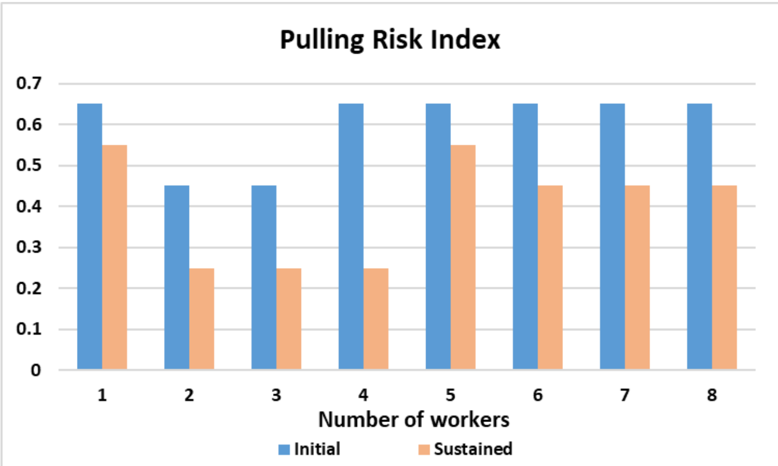

Figure 6. Graph of pulling risk index

4.2 Discussions

There are many ways to lower the risk index for workers while working, such as by using material handling equipment for pulling and pushing. Material handling equipment not only reduces pressure but also improves the risk index score to a lower level, indicating that workers are performing tasks using good methods and under favorable conditions.

Figure 7. Example of a trolley for material handling

Figure 7 shows suitable material handling equipment that can be used to ease material handling at the workplace. These small and compact trolleys are suitable for use by workers and fit well in the aisle size of the petrol station. Moreover, the four wheels make it easier for workers to handle stocks. On the other hand, the risk index can be improved by changing the body posture of workers while working. Typically, workers do not pay attention to their body postures while working because their aim is solely to finish the job. They may not realize that bad posture can lead to injuries. Good body posture is important because it affects how workers handle pressure or loads while working. In this project, workers put pressure on their backs, which can lead to back pain. As back pain develops, workers may feel uncomfortable or have difficulty performing tasks.

The 3D Static Strength Prediction Program (3DSSPP) illustrates the percentage of strength to highlight the difference when changing the body posture. The green region depicts an acceptable strength value, while the red region depicts an unacceptable value. Figure 8 shows the scores of workers lifting without bending their knees. The scores indicate that the strength percentage for the knees, ankles, hips, and torso is low, which means it is still acceptable but not recommended because this posture results in high low back compression, thus increasing the risk of injury.

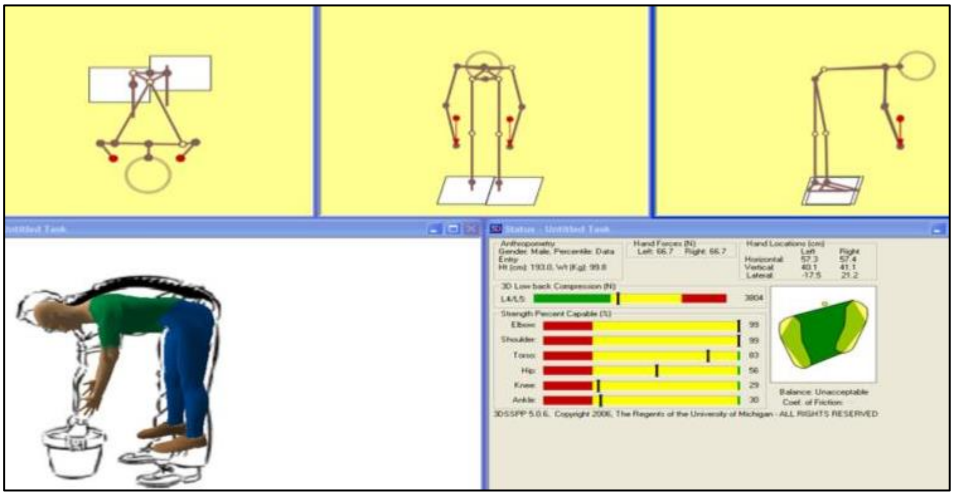

Figure 8. 3DSSPP of workers lifting an object without bending their knees

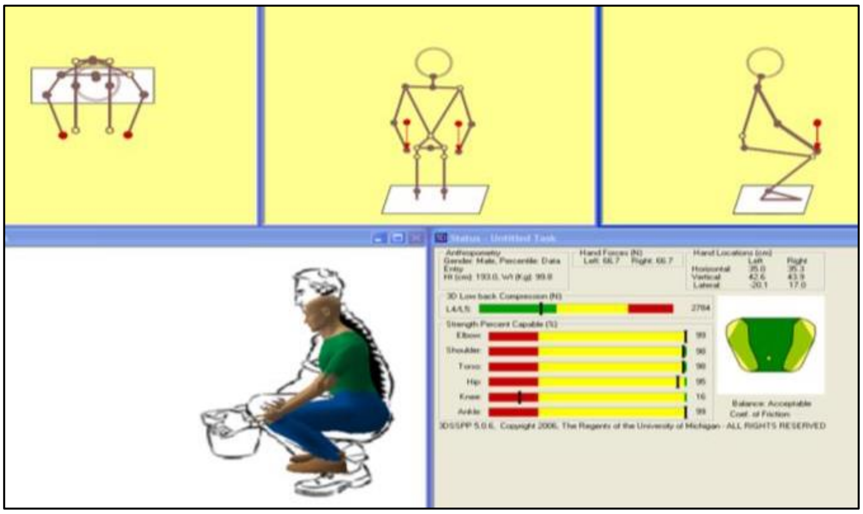

Figure 9. 3DSSPP of workers bending their knees when lifting

As shown in Figure 8, the balance is unacceptable, which leads to the risk of ergonomics for unbalanced work postures. Conversely, Figure 9 shows the workers lifting with bent knees, and the strength percent score for all parts is acceptable except for the knees. Low back compression indicates that this method is acceptable and lowers the risk of injuries. Comparing both Figures 8 and 9, the body posture when lifting in Figure 8 has lower balance compared to Figure 9. The workers put pressure on the back, which becomes a support for them while lifting. The low back compression for Figure 8 is in the yellow zone, while the low back compression for Figure 9 is in the green zone. This indicates that the postures in Figure 9 are better than the postures in Figure 8 for lifting. Although 3DSSPP might appear as a simple method, it has an impact on the postures of workers and reduces the compression of the lower back.

Furthermore, asymmetric lifting, as shown in Figure 10, will help workers reduce back pain. Examining the correlation between manual lifting of heavy objects and the stress imposed by compression and shear forces on the lumbar area highlighted that the distinction between novice and seasoned workers lies in their understanding; specifically, experienced workers possess superior knowledge, resulting in more ergonomic postures when handling loads (Jeong et al., 2016).

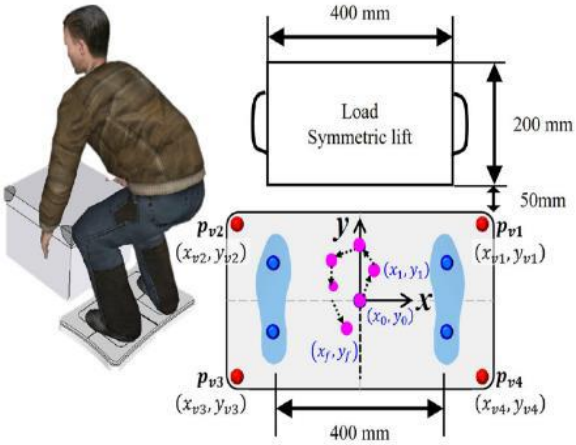

Figure 10. Experimental symmetry in environments used in COP (Centre of Pressure) measures

5. CONCLUSION

The findings of this study suggest that most workers at this store lack knowledge of doing work from the health and safety aspect. The workers only care about the work being done and neglect the unhealthy postures during work. As observed, no material handling tools are provided to the workers at this store to minimize the risk of ergonomic disease and to ease the handling of items or goods. The workers need to handle heavy items or goods every day.

Despite the mainly young age demographic of workers at this store, accidents can still occur, posing risks such as falling objects and back pain. The posture adopted by workers during tasks also contributes to these risks, with Snook's Table indicating high-risk levels for certain activities. Particularly concerning is the increased pressure on the back compared to the arms, which can lead to discomfort and injuries, especially considering the prolonged eight-hour workdays. Continuously maintaining such postures can intensify the risk of injuries in a relatively short period. To enhance this project, conducting similar assessments in larger wholesale or supermarket environments would be beneficial. These settings typically accommodate more workers and entail a broader range of activities, providing a more comprehensive understanding of ergonomic risks in material handling.

In addition, any available and suitable ergonomic software can be used to better visualize the awkward posture and highlight the concerned body parts that contribute to any ergonomic risk of WMSD (work related musculoskeletal disorder). It is also easier for people with no knowledge of ergonomics to understand the risks of having awkward posture while working.

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AUTHORS' CONTRIBUTION

The author fully prepared the manuscript, including the research, drafting, revising, and finalizing the content.

AVAILABILITY OF DATA AND MATERIALS

The data supporting this study's findings are available on request from the corresponding author.

ETHICS STATEMENT

Not applicable.

CONFLICTS OF INTEREST

The author declares no conflicts of interest.

GENERATIVE ARTIFICIAL INTELLIGENCE DECLARATIONS

The author(s) declare that no generative AI or AI-assisted technologies were used in the writing of this manuscript. All content, including text, figures, and tables, was created by the author(s).

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