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# Assessing safety performance of tire retreading production employees

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**Abstract.** Occupational health and safety are one of the important studies that must be applied in the company. This study aims to determine the index of occupational hazards on tire retreading activities in PT. Inti Vulkatama. Direct observation of work behavior is done by evaluating hazard as well as with safety performance index (SPI) approach. The instruments were used in this research are critical behavior checklist (CBC) questionnaire and analytical hierarchy process questionnaire (AHP) for each workstation in the processing department of the hot and cold process. Based on the results of SPI calculations that have been integrated between the results of questionnaires CBC and AHP obtained workstation with the value of  $SPI < 0,5$  indicated unsafe is scrape workstation with SPI 0.498, side cut workstation with SPI 0.496, and hot process workstation with SPI 0.492.

## 1. Introduction

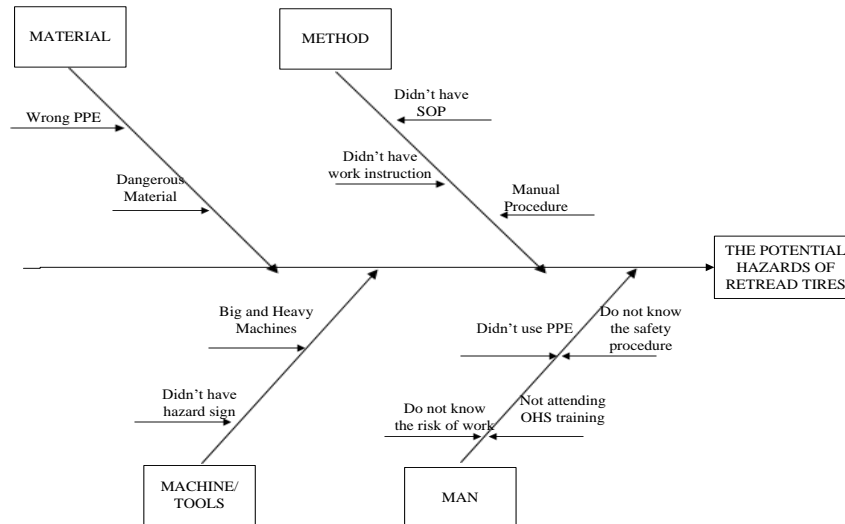
Human resources are one of the important assets owned by a company [1]. Safety and comfort in the work are required for employees to work optimally to achieve corporate goals [2]–[4]. A systematic HSE management is needed in a company and the right standard of OHS operational procedures, to prevent the occurrence of accidents to employees for the desired goal of the company in the form of optimal work can be achieved.

According to Heinrich's theory, there are two causes of work accidents: unsafe act and unsafe condition [5]–[8]. Hidayat and Hijuzaman (2015) prove that the work accident happened 85% caused by unsafe behavior (unsafe act). The unsafe behavior is meant more for the person or the worker himself, which may be affected by the physical and psychological condition of the worker, lack of workstations, no use of personal protective equipment (PPE), and so on. While unsafe conditions are the condition of the workplace environment that is less conducive, dirty, and so forth. There are so many researches about safety and health because this topic is very important for the company to maintain its productivity in working [5], [7], [9], [10].

PT. Inti Vulkatama is a business incorporated as a limited liability company (PT). This company is engaged in tire retreading, which is processing the damaged or bald tires to be installed new palms with a series of processes to be reusable. There are three types of processes carried out in tire retreading in PT. Inti Vulkatama, the heating process, cold process, and OTR (Off The Road). Vulcanization stage heat process is carried out at relatively high temperatures ranging from 150°C, and in the cold process is done with relatively low temperatures ranging from 110°C. OTR is a vulcanized process for very large tires, such as tires for heavy equipment with a temperature in the process ranging from 150°C. Heat process on tire is retreading in PT. Inti Vulkatama through inspection stage, buffing, brush, gluing, gum insertion, building, side cutting, printing, and finishing. While in the cold process, through the same stages with the process of heat from the stage of inspection to gluing, the



next stage is the provision of cushion gum, unification of the palm connection, wrapping the tire, cold printing, and finishing. (PT Inti Vulkatama, 2017). The potential hazards of the tire retreading process can be explained in the cause and effect diagram shown in Figure 1.



**Figure 1.** Cause and effect diagram  
(Source: Interview at PT. Inti Vulkatama, 2017)

Based on the observations made in PT. Inti Vulkatama in December 2017, there is one of the unsafe act on the production employee during the activities, that is using sorbet cloth tied to the mouth and nose cover so that workers can still inhale the harmful substances contained in tire rubber being processed. Based on the results of interviews conducted with the company's managers, employees only consider the convenience of working, but less concerned about workplace safety, it happens because of the employee's ignorance of the impact on long-term health. Employees work based on their daily experience, and there is no standard operational procedure (SOP) in every work activity in each workstation. The level of hazard to each workstation is not yet known so that it is necessary to review which workstations are in hazardous categories and should be emphasized in the application of safety in employee activities. The observation of work behavior is done by evaluating the hazard and index of work in every workstation with safety performance index approach. Safety performance index is needed to determine the safety index in job activity. Given the safety performance index is expected employees can find out how the index of work hazards at each workstation, to increase employee awareness of safety behavior in work. This research was conducted by using critical behavior checklist (CBC) questionnaire and AHP questionnaire to determine safety performance index.

## 2. Method

The method used in determining the solution to the problem is the Safety Performance Index (SPI) method. This method is used because the SPI value is an index used to assess the level of job security of an activity. Questionnaire data collection to determine the value of SPI is done in two stages:

### 2.1 Behavior-based safety (BBS)

The BBS method is chosen because it is effective in the inclusion of safety enhancement between management and labor, perceptions, feedback, responsibilities, including performance measurement [3]. BBS method that conducted in the research includes behavior target, and observation of behavior target by using questionnaire and after that done SPI calculation. The data collected in this research is primary data that is in the form of direct observation data on employee work behavior of each workstation in hot process department and cold process department based on the seven criteria contained in Table 2. Instruments used in data collection that is by using questionnaire critical behavior checklist.

### 2.2 Analytical Hierarchy Process (AHP)

SPI calculations were also performed using AHP pairwise comparison questionnaires with Software Expert Choice 11. The AHP method was used to determine the weight of importance between each of the target behavior criteria<sup>[4]</sup>. SPI value is integrated with CBC and AHP so that SPI assessment is not only based on employee's perspective on BBS method but also with expert opinion and judgment as an expert in tread vulcanization that is Alamsyah, Iyad and Sutarman as the coordinator of PT. Inti Vulkatama. The AHP questionnaire uses the Saaty scale contained in Table 1. Table 2 showed total employee in Inti Vulkatama Company.

**Table 1.** Saaty's Scale

Intensity of Interest	Definition
1	Both elements are equally important
3	One element is slightly more important than the other
5	One element is very important than the other
7	One element is more important than the other
9	One element is important than the other
2,4,6,8	Values between two adjacent consideration

**Table 2.** Factor Criterion

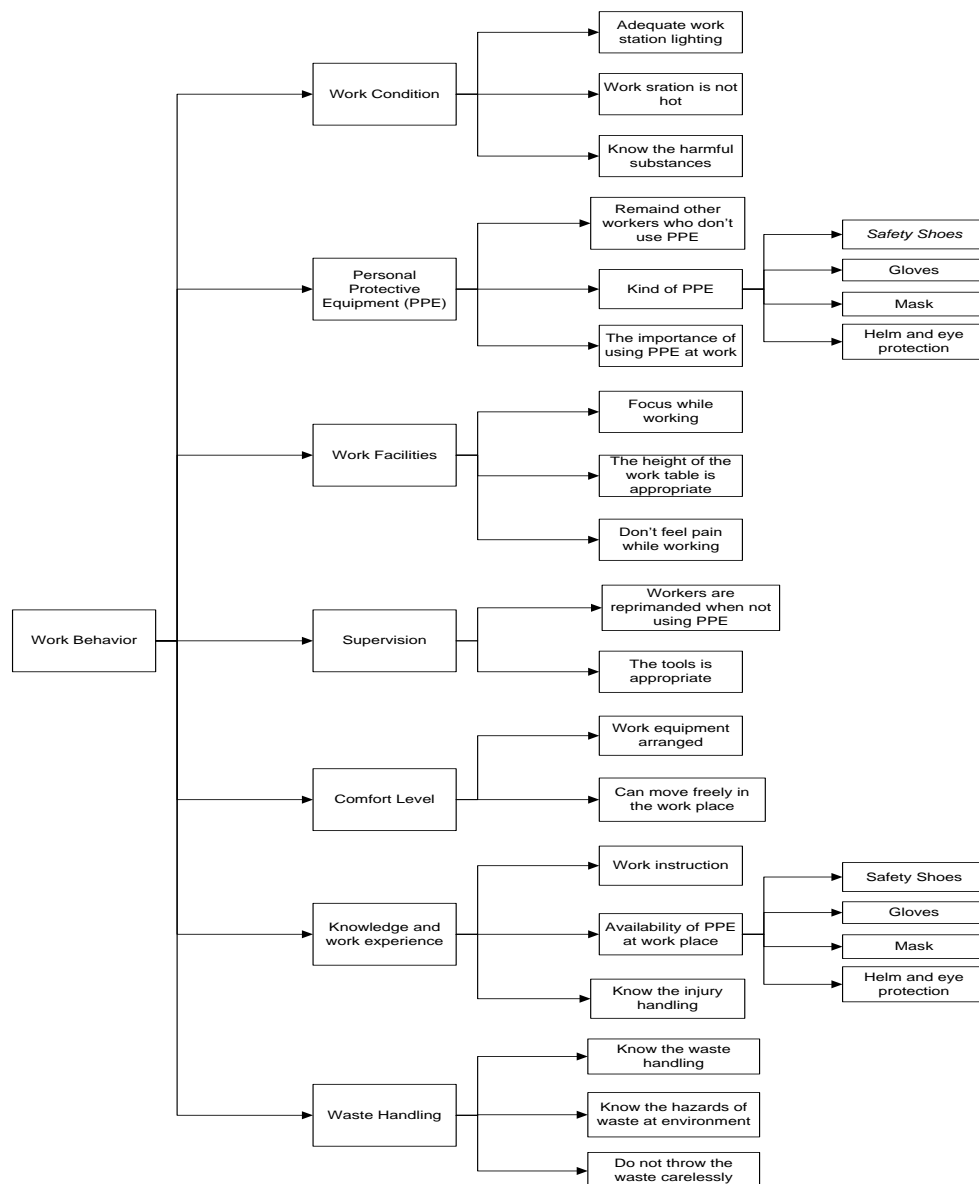
No	Behavior Target
1	Work condition
2	Personal protective equipment
3	Work facilities
4	Supervision
5	Comfort level
6	Knowledge and work experience
7	Waste handling

The hierarchy of AHP criteria as shown in Figure 2.

### 2.3 Safety performance index

At this stage, the measurement of the performance of the worker behavior by looking at the ratio value between the safe attitude of the observation (safe observed) with the total observation attitude (total observed). Safe observed and total observed values were obtained by integrating BBS and AHP. It is intended that the assessment of behavioral performance obtained is not only based on the assessment of work behavior of the Critical behavior checklist (CBC) questionnaire on the BBS method but also by considering the weight of importance obtained from the AHP method. It is expected that the value of performance behavior can describe the actual situation in PT. Inti Vulkatama. Implementation of field observation, analysis, and communication on unsafe behavior helps workers to recognize the workstations of unsafe behavior and can increase the target of prevention achievement as well as the reduction of unsafe behavior. SPI can denote behavior performance assessment. The following equation does assessment:

$$SPI = \frac{\text{safety observed}}{\text{safety observed} + \text{at riwork station(unsafe observed)}} \times 100\%$$



**Figure 2.** Hierarchy criterion

### 3. Result and discussion

In general, the process of heat and cold on tire retreads begins with an inspection, scrape, brush, and gluing. If the tire wants to be in the heating process, then the next process is gum insert, paste, side pieces, heat print, and finishing. But if the tire wants to be a cold process, after the gluing will be done adding cushion gum, paste, union of palm joints, tire wrapping, cold process, and finishing. The table shows the number of employees of each workstation on the process of heat and cold process that respondents in the study. The CBC questionnaire was filled with direct observation and interview with the workers about daily activities which was done based on the seven factors contained in the Table. Subsequently, scoring of observations and interviews on the CBC questionnaire in each workstation and SPI calculations using the formulas, Figure 3 is the result of CBC scoring and SPI calculation on the inspection decree.

Critical Behavior Checklist				
Periode Observasi (Tanggal)		25 April 2018 - 27 April 2018		
Observer		Karyawan SK Pemeriksaan		
Jumlah Karyawan		2 orang		
Diperiksa Oleh		Alamsyah		
No	Target Perilaku	Safe Observation	At-Risk Observation	SPI per Target Perilaku
1	Kondisi kerja	30	18	0,625
2	Alat pelindung diri (APD)	24	48	0,333
3	Fasilitas kerja	48	18	0,727
4	Pengawasan	24	48	0,333
5	Tingkat Kenyamanan	30	42	0,417
6	Pengetahuan dan pengalaman	48	18	0,727
7	Penanganan limbah	30	36	0,455
<b>Total</b>		234	228	
$SPI = \frac{Safe}{(Safe + At-Risk)} \times 100\%$		0,51		

**Figure 3. CBC**

After scoring of each workstation, then obtained SPI value on each workstation that can be seen in Table 3 and Table 4.

**Table 3. Heat departement**

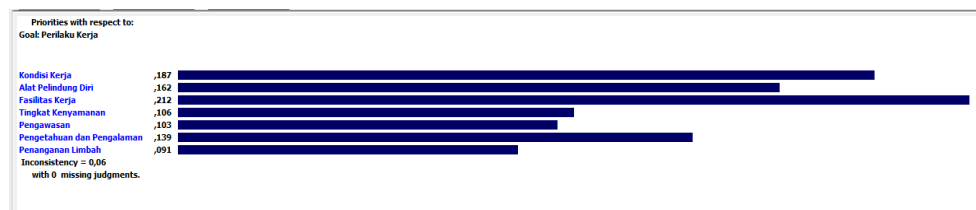
No	Workstation	SPI
1	Inspection	0.51
2	Scrape	0.47
3	Brush	0.58
4	Glue	0.61
5	Gum Implied	0.54
6	Patch	0.49
7	Cut Side	0.53
8	Hot Process	0.54
9	Finishing	0.58

Workstations that have a small SPI value of 0.5 are workstation scrape, patch, cut side, and heat process. This indicates that the level of hazard of work on the decree is high so it is necessary to do the right procedure when working to avoid work accident. The SPI value of each workstation in the cold process department can be seen in Table 4.

**Table 4. Cold department**

No	Workstation	SPI
1	Inspection	0.51
2	Scrape	0.47
3	Brush	0.58
4	Glue	0.61
5	Cushion Gum	0.54
6	Patch	0.49
7	Connected tread	0.53
8	Wrapping the Tires	0.54
9	Cold Process	0.49
10	Finishing	0.58

The results of SPI calculations are still based on the results of the CBC questionnaire and have not considered the weight of importance on each of the seven factors, then calculate the weight of importance of each criterion by using AHP method with Software Expert choice 11, the result of the importance of each criterion can be seen in Figure 5.

**Figure 4.** Weight of interest

Based on the calculation of AHP, the most important criteria in the tire retreading activity is the work facility with the importance of 21% more important than the other 6 factors, the second level of interest factor is the working condition with the importance of 19% more important than other factors, then other factors with interest rate below 19%. Based on the calculation of SPI integration between CBC and AHP, a workstation which has  $SPI < 0.5$  is workstation scrape, workstation cut side and hot workstation process with the result of the calculation as follows. It can be seen in Table 5, 6, and 7.

**Table 5.** Scrape workstation

No	Behavior Target	Weight of Importance	CBC Observation		Integration Result	
			Safe	At-Risk	Safe	At-Risk
1	Work Condition	0.187	24	18	4.488	3.366
2	PPE	0.162	18	48	2.916	7.776
3	Work Facilities	0.212	36	12	7.632	2.544
4	Supervision	0.106	18	48	1.908	5.088
5	Comfort Level	0.103	24	36	2.472	3.708
6	Knowledge and Work Experience	0.139	48	24	6.672	3.336
7	Waste Handling	0.091	30	36	2.73	3.276
Total of Integration					28.82	29.094
SPI					0,498	

**Table 6.** Cut side workstation

No	Behavior Target	Weight of Importance	CBC Observation		Integration Result		SPI
			Safe	At-Risk	Safe	At-Risk	
1	Work Condition	0.187	12	9	2.24	1.683	0.571
2	PPE	0.162	12	18	1.94	2.916	0.4
3	Work Facilities	0.212	24	12	5.09	2.544	0.667
4	Supervision	0.106	9	24	0.95	2.544	0.273
5	Comfort Level	0.103	12	21	1.24	2.163	0.364
6	Knowledge and Work Experience	0.139	21	18	2.92	2.502	0.538
7	Waste Handling	0.091	15	18	1.37	1.638	0.455
Total of Integration					15.8	15.99	
SPI							0,496

**Table 7.** Hot process workstation

No	Behavior Target	Weight of Importance	CBC Observation		Integration Result		SPI
			Safe	At-Risk	Safe	At-Risk	Per Behavior Target
1	Work Condition	0.187	27	36	5.049	6.732	0.429
2	PPE	0.162	36	72	5.832	11.664	0.333
3	Work Facilities	0.212	72	27	15.264	5.724	0.727
4	Supervision	0.106	36	72	3.816	7.632	0.333
5	Comfort Level	0.103	45	63	4.635	6.489	0.417
6	Knowledge and Work Experience	0.139	63	36	8.757	5.004	0.636
7	Waste Handling	0.091	36	54	3.276	4.914	0.4
Total of Integration SPI					46.629	48.159	0.492

After obtaining the weight of importance of each assessment criteria, then the integration of SPI values obtained based on the CBC questionnaire with the weight of interest on the AHP method that can be seen in Table 8.

**Table 8.** Integrated SPI in hot process department

No	Workstation	First SPI	Integrated SPI
1	Inspection	0.506	0.535
2	Scrape	0.471	0.498
3	Brush	0.579	0.610
4	Glue	0.608	0.638
5	Gum Implied	0.558	0.577
6	Patch	0.494	0.518
7	Cut Side	0.467	0.496
8	Hot Process	0.467	0.492
9	Finishing	0.579	0.597

In the department of the process of heat, there is a change of workstation category indicated by unsafe that is in workstation paste, wherein SPI with CBC workstation questionnaire workstation indicated unsafely, but after considering the importance level of each target behavior SPI value on workstation stick to rise and above 0, 5 so that the workstation stick on the heating process is safe. Workstation unsafe indication based on SPI result of integration that is workstation scrape, sidecut, and hot print. The SPI value of integration results in all workstation in cold process department can be seen in Table 9.

**Table 9.** Integrated SPI in cold process department

No	Workstation	First SPI	Integrated SPI
1	Inspection	0.506	0.535
2	Scrape	0.471	0.498
3	Brush	0.579	0.610
4	Glue	0.608	0.638
5	Cushion Gum	0.539	0.566
6	Patch	0.494	0.518
7	Connected tread	0.525	0.538
8	Wrapping the Tires	0.539	0.550
9	Cold Process	0.487	0.514
10	Finishing	0.579	0.597



In the cold process department, there was also a change in the SPI value of the CBC questionnaire results with the integration results on the sticky and cold print deck. So in the cold process indicated unsafe only scrape workstation, where scrape workstation traversed by tires that will follow the process of hot or cold.

#### 4. Conclusion

Based on the results and data processing based on the CBC questionnaire, several workstations indicated unsafe marked with SPI value  $<0,5$  are scrape, gum implied, cut side, hot process, patch, and cold process. While based on the result of CBC integration and weight of interest of AHP, workstations that indicated unsafe only on scrape with SPI=0,498, cut side with SPI = 0,496, and hot process with SPI = 0,492. But overall SPI value on each workstation is on the safe threshold; this can be seen on SPI value of each workstation which ranged between 0,5.

#### References

- [1] I. Gabčanová 2011 the Employees – the Most Important Asset in the Organizations *Hum. Resour. Manag. Ergon.* vol. V pp. 1–12
- [2] L. Lundgren S. Brorsson and A. L. Osvalder 2012 Comfort aspects important for the performance and safety of kitesurfing in *Work* vol. 41 no. SUPPL.1 pp. 1221–1225
- [3] D. Wallace 2003 Commentary: Creating a comfortable working environment is important *St. Charles County Business Record* p. 1
- [4] Å. Svendsen *et al.* 2013 Safety, performance and comfort on EuroMoonMars MDRS mission simulation in *64th International Astronautical Congress 2013 IAC 2013* vol. 5 pp. 3734–3743
- [5] B. Alaimo 2006 Unsafe behavior or unsafe condition - That is the question? [8] *Journal of Chemical Health and Safety* vol. 13 no. 1. pp. 48–49
- [6] S. Aditama and E. A. Gunawan 2013 Evaluasi Perilaku Tindakan Tidak Aman (Unsafe Act) Dan Kondisi Tidak Aman (Unsafe Condition) Pada Proyek Konstruksi Gedung Ruko Bertingkat Di Palangka Raya *Manaj. Konstr* vol. 7 no. KoNTekS 7 pp. 24–26 [in Indonesian]
- [7] T. S. Abdelhamid and J. G. Everett 2000 IDENTIFYING ROOT CAUSES OF CONSTRUCTION ACCIDENTS.(Statistical Data Included) *J. Constr. Eng. Manag.* vol. 126 no. 1 p. 52 2000
- [8] M. Shin H.-S. Lee M. Park M. Moon and S. Han 2014 A system dynamics approach for modeling construction workers' safety attitudes and behaviors *Accid. Anal. Prev.* vol. 68 pp. 95–105 2014 [in Indonesian]
- [9] Health and Safety Executive 2013 Managing For Healthy and safety *Managing for health and safety HSG65*
- [10] P. Fithri N. A. Riva L. Susanti and B. Yuliandra 2018 Safety analysis at weaving department of PT. X Bogor using Failure Mode and Effect Analysis (FMEA) and Fault Tree Analysis (FTA) in *2018 5th International Conference on Industrial Engineering and Applications ICIEA 2018* 2018, pp. 382–385