

The Use of Initial Ergonomic Risk Assessment Tools to Identify Work-Related Musculoskeletal Disorders Among Waterbase Operators in Adhesive Manufacturing Company

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Abstract

Work-related Musculoskeletal Disorders (WMSDs) are prevalent among workers in industries involving manual handling, repetitive tasks, and poor posture, contributing to both health issues and decreased productivity. This study focuses on ergonomic risks at the adhesive manufacturing company, a manufacturer in the adhesive and sealant located in Industrial State of Senawang, Negeri Sembilan. The research examines ergonomic challenges, identified that the Waterbase production area, where operators engage in manual lifting and material handling that expose them to musculoskeletal disorders are more likely in high risk. Using a combination of ergonomic risk assessment tools from the Department of Occupational Safety and Health (DOSH) Guidelines, including the Initial Ergonomic Risk Assessment (ERA). This study inferred that of all the critical tasks that has been observe showed the majority of the assessment required advanced ERA. The research aims to recommended effective corrective measures and preventive strategies to improve workplace ergonomics, reduce physical strain, and enhance overall productivity by recommending risk control to mitigate the risk.

1. Introduction

Work-related Musculoskeletal Disorders (WMSDs) represent a significant concern across various industries, with a high prevalence of injuries linked to ergonomic factors. These disorders are commonly associated with tasks that involve manual handling, lifting, twisting, and repetitive motions, all of which are further exacerbated by improper postures during work activities [1]. Employees engaged in physically demanding roles are particularly vulnerable to these musculoskeletal issues. A critical issue for manufacturers, known for their specialized production processes, is the direct involvement of their workforce in tasks that often place considerable strain on the body [1, 2]. These ergonomic-related challenges, if left unaddressed, can lead to both short-term discomfort and long-term health complications, ultimately impacting productivity and worker well-being. Employees across diverse jurisdictions and industrial domains report a variety of WMSDs, including lower back pain, neck discomfort, and upper extremity ailments [8]. The widespread nature of these injuries

underscores the urgent need for targeted ergonomic interventions and the implementation of preventive strategies within workplace environments.

As a company specializing in adhesive manufacturing with both domestic and global sales and marketing, the use of heavy machinery is common across various production areas. These areas are divided into six sections: Waterbase, Cartridge & Sausage, Hot Melt EVA/PSA, Warehouse, and Powder. Among these, Waterbase, Powder, and Hot Melt sections are particularly reliant on heavy machinery and mixing tanks. However, this study focuses primarily on the Waterbase section, as it involves a higher number of tanks and operators at risk for work-related musculoskeletal disorders (WMSDs), based on the headcount data from the Human Resources Department and the operational procedures mandated by the employer. In the Waterbase section, tanks are used to blend adhesive mixtures, and operators are required to lift and carry up to 25 kilograms of raw materials during the mixing and blending process. These tasks expose workers to significant ergonomic risks, particularly when handling heavy bags of mixed materials, making it essential to assess and address these hazards [6, 7].

This paper aims to explore the nature of WMSDs, identify the ergonomic factors contributing to these disorders, and discuss potential approaches for mitigating their impact on workers in the manufacturing sector. Through a thorough analysis of existing literature and industry practices, the study will provide insights into effective ergonomic solutions that can be adopted to reduce the incidence of musculoskeletal injuries and improve overall employee health and productivity.

2. Methodology

In this study, the population and sample size were determined by researcher based on the small number of employees in the Waterbase department, due to the small quantity of headcounts comparing to the total workforce of the adhesive manufacturing company for production operators from powder and hotmelt division. The qualitative analysis findings indicate that Waterbase employees are exposed to a medium level of intensity for ergonomic risk factors (ERFs), suggesting that while the risks are present, they are not at the highest level but still require attention and intervention.

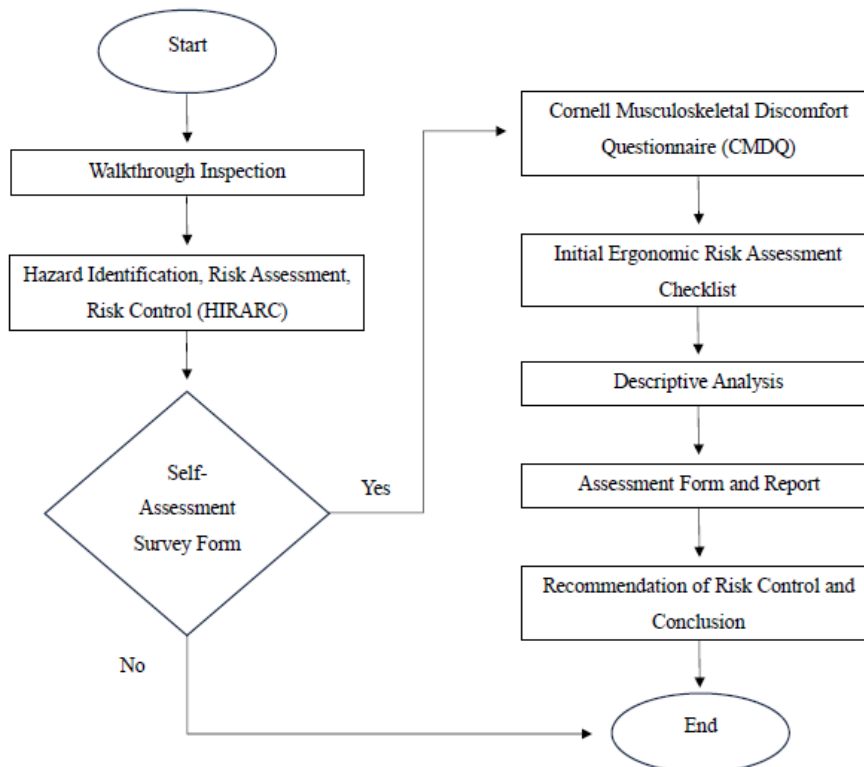


Fig. 1: Research Flowchart

The figure 1 outlines a systematic procedure starting with a walkthrough inspection to identify ergonomic risks in the area using tools like cameras or mobile phones for documentation. The next step involves hazard identification and assessment through the Occupational Risk Assessment (ORA). This phase sets the foundation for the subsequent survey process, which includes the Self-Assessment Musculoskeletal Pain/Discomfort Survey

and Cornell Musculoskeletal Discomfort Questionnaire (CMDQ) for waterbase operators. Finally, the Initial Ergonomic Risk Assessment Checklist is completed to gather relevant ergonomic data.

2.1 Research Instrument

2.1.1 Qualitative Analysis

This study outlines a comprehensive process for assessing ergonomic risks at the adhesive manufacturing company. By referring to the Figure 1, the study commenced by conducting a walkthrough inspection as part of the screening method [5]. This first step was intended to provide a complete analysis of their work routines in real time. Hence, the findings and observations were thoroughly documented using a variety of electronic devices such as camera and mobile phones. Next, followed by the Hazard Identification, Risk Assessment, and Risk Control (HIRARC) method. The Occupational Risk Assessment (ORA) format was used to identify job-specific ergonomic risks, focusing on waterbase operators. This instrument has three primary columns. Column A describes the job steps, as well as the tools and chemicals utilized during the operation. Column B focuses on the tasks' acute risks whereas Column C addresses chronic risks that may arise over time but specifically for chemical involvement [2].

2.1.2 Semi-quantitative Analysis

The assessment included a survey, utilizing the Self-Assessment Musculoskeletal Pain/Discomfort Survey and Cornell Musculoskeletal Discomfort Questionnaire (CMDQ), which evaluates discomfort or pain in various body regions [5, 7]. The survey also examines the frequency, severity, and possible causes of symptoms, particularly for standing workers and those experiencing hand-related issues. Additionally, the study incorporates checklists from the Department of Occupational Safety and Health (DOSH) to identified ergonomic hazards based on worker movements and durations. Ultimately, the use of Initial ERA Form was used to evaluate the outcome of the findings, led to the development of recommendations for risk control measures to enhance workplace ergonomics and employee safety [5].

3. Results and Discussion

This section includes the initial ergonomic risk assessment survey and questionnaires based on the guidelines provided by the Department of Occupational Safety and Health (DOSH). The results of these assessments are elaborated upon in the following subchapters with a detailed analysis of the data collected during the survey process.

3.1 Qualitative Analysis

The survey involved a total of 13 male respondents, all of whom work in the same department. Among the participants, one individual holds the position of supervisor, while the remaining 12 are operators and their roles primarily involve tasks related to the operation and production processes. Moreover, the walkthrough inspection managed to identify nine critical tasks, each involving different work methods and processes, leading to distinct ergonomic risk factors. Moreover, in the Appendix A, one task is categorized as medium critical, indicating a medium priority for risk mitigation based on the corporate method. Three tasks were identified as low priority, while the majority of the tasks were considered not critical for ergonomic concerns. Additionally, this demographic profile highlighting that all participants are male and mostly occupy operational roles within the department. This information is relevant for analyzing the findings from the survey and assessing the specific ergonomic challenges faced by male workers in these positions.

3.2 Semi-quantitative Analysis

3.2.1 Self-assessment Musculoskeletal Pain/Discomfort Survey Form

The table illustrates the prevalence of work-related musculoskeletal disorders (WMSDs) experienced by 13 workers over the past 12 months, reflecting discomfort or pain associated with their job tasks. The data highlights the physical strain and potential injuries resulting from their daily activities. Workers reported musculoskeletal discomfort across various body parts, underscoring the impact of work-related tasks on their

physical well-being. These findings emphasize the need to address and mitigate the risks of WMSDs in the workplace to reduce discomfort and prevent long-term injuries.

Table 1: Frequency (f) and Percentage (%) for prevalence of WMSDs that come from work

Body Parts (n = 13)	During the last 12 months					
	Both		Left		Right	
	f	%	f	%	f	%
Neck	4	30.77	-	-	-	-
Shoulder	8	61.54	-	-	-	-
Upper back	5	38.46	0	0	1	7.69
Upper arm	2	15.38	1	7.69	0	0
Elbow	1	7.69	0	0	1	7.69
Lower arm	1	7.69	1	7.69	0	0
Wrist	2	15.38	1	7.69	0	0
Hand	3	23.08	0	0	1	7.69
Lower back	8	61.54	-	-	-	-
Thigh	2	15.38	0	0	1	7.69
Knee	2	15.38	0	0	1	7.69
Calf	1	7.69	1	7.69	0	0
Ankle	2	15.38	0	0	1	7.69
Feet	3	23.08	1	7.69	0	0

Over the past 12 months, musculoskeletal discomfort was reported by 13 workers across various body parts, with the neck, shoulder, and lower back being the most commonly affected areas. The survey showed that 30.77% of workers experienced neck discomfort, 61.54% reported shoulder discomfort, and 61.54% had lower back discomfort, with no preference for side dominance in these areas. Other frequently reported discomforts included the upper back (38.46%) and hands (23.08%), followed by less frequent occurrences in the upper arm, wrist, thigh, elbow, and lower arm. Notably, certain areas such as the wrist, upper arm, and calf showed a higher prevalence of discomfort on the left side. Overall, the data highlights the widespread nature of musculoskeletal discomfort, particularly in the neck, lower back, and shoulder, with the left side of the body often being more affected in specific areas.

3.2.2 Cornell Musculoskeletal Discomfort Questionnaire

The Cornell Musculoskeletal Discomfort Questionnaire (CMDQ) is structured into four categories, each addressing different aspects of musculoskeletal discomfort [7]. For this research, only three categories were utilized: standing symptoms and hand symptoms, with separate evaluations for both the left and right sides of the body. These categories specifically assess discomfort and limitations related to standing and hand function, offering insight into how these factors impact the participants' daily activities and overall well-being. The table below presents data from the standing category of the CMDQ, focusing on discomfort, pain, fatigue, and physical limitations experienced by individuals during prolonged standing. This data highlights the frequency and percentage of affected areas among waterbase workers and the scoring method is simply counting the number of symptoms per person [4, 7].

Table 2: Frequency (f) and Percentage (%) of Prevalence of WMSDs (Body Region)

Body Parts (n=13)	During last work week									
	Never		1 – 2 times		3 – 4 times		Once daily		Several times daily	
	f	%	f	%	f	%	f	%	f	%
Neck	5	38.46	4	30.77	0	0	1	7.69	0	0
Shoulder	3	23.08	5	38.46	0	0	0	0	0	0
Upper back	6	46.15	1	7.69	1	7.69	1	7.69	1	7.69
Upper arm	4	30.77	3	23.08	0	0	0	0	1	7.69
Lower back	2	15.38	4	30.77	1	7.69	0	0	3	23.08
Forearm	6	46.15	1	7.69	1	7.69	0	0	1	7.69
Wrist	5	38.46	1	7.69	2	15.38	0	0	1	7.69

Hip/Buttocks	5	38.46	1	7.69	1	7.69	0	0	1	7.69
Thigh	5	38.46	2	15.38	0	0	0	0	2	15.38
Knee	4	30.77	4	30.77	0	0	0	0	1	7.69
Lower Leg	6	46.15	1	7.69	0	0	0	0	2	15.38
Foot	5	38.46	2	15.38	0	0	0	0	2	15.38

Table 2 presents data on musculoskeletal discomfort (WMSDs) experienced by workers, based on responses from 13 participants using the Cornell Musculoskeletal Discomfort Questionnaire. The findings reveal that neck and upper back discomfort were the most commonly reported issues, with 38.46% and 46.15% of workers respectively experiencing these problems. Other areas, such as the lower back, forearm, wrist, and thigh, also showed significant discomfort levels. Notably, 23.08% of workers experienced lower back discomfort daily, while wrist and thigh discomfort occurred multiple times throughout the week for 15.38% of workers. These results underscore the widespread prevalence of WMSDs, highlighting the need for ergonomic interventions to reduce physical strain from repetitive tasks and awkward postures, which may help prevent long-term musculoskeletal problems.

Meanwhile for the hand symptoms, Appendix B shows the shaded area corresponds to a particular location on the hand where discomfort or symptoms may be experienced.

Table 3: Frequency (f) and Percentage (%) of Prevalence of WMSDs (Hand Region)

Area (n = 13)	During last work week									
	Never		1 – 2 times		3 – 4 times		Once daily		Several times daily	
	f	%	f	%	f	%	f	%	f	%
Right Hand										
A	5	38.46	3	23.08	0	0	0	0	1	7.69
B	5	38.46	3	23.08	0	0	0	0	1	7.69
C	5	38.46	3	23.08	0	0	1	7.69	1	7.69
D	4	30.77	3	23.08	1	7.69	0	0	1	7.69
E	4	30.77	4	30.77	0	0	2	15.38	0	0
F	4	30.77	4	30.77	0	0	0	0	1	7.69
Left Hand										
A	6	46.15	2	15.38	0	0	0	0	1	7.69
B	5	38.46	3	23.08	0	0	0	0	1	7.69
C	5	38.46	3	23.08	0	0	1	7.69	1	7.69
D	6	46.15	2	15.38	0	0	0	0	1	7.69
E	6	46.15	2	15.38	0	0	2	15.38	0	0
F	6	46.15	2	15.38	0	0	0	0	1	7.69

Table 3 included in the questionnaire features six shaded areas (A, B, C, D, E, and F) representing specific regions of the hand, which participants refer to when assessing their hand symptoms. These areas help identify the locations of discomfort or limitations experienced during hand-related activities. The data from the questionnaire shows the frequency of work-related musculoskeletal disorders (WMSDs) in these six hand regions. For Areas A and B, most participants (38.46%) reported never experiencing symptoms, with a smaller proportion (23.08%) reporting symptoms 1-2 times, and one participant (7.69%) experiencing symptoms several times daily. Area C followed a similar pattern, with 38.46% reporting no symptoms and a smaller percentage (7.69%) experiencing symptoms once or several times daily. In Area D, 30.77% reported no symptoms, while 7.69% reported symptoms occurring 3-4 times or several times daily. Area E showed a more balanced distribution, with 30.77% reporting no symptoms, 30.77% experiencing symptoms 1-2 times, and 15.38% reporting symptoms once daily. Area F also saw 30.77% of participants reporting no symptoms, 30.77% experiencing symptoms 1-2 times, and 7.69% experiencing symptoms several times daily. As well as data on left-hand symptoms, where again, most participants reported never experiencing symptoms in the six areas, though a smaller proportion reported experiencing symptoms 1-2 times or several times daily. Overall, the data suggests that the majority of participants did not experience frequent hand symptoms, with discomfort occurring more infrequently across the areas.

3.2.3 Initial Ergonomic Risk Assessment Analysis and Results

The analysis of Initial Ergonomic Risk Assessment resulted that out of the six identified tasks requiring advanced risk assessment, which the task required the employees to fill in raw materials into the tank was determined to be the most critical activity for conducting an advanced ergonomic risk assessment. This task involves significant physical strain, such as lifting and handling heavy materials, often in awkward positions, which increases the risk of musculoskeletal disorders.

Table 4: Score of IERA Form

ERFs	Total Score	Min \geq Advanced ERA	Result of IERA	Pain/Discomfort of ERFs (YES = \checkmark)		Need Advanced ERA? (Yes/No)
Awkward Postures	5	≥ 6	2	Neck	\checkmark	No
Static and Sustained Work Posture	0	≥ 1	0	Shoulder		No
				Upper back		
Forceful Exertion	3	1	1	Upper arm		Yes
Repetitive Motion	3	≥ 1	1	Lower back	\checkmark	Yes
Vibration	0	≥ 1	0	Forearm		No
Lighting	0	1	0	Wrist		No
Temperature	1	1	1	Hand		Yes
Noise	0	1	0	Hip/buttocks		No
				Thigh		Yes
				Knee		
				Lower leg		
				Feet		

Table 4 highlights the activity that requires most an advanced ergonomic assessment. The results indicated that factors such as forceful exertion, repetitive motion, temperature, and noise all scored higher than the minimum requirements, emphasizing that these elements contribute significantly to work-related musculoskeletal disorders in the waterbase department. This activity, therefore, plays a key role in the ergonomic risks faced by workers and requires focused attention to reduce potential harm.

4. Conclusion and Recommendation

4.1 Conclusion

The conclusion of this study highlights key findings regarding work-related musculoskeletal disorders (WMSDs) among waterbase workers. The physical demands of their job, including heavy lifting, awkward postures, and repetitive tasks, contribute to a high risk of strain and injury, particularly in areas such as the neck, shoulders, and back. The predominance of male workers in these roles further emphasizes the physical nature of the work. Previous research supports these findings, noting that physical work demands and poor ergonomic conditions increase the likelihood of musculoskeletal complaints. To mitigate these risks, ergonomic interventions, such as posture recognition systems and proper training, are recommended. These measures can help reduce workers' exposure to hazardous postures, prevent injuries, and improve overall health and productivity. The study reinforces the importance of incorporating ergonomic assessments and safety measures to minimize WMSDs in physically demanding occupations, contributing valuable insights for future research and interventions.

4.2 Recommendation

Based on the results of this study, several recommendations are proposed to address the identified issues and reduce the occurrence of work-related musculoskeletal disorders (WMSDs) among waterbase workers. Also, to improve overall well-being and mitigate ergonomic risks, a thorough ergonomic risk assessment is recommended, focusing on factors such as work hours, shift patterns, and work-rest periods [2]. Additionally, assessing behavior-based working methods during manual handling tasks is crucial, as industries with manual labor tasks tend to have higher rates of WMSDs, according to the U.S. Bureau of Labor Statistics (2009). The

study also emphasizes the need for an advanced risk assessment to better understand the severity of ergonomic risk factors (ERFs) identified in the production process, as such assessments can enable targeted control measures, preventing long-term injuries [3]. Finally, the findings align with the study's objective of recommending interventions tailored to the specific needs of the adhesive manufacturing company, ensuring that ergonomic improvements are based on detailed insights into the unique challenges faced by waterbase workers.

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Conflict of Interest

There is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm responsibilities for the following: study conception and design, data collection, analysis and interpretation of results, and manuscript preparation.

Appendix A: Occupational Risk Assessment

Bostik WORK HAZARD ANALYSIS

Job / Department: **WATERBASE WORK PROCESS**

Task Name: **WATERBASE WORK PROCESS**

Job Description: **Waterbase**

Approved by: **Muzak**

JOB STEPS, TOOLS AND CHEMICALS USED	ACUTE										CHRONIC																		
	HAZARDS			RISK RANKING			EXISTING CONTROLS				CRITICALITY		RECOMMENDATIONS			HAZARDS			RISK RANKING			EXISTING CONTROLS				CRITICALITY		RECOMMENDATIONS	
Job Details (sequence of basic job steps)	Equipment or Tool used	Chemical Involved	Potential Adapters/Injuries	G	R	P	Engineering Controls	Administrative Controls	PPE	CF	CP	Priority	Priority	Recommended Controls/Action or Safe Practice	Potential Injuries or Illness	G	R	P	Engineering Controls	Administrative Controls	PPE	CF	CP	Priority	Priority	Recommended Controls/Action or Safe Practice			
Collect and prepare raw materials		TSD	Back strain/spine, Shoulder injuries, Wrist/hand strain, Lower back discomfort	2	2	1						2	LOW	Rest break															
Moving raw materials close to the tank	Forklift	TSD	Back strain/spine, Muscle injuries, Wrist/hand strain, Lower back discomfort	2	2	1	Provide pallet rack					2	LOW	Make the right tool to move material															
Filling raw materials into tank		TSD	Back strain/spine, Shoulder injuries, Wrist/hand strain, Lower back discomfort	2	2	1						2	LOW	Build system															
Logging down work sheet			Tired finger, upper back discomfort	2	2	1	Table for writing					2	LOW	Write the document on table provided															
Raw Cleaning	Wrench		Muscle strain trigger finger	2	2	1						2	MEDIUM	Build system															
Stamping on sticker for packaging			Shoulder clamps, work stress	2	2	1						2	LOW	Install auto stamping machine															
Measuring/feeding goods for raw packing			Tension neck syndrome	2	2	1						2	LOW	Provide stool to achieve the same level of view															
Weighing goods			Back strain/spine, Shoulder injuries, Wrist/hand strain	2	2	1						2	LOW	Rest break															
Packing and transfer finished goods to pallet			Back strain/spine, Shoulder injuries, Wrist/hand strain, Lower back discomfort	2	2	1						2	LOW	Build system															

I read and understand the Work Hazard Analysis and will comply with the listed safety measures and practice.

Job Owner: _____

Appendix B: Cornell Musculoskeletal Discomfort Questionnaires (Hand Symptoms)

The shaded areas in the diagrams below show the position of the body parts referred to in the questionnaire. Please answer by marking the appropriate box.

Complete only for **RIGHT HAND**

Pinch: Ring Middle Index

Thumbs

	Never	1-2 times last week	3-4 times every day	Once every day	Several times every day	Slightly uncomfortable	Moderately uncomfortable	Very uncomfortable	Not at all	Slightly interfered	Substantially interfered
Area A (Shaded area)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Area B (Shaded area)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Area C (Shaded area)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Area D (Shaded area)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Area E (Shaded area)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Area F (Shaded area)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

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